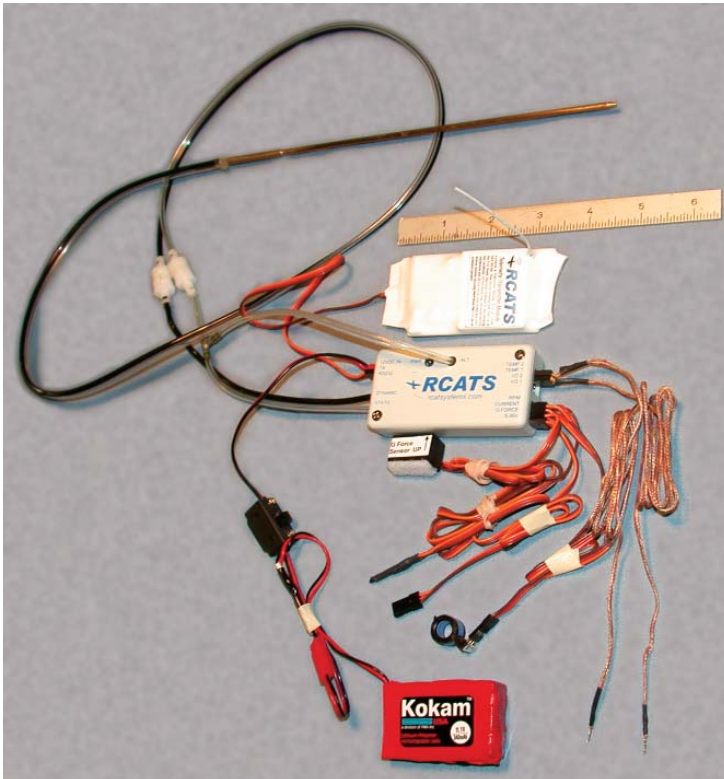


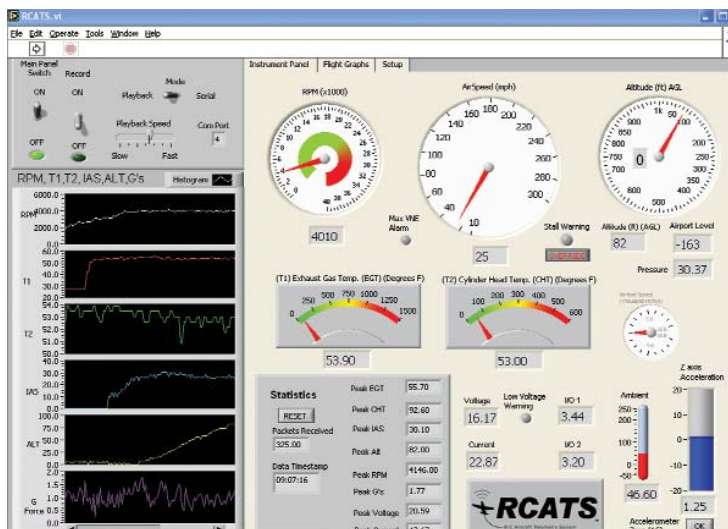
RCAT System tested in Electric Models

Get real time information on airborne model performance

by Tom Hunt



The RCATS Sport Unit includes a processor, transmitter, power supply switch harness (a 3-cell Li-Poly pack is not included; Kokam 3S1P 340mAh pack shown), two thermocouples, rpm sensor, battery cable brass pitot tube assembly, pressure tubing, T-fitting and quick disconnects. The current and G sensor (accelerometer) are sold separately. Other sensors can be added, such as additional temperature probes and a fuel level sensor. Typical weight of the system as shown is 6 to 7 ounces.



Data is presented by the RCATS software in digital, analog and graph format for all the onboard instrumentation. Low voltage and stall warning alarms can be set.

Have you ever wondered how or why one model flies faster, turns tighter, or climbs higher than another climbs? Until recently, the relative performance differences between two models was purely subjective, as the data collected was merely your visual observation. Now, we can put “real” numbers to many of the attributes we look for in a model aircraft. The RCAT (R/C Aircraft Telemetry) System (www.rcatsystems.com) offers the modeler a more precise way to determine the flight qualities of his aircraft. Parameters such as airspeed, rpm, altitude, and rate of climb are radioed back to a ground station from your model for instant viewing and recording.

This article will concentrate on using this system for electric model aircraft. Although not originally designed for this type of vehicle, the manufacturer has added enough capability to the unit to make it extremely useful for this task. The author and a fellow modeler/software programmer have enhanced the “post processing” of the data to make it more useful to the E-modeler, as you will see.

The “basic” system includes sensors and supporting hardware for rpm, altitude, temperature (two discrete temp measurements), ambient temperature, voltage and airspeed. Additional sensors can be added at an additional cost for current, “Gs” (accelerometer), two secondary voltages, and fuel level (though this is not a concern for the E-modeler!). The package also includes a complete installation and use manual. Software updates (for the PC/laptop ground station) are to be available on the RCATS system web site.

SPECS

PROCESSOR: 3.18 x 1.63 x .75 in. (1.6 oz.), 11 data acquisition channels

TRANSMITTER: 3.00 x 1.75 x .5 in. (1.2 oz.)

TRANSMITTING FREQUENCY: 902-928 MHz (spread spectrum, frequency hopping), 2.4 GHz also available

POWER

REQUIREMENTS: Aircraft: 12V (approx. 250mA drain), Receiver: 9V (transistor battery, approx. 2hr capacity)

TOTAL AIRBORNE SYSTEM WEIGHT AS REVIEWED: 6.3 oz. (with 3-cell Kokam 340mAh cells)

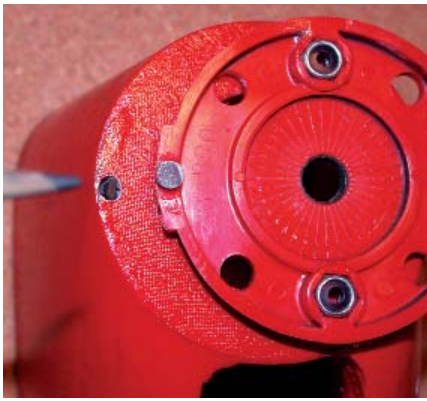
SOFTWARE: Supplied on CD-ROM

COMPUTER (GROUND STATION) REQUIREMENTS:

- PC or Laptop with Windows 95 or newer
- 500 MHz or higher processor
- 50 MB of free hard disk space
- 256 MB of RAM
- CD-ROM Drive
- 9-pin serial port (direct USB support available in future, USB serial adapters can be used)

SPORT UNIT BASE

PRICE: \$749.95 (as tested); \$829.85 (current and accelerometer added)



The rpm instrumentation consists of a “Hall effect” sensor mounted in the cowl and one or more magnets mounted on the backside of the prop or spinner. The sensor should be mounted with the tip of the unit within 1/16 in. from the aft face of the magnet. For low rpm applications (big props on gearboxes/belt drives,) the magnets can usually be secured with CA. For higher rpm applications (direct drive motors and smaller props,) it would be wise to use epoxy or silicon glue.

MOUNTING THE RCAT SYSTEM

The 11-channel RCATS processor, transmitter and sensors mount in the model quite easily. Many components can be held in place using Velcro hook and loop fasteners anywhere in the model that is convenient. The full complement of sensors, processor, transmitter and supporting 12V power supply (Kokam 3-cell (3S) 340mAh Li-Poly) weigh just over six ounces. Though the sensors are small and unobtrusive, the processor is about the size of a large RC receiver and the transmitter about the size of a credit card and 1/2 inch thick. This requires that the model not only have sufficient volume to carry these items, but be capable of carrying the extra six ounces without burdening the model’s flight performance. I would venture to say that any “glow 40” (14 to 16-cell NiCd/NiMH) size model or larger is appropriate for this system.

A “Hall effect” sensor mounted behind the spinner (or prop) in the cowl gathers rpm data. The modeler is left to his own ingenuity to mount the sensor. One to four small “pill” magnets can be mounted on the backside of the spinner or prop (one magnet is provided with the system). It is important to pay attention to the orientation of the magnetic field, and magnets supplied by the manufacturer are marked as to which side faces the sensor. The software must be told how many magnets are used; this is a simple line item to change.

The current sensor is also a “Hall” type sensor. One of the battery leads is passed through the coil (sensor). It is preferable to have the wire pass through the coil at least twice to get good resolution from the sensor. The software must also be changed to



The pitot tube must be installed outside of the prop wash to acquire good data. The tube must also extend out in front of the model at least 3 inches. The pitot tube is shown mounted inside a balsa block that has been Velcro’d to the bottom on the wing of the test vehicle. The pressure tubes were simply taped to the bottom of the wing and routed to the fuselage externally.

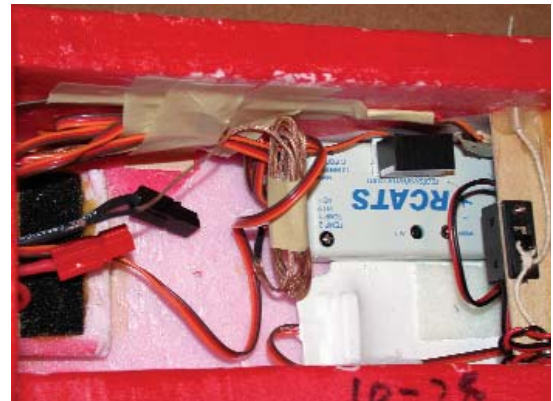
reflect the number of passes the wire makes through the coil.

Voltage measurement leads are the easiest to install. Simply have an additional shielded male connector (Futaba or JR receiver type is fine) available on leads that are connected to those on the motor battery pack. The unit is supplied with a cable (female jack) that will connect the battery to the processor.

The ambient temperature sensor is inside the processor, so the modeler doesn’t have to mount a temperature sensor. Because the sensor is mounted inside the processor, and the processor is inside the model (generally), the data will be influenced by possible passive solar heating (clear canopy?) or by the warming of the motor battery pack. An optional remote ambient temperature probe can be purchase and installed if the true ambient air temperature is required in your flight-testing.

Two discrete temperature probes (thermal couples) are provided with the basic unit. These probes merely have to be taped or glued to the object from which you wish to have the temperature recorded. I usually have the motor battery and the case of the motor instrumented.

The altitude sensor is also inside the



The processor can be seen on the right hand side of the fuselage behind the battery. The RCATS transmitter is on the left hand side underneath the system battery and aircraft receiver battery. The small rectangular box on top of the processor is the accelerometer for measuring “Gs.”



The Model Motors AXI 4130/20 “outrunner” motor replaced the original DeWalt/belt drive system in the Modelair-Tech Megawatt for the flight tests. The motor case was instrumented with one of the two provided thermocouples to measure the motor temperature.



Detail of the internal wiring of the Hall sensor that measures rpm.

processor. A separate static port on the processor is provided. You should connect the static port on the pitot tube to the altitude port on the processor module. This will yield more accurate data than when using the static pressure sensor inside the fuselage.

Provided with the basic unit is a switch harness for the RCATS transmitter/proces-

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tor power, equipped with “JST” type connectors. I chose to use a Kokam 3S1P 340mAh Li-Poly pack, as this would supply well over an hour of flight data acquisition time.

EXTERNAL SENSORS

Airspeed data is collected by a conventional “pitot” tube. The pitot tube can be mounted anywhere on the model outside of the prop wash. The pitot tube’s two pressure ports (static and dynamic; “dynamic” is sometimes referred to as “total”) are connected to the processor through soft plastic tubing supplied with the unit. It would be preferable to mount the pitot tube out on the wing and to install the connecting tubing inside the wing, but this is not always practical after a model is built. Most models, where absolute top speed measurements are not required, can have the pitot and connecting tubing externally mounted on the lower side of the wing. A Velcro™ platform for the tube can be made, and the tubing simply taped to the lower wing surface.

The “static” and “dynamic” ports on the pitot tube must be identified to connect them to the processor correctly. It is a simple matter to blow back through the tube to find out which of the two brass tubes exiting the pitot assembly is the static or dynamic port. The static port(s) is the series of four holes around the outside of the probe, just aft of the very front. The dynamic port is the hole in the very front of the probe. It is recommended that the very front of the pitot tube be at least three inches ahead of the leading edge of the wing.

SOFTWARE TIPS

The supplied software (which you load onto your PC and/or laptop) collects, displays and records the data. A playback mode of the recorded data is also available. A real-time window (the format of which can be modified in some aspects by the modeler) displays the data in analog (gauges, dials) and digital formats, as well as histogram graphs. Peak values of some of the data are also displayed on the screen.

Although there is an option to *not* record the data, I cannot see any real use for this option. In fact, although the real-time data is a nice feature, the pilot is not able to look at it and fly the model at the same time! During some flight tests, I did have a helper call out some of the data to me so I could immediately see the effect of the flight profile on my piloting inputs.

The recorded data is stored in the RCATS directory under a file name you choose when



The author chose his Modelair-Tech Megawatt as the RCAT system review vehicle. The model has been flown for many years on 16-21 cells on a Power Tool (DeWalt) motor and belt drive system. The RCAT system was easily installed in this model. The 7lb. model, with 1,300 sq. in. of wing area, easily carried the 6.3 oz. system weight of the data telemetry system. With good planning, smaller models can carry the RCAT system.

the RCATS program is launched. Approximately 10 data points per second are recorded from the time the RCATS Tx/Rx are turned on to the time the software is stopped, or the RCATS receiver is turned off. No software is supplied to view the raw data. The data is “tab delimited” and can be easily imported into a Microsoft Excel spreadsheet.

If you are familiar with the Excel program, creating your own columns, post processing and graphs can be almost as much fun as collecting the data. I, however, am not that good at Excel. A good modeling friend of mine, Joe Cabana, set up a start-up Excel spreadsheet with macros that will organize and average the data (within the one second interval), create an elapsed time and watts (input) column, compute amp-hrs used in the motor battery pack, and compute a rate of climb based on the averaged data. This start-up spreadsheet, tailored for formatting the RCATS data file and specific to analyzing electric models, is available for download at www.flyrc.com/rcats.

CREATING YOUR FLIGHT CARD

In full-scale flight testing, a “flight maneuver” card is generated for the pilot before takeoff. This card details the order in which the maneuvers will be made, at what speed, altitude and many other parameters. This is done so that all parties involved in analyzing the data understand the manner in which it was collected. It also helps “debrief” the test pilot after a flight. Not being “inside” the vehicle can be a disadvantage: It is difficult to be consistent in your testing when you cannot casually look down at your flight instruments and many other parameters while collecting data.

Therefore, performing your high-speed passes without gaining or losing altitude has to be practiced. “Feeling out” the proper rate of climb of the model may take a few tries, so don’t expect to get “good” data on your first try. It will take a few flights with the system on board, in addition to analysis of the data

after a flight, before you can set up a “flight card” that will help give you consistent data throughout all flight tests. Once you have a “flight card” that works, follow it religiously! You will also find that you may have to repeat tests on subsequent tests to “confirm” that the change you made was for the better (or worse!).

TYPICAL FLIGHT TEST

Here is how I suggest you go about a flight test program of a typical “sport” model.

- (1) Run a 10 to 15-second full power static test on the ground first, before sending the model aloft. Always advance the power slowly, but reduce it abruptly. The abrupt reduction of the throttle will be evident in the data and help you see the end of one event and the beginning of another. Avoid taxiing the model before takeoff. It is better to have it already positioned into the wind after the static test run.
- (2) Advance the throttle very slowly and let the model take off from the ground on its own (do not force it off).
- (3) Climb out at the steepest angle you can while keeping the model in a straight heading (a model that is climbing too steeply is usually very difficult to precisely control and wanders around in all the axes). Allow the model to climb at full throttle for 15 to 20 seconds.
- (4) Reduce the throttle abruptly after the climb and push the model into level flight with down elevator. This will easily show the end of this sequence in your data when you review it later.
- (5) Perform a power-off glide back to the field until it reaches an altitude of only a few feet.
- (6) Add power slowly to full throttle and climb less steeply than the initial climb-out. Repeat this sequence a number of times at different climb angles if climb performance is important.
- (7) After the last climb, abruptly reduce the power and hold it off for a few seconds. Then, add power slowly and perform a few high-speed passes across the field, abruptly reducing the power between each pass. Concentrate on holding a constant altitude.
- (8) Fly the model at a constant altitude at a “comfortable” cruise speed. Have a helper read the real-time data and inform you of that airspeed.

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TIME	ELAPSED TIME	RPM	AIR SPEED	BATTERY VOLTAGE	BATTERY CURRENT	WATTS	ALTITUDE	CRTC	G	BATTERY TEMP	MOTOR TEMP	AIR TEMP
8:49:46	0:00:54	2418	1.9	16.6	37.3	619	0	0	1.01	74	42	59
8:49:47	0:00:55	3608	9.8	16.1	37.5	604	-1	-60	0.87	73	63	58
8:49:48	0:00:56	3692	23.4	16.0	32.3	517	-6	-300	0.98	73	65	58
8:49:49	0:00:57	3778	28.4	16.3	32.7	532	-1	300	1.35	72	66	58
8:49:50	0:00:58	3796	31.1	16.2	29.7	483	6	420	1.32	72	65	58

This screen shot of an Excel® file shows post-processed data from the RCAT system. The author and Joe Cabana developed a spreadsheet “macro” that averages the raw data within any one-second period, computes input watts (from voltage and amperage), computes “rate of climb” from the averaged altitude changes, and adds an elapsed time column. When the data is presented in this format, it is much easier to assess the meaning of the data, even before it is graphed. The most current version of this spreadsheet now includes battery amp-hrs consumed during the flight. Download a free copy from www.flyrc.com/rcats.

(9) Make passes up and down the field at indicated airspeeds below and above that airspeed by about 5 mph. If the airspeed gets too slow, this will be evident in an erratic flight path.

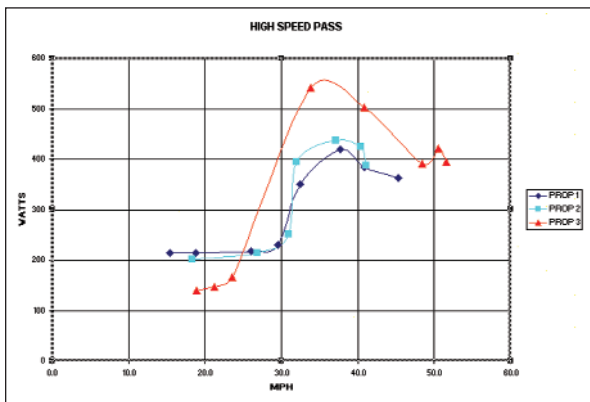
(10) Perform a full power loop from level flight, keeping the power constant.

(11) Land the model normally.

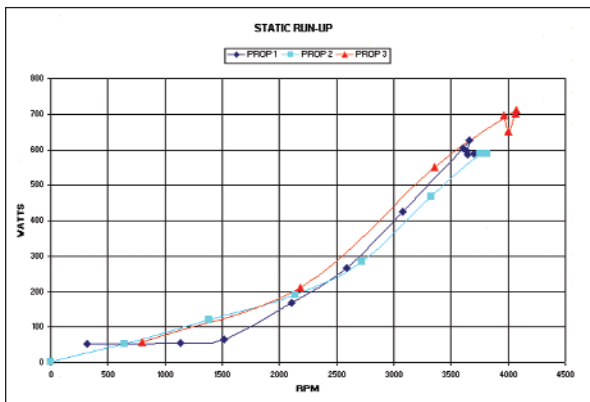
If you get the sense that your model stalls at an airspeed that is greater than 15 mph (the system has poor resolution below this

value), then you can throw in a few power-off and power-on stalls before you land. It takes practice to get a model into a consistent stall in either mode. You may exhaust an entire battery pack on each new model just on this one maneuver!

You might not need all this data with other types of models. A sport aerobatic model might lead you to investigate only parameters such as rate of climb and “Gs” pulled; high speed and cruise flight may be of no concern. With duration models, you may only be concerned with optimizing cell count or prop sizes for the best “cruise power.”



Data from the RCAT system can be plotted in Excel to help you visualize the difference in performance between two or more configuration changes. Here, three different propellers were test flown and compared in a mph vs. watts (input) graph.



Before each flight, the motor/prop combination is run “statically” on the ground for a few seconds. This is done to show how each prop performs in a static test as compared to an airborne test.

ANALYZING THE DATA

Once the volumes of data are collected, what do you do with it? I first have to assume that anyone interested in this type of system has more than a basic knowledge of aerodynamics. If your reason for using the system is to make a better model (higher speed, faster climb, longer duration), then you can interpret the tabulated or graphed data to make an “educated” decision on the next step. You can determine which configuration proved to be the best.

Graphing the data to compare two different data streams, such as rate of climb versus input watts, can clearly show which propeller or cell count performed the best. Graphing cruise power against input watts at various airspeeds can clearly show that a model actually needs to fly faster to be more efficient, even though intuitively one would think that a higher speed means more power

consumed! Plotting (vertical) Gs against airspeed can give you a good indication of stall speed. When the “Gs” abruptly change from “1” (level flight, constant altitude flight) to a negative number as the speed decays, this is a good indication of a stall. Pulling consecutive loops at an ever-increasing tighter radius until the model stalls, or until a max G reading is obtained, can give the modeler a sense of the maximum lift coefficient of which the model is capable.

Generally, I think that an E-modeler would get the most out of this system by using it to assess which propeller and/or cell count combination “really” flies the model best, despite one’s best intuition. The model “configuration” is generally “fixed” i.e. its physical outward appearance. The only real change one would make is the prop, motor, gearbox ratio (if used) and cell count (which directly and significantly affects the weight).

CONCLUSION

I certainly wish I had this system back in 2001 when my club and I (SEFLI, Silent Electric Flyers of Long Island) flight tested and flew an electric seaplane round trip from Long Island, NY to Bridgeport, CT—a distance of 28.8 miles in 1 hour and 12 minutes. At that time, we were “optimizing” the model configuration with the help of an onboard, scratch-built downlink “watt meter” and a commercially available hand-held GPS unit.

RCATS, to me, can be as addictive as the internet. I now have a tool that opens many doors and asks almost as many questions as it gives answers! I look forward to using this tool to “truly” investigate the world of model flight for years to come. No longer do I need to say, “Gee, that model flies great!” Now I can say HOW great! 🌟

Links

Kokam Batteries, distributed by FMA Direct, www.fmadirect.com, (800) 343-2934.

RCAT Systems, www.rcatsystems.com, (408) 292-9794.

For more information, please see our source guide on pg. 177.