Precision Aerobatics Thrust 40 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	37.2mm
Length	41mm
Weight (gr/oz)	140gr / 4.9oz
Motor Shaft Dia.	5.0mm
Mounting Bolts Dia.	M3
Max efficiency Current A *	35 A
Peak current A (15 sec)*	45 A
Battery pack range **	2~4 LiPo / 6-12 NiCd
Poles	14
KV rpm/V	850kv
Recommended ESC	PA Quantum 45
Peak Watts	500 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.*

*** PA 3cells (11.1V) 2200mAh V2 pack is recommended. With 4 cells pack the chosen propeller must fit within the motor's limits (current drawn).*

Prop selection for PA2200mah 20C-40C V2 Packs

APC 12x6E - Good lower range general sport propeller for the T40 with long flight duration.

VOX 13X6.5 - Good lower range overall propeller for aerobatics and basic 3D flying. It has very similar characteristics to the APC 13X6.5E with a little lower flight speed but with higher efficiency, longer flight duration and additional thrust. Good alternative with a sexy wood finish and lighter weight (faster spool up). It has a very nice prop sound as well.

VOX 13x7 - Offers a little more flight speed with less thrust than the VOX 13X6.5

VOX 13x8 - Excellent choice for IMAC and precision aerobatic flyers due to the higher constant flight speed.

VOX 14X7 - **Perfect match to the Thrust 40!** Excellent higher range propeller for 3D, freestyle aerobatics and pattern flying. Excellent 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 Ultimate AMR especially for low and slow 3D. Even though it is much larger prop than the APC 13x6.5E it draws lower amps and produces a whopping 90.56oz 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.

APC 14X7E - This is the highest range prop for the T40 and a good overall prop for 3D and freestyle. A little faster flight speed BUT much lower efficiency (shorter flight duration) than the VOX 14x7 with less thrust, therefore we recommend the VOX 14x7 as a better alternative. Adequate airflow to cool down the motor and ESC is mandatory, as well as **strict** throttle management. **Not** recommended for the Ultimate AMR.

VOX T40-X - **TBA**

We recommend getting a few different size propellers with your Thrust 40 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 40, Quantum 45, PA 2200mah 20C-40C V2

Prop Type	Battery Voltage (V)	Current (A)	RPM	Watts (W)	Static Thrust (oz)	Static Thrust (gr)
VOX 12x6	11.42	27.9	8055	319	60.96	1,728.0
APC 12x6E	11.42	28.6	8010	327	63.84	1,810.0
VOX 13x6.5	11.38	34.9	7635	398	75.36	2,136.0
VOX 13x7	11.15	34.6	7455	386	71.84	2,036.0
VOX 13X8	11.03	36.8	7230	406	67.68	1,919.0
APC 13x6.5E	11.24	39.5	7290	444	72.80	2063.9
VOX 14x7	11.19	38.0	7215	425	90.56	2,567.0
APC 14x7E	11.06	43.1	6900	477	87.84	2,490.0
VOX T40-X	11.21	40.7	7155	457	99.68	2,826.0

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.

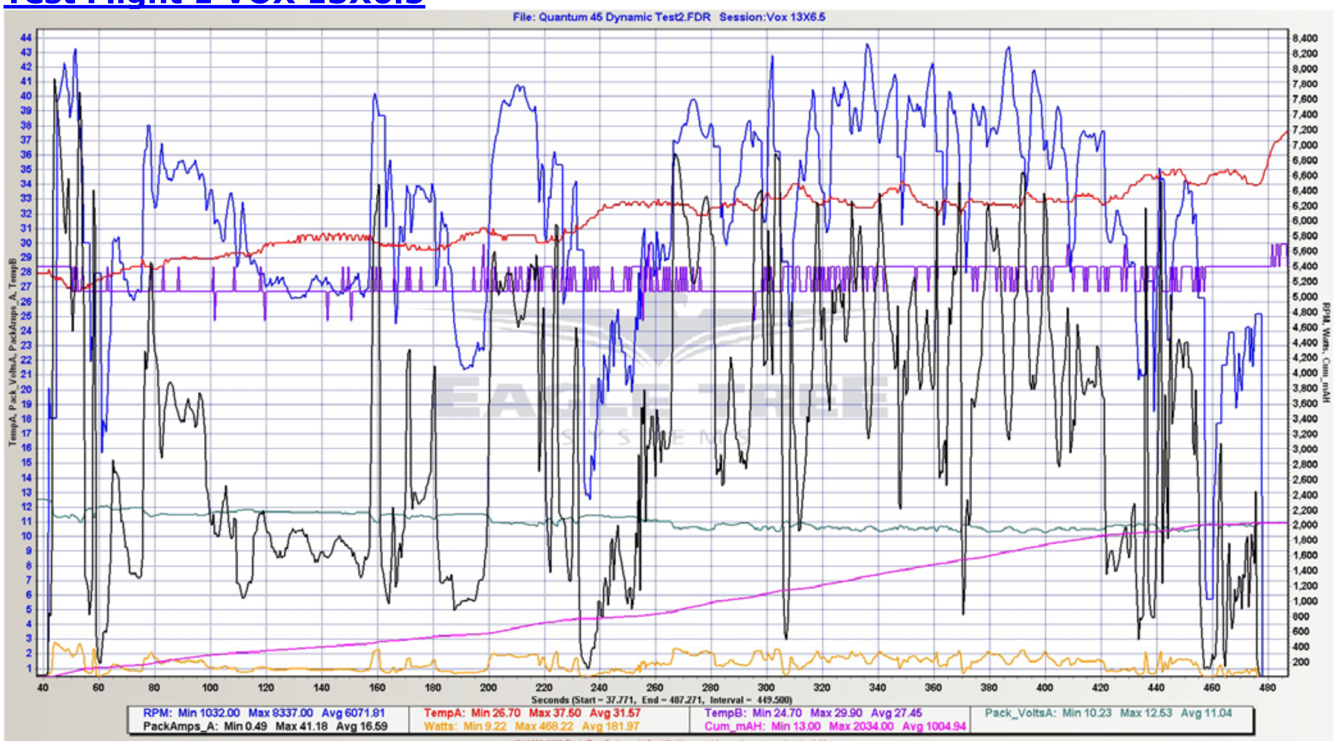
You may also want to look at all the temperature traces on the graph that indicates a fairly constant operating temperature throughout the flight in relation to the dynamic loads imposed by the propeller. This is where our exclusive Rotorkool® feature comes into action to keep motor core temperature 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 40, PA Quantum 45, PA V2 2200mah 20C-30C (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 13X6.5



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a hot summer day with ambient Air temperature of 27.5 Deg C (81.5F). 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.

The **red line (Temp A)** shows the fairly constant motor operating temperature band throughout the fight to be between 29.5–34.0 Deg C (85.1-93.2F) rising and dropping within a narrow 4.5 Deg C (8.1F) 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).

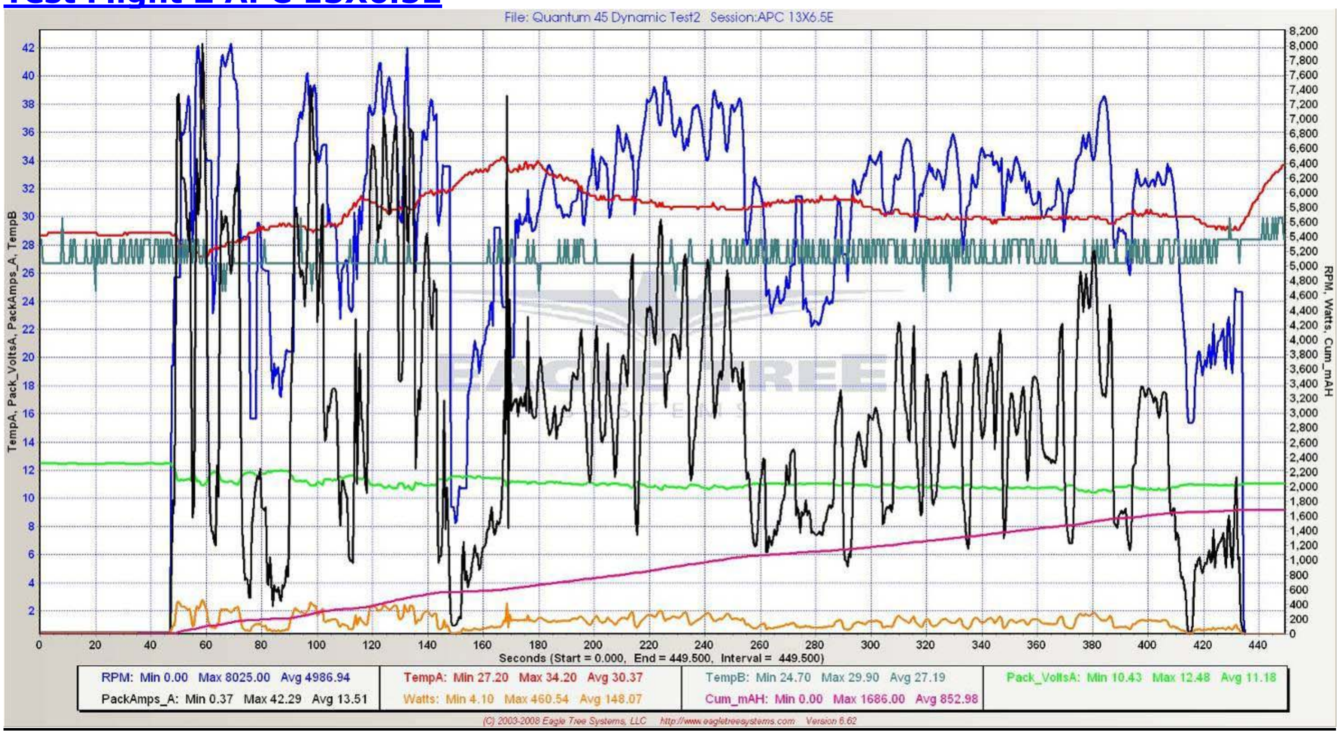
The cumulative battery capacity (**pink line**) after the 8 minute flight indicates that 2,036mAH was consumed.
This coupled with the high peaks of the RPM (**blue line**) clearly demonstrates that this flight was predominantly done performing lots of high energy maneuvers.

The **purple line (Temp B)** records the operating temperature of the Quantum 45 responding to the flight loads imposed by the Thrust 40 which in this flight shown at about the ambient air temperature throughout the entire flight and only rose after the motor stopped.

The battery voltage (**green line**) also shows a very constant voltage throughout the flight and never fell below 10.23V for the entire flight duration providing very consistent performance throughout the entire session without the need to rearrange any flight maneuver. The peak watts (**orange line**) in this test flight was **468.22W** with a maximum peak current of **41.18A** (**black line**).

No issues were noted on the Quantum 45 and the throttle response was smooth and linear with consistent performance in all maneuvers.

Test Flight 2 APC 13X6.5E



Graph interpretation & Flight Report:
Dynamic test was deliberately conducted in a hot summer day with ambient Air temperature of 26.6Deg C (79.88F). 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.

The **red line (Temp A)** shows the motor operating temperature throughout the flight between 29.5 Deg C to 34.5 Deg C (85.1-94.1F) i.e. **lower than a normal human body temperature!** The operating temperature rises and drops corresponding to the loads being imposed and only rises after the motor has stopped (after landing) indicating the Rotorkool® HVFCV feature was managing the temperature while the motor was in operation. This is indicative of both the **blue** (RPM) and **Black** (Motor current) lines.

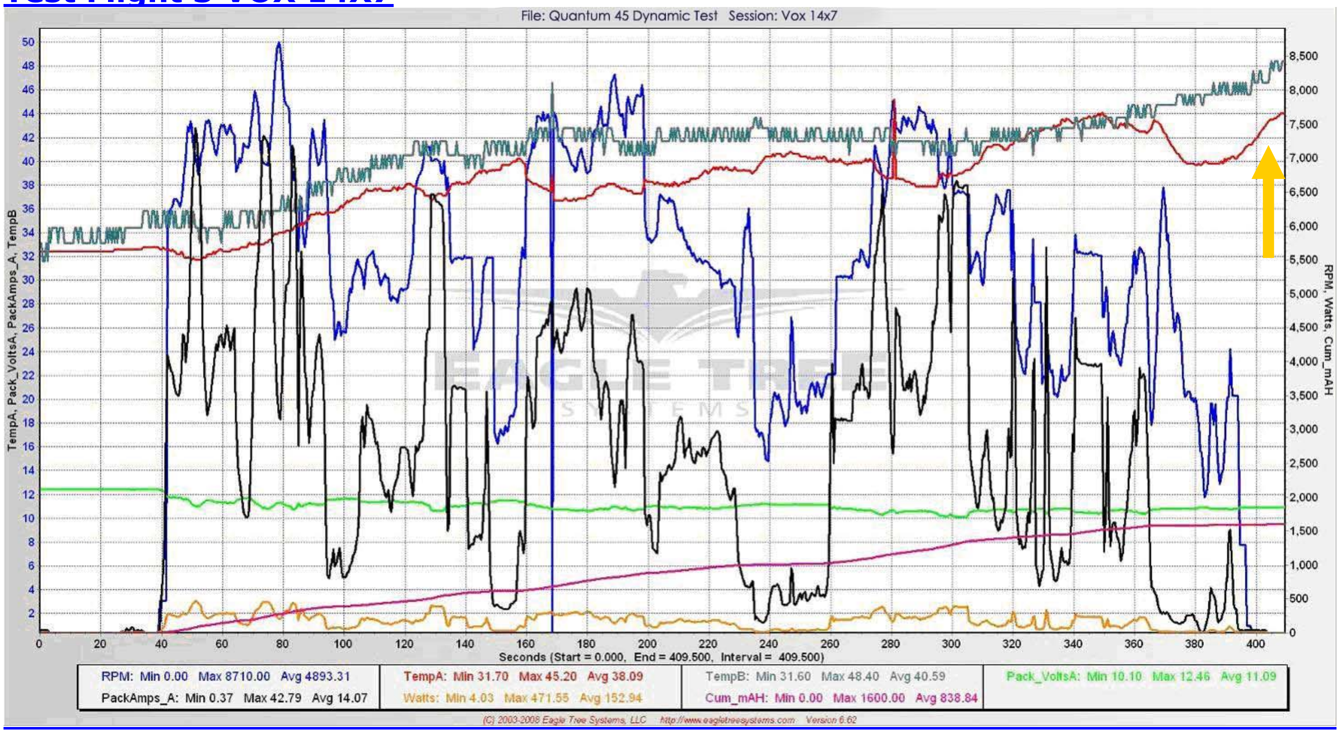
Please note that the momentary max current draw (**42.29A**) caused by a full powered vertical climb after takeoff is actually higher than the static bench test results clearly underscores the importance of dynamic flight testing as opposed to being solely reliant on static bench test results for proper gear selection.
The **turquoise line (Temp B)** records the operating temperature of the Quantum 45 responding to the flight loads imposed by the Thrust 40 which in this flight shown at about the ambient air temperature throughout the entire flight.

The **green line** shows the voltage performance of the PA2200mAH V2, 20C-30C packs throughout the flight. Here you can see the pack's ability to hold a fairly constant voltage and never fell below 10.43V throughout the entire duration of the flight providing very consistent performance from end to end without the need to make any compromises on the sequence of maneuvers throughout this session.

The cumulative mAh (**Pink line**) indicates the accumulated battery capacity throughout the flight and consumed approximately 76% (1,686mAH) of the pack's capacity after this 7.1 minute flight.

The **orange line** (watts) shows the motor power output throughout the flight peaking at **460W**.
No issues were noted on the Quantum 45 and the throttle response was smooth and linear.

Test Flight 3 VOX 14X7



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a very hot mid-summer day with ambient Air temperature of 31.9 Deg C (89.4F). 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 45 and the tested airframe. This test flight is a consecutive flight.

The **red line (Temp A)** shows the very constant motor operating temperature throughout the fight to be between 37–39 Deg C (98.6-102.2F) rising and dropping corresponding to the loads being imposed by the large wooden 14X7 prop.

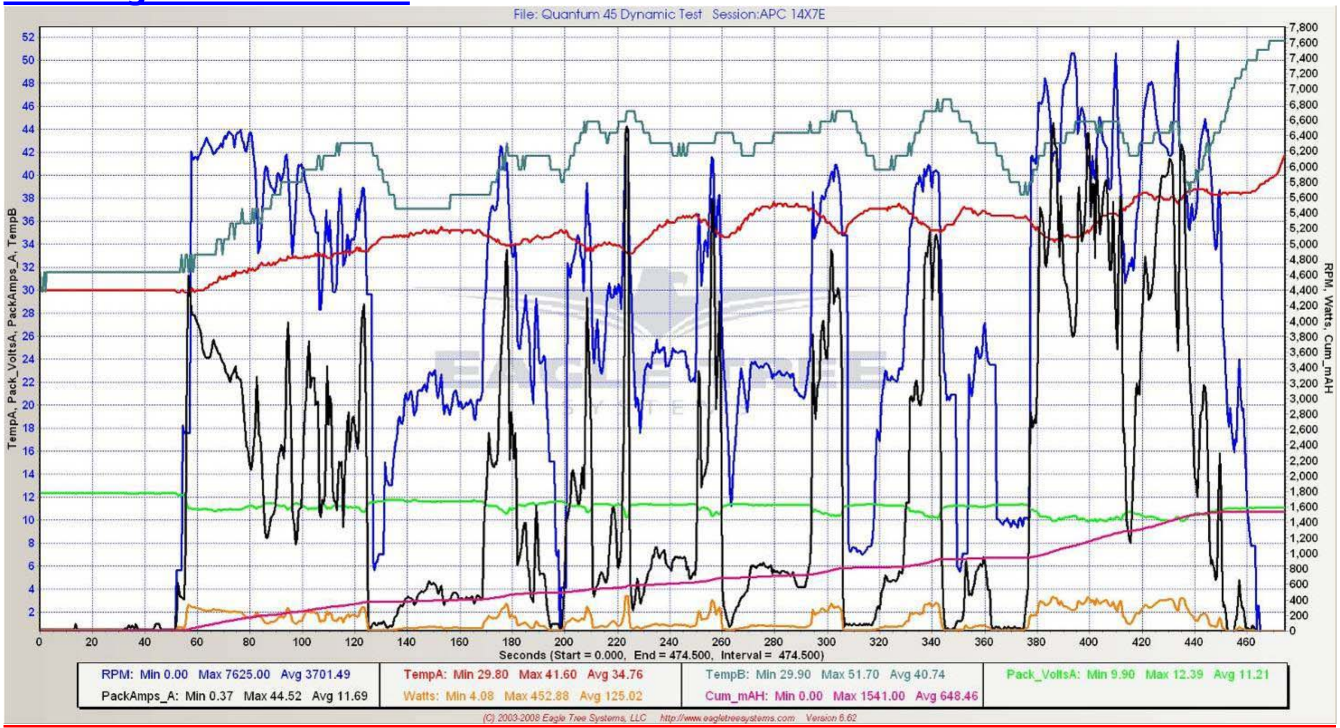
The very constant nature of the temperature trace on this flight demonstrates how well Rotorkool® controls the temperature maintaining it within a narrow band. A rise in temperature starting at 400 seconds was when the aircraft landed and the motor stopped (Refer to the orange Arrow on the graph). The **turquoise line (Temp B)** records the operating temperature of the Quantum 45 responding to the flight loads imposed by the Thrust 40.

The cumulative battery capacity (**pink line**) after the 6.6 minute flight drew only **1,600 mAH** which demonstrates the efficiency of the iPAs setup.
The battery voltage (**green line**) also shows a fairly constant voltage throughout the entire flight and never fell below 10.0V therefore provided very consistent flight performance with absolutely no compromises on the maneuvers from start to end.

A whopping peak watts (**orange line**) of **471.55W** on this test flight with a maximum peak current of **42.79A** (**black line**) clearly demonstrating the efficiency of the VOX 14X7 prop over the APC 14x7E and the capabilities of the PA 2200mah V2 pack for maintaining a higher sustained voltage (i.e. a higher watts output with lower amp drawn).

No issues were noted on the Quantum 45 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 14X7E



Graph interpretation & Flight Report:

Dynamic test was deliberately conducted in a very hot summer day with ambient Air temperature of 30 Deg C (86.0F). 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 45 and the tested airframe.

The **red line** shows the motor operating temperature throughout the fight to remain exceptionally constant within a narrow band of 33–37.9 Deg C (91.4-100.22F) rising and dropping corresponding to the loads being imposed by the larger APC 14X7E prop coupled with unrestrained power of the higher performance V2 pack. Note that the temp only rose after the motor was stopped (after landing).

The **turquoise line (Temp B)** records the operating temperature of the Quantum 45 responding to the flight loads imposed by the Thrust 40.

The cumulative battery capacity (**pink line**) after the 7.6 minute flight drew only 70% (1,541mAH) of the pack's capacity. The battery voltage (**green line**) also shows a very constant voltage throughout the entire flight and never fell below 9.9V providing very consistent performance throughout the entire session in-spite of being flown hard with the huge APC 14X7E prop. It also indirectly demonstrates the superior capabilities of the PA2200mAH V2 pack at the same time and as such did not impose any compromises on the sequence of maneuvers throughout this session.

The peak watts (**orange line**) drawn on this test flight was **452.88W** with a maximum peak current of **44.52A** (**black line**).
No issues were noted on the Quantum 45 ESC (in momentary short burst to 44.52A) 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.