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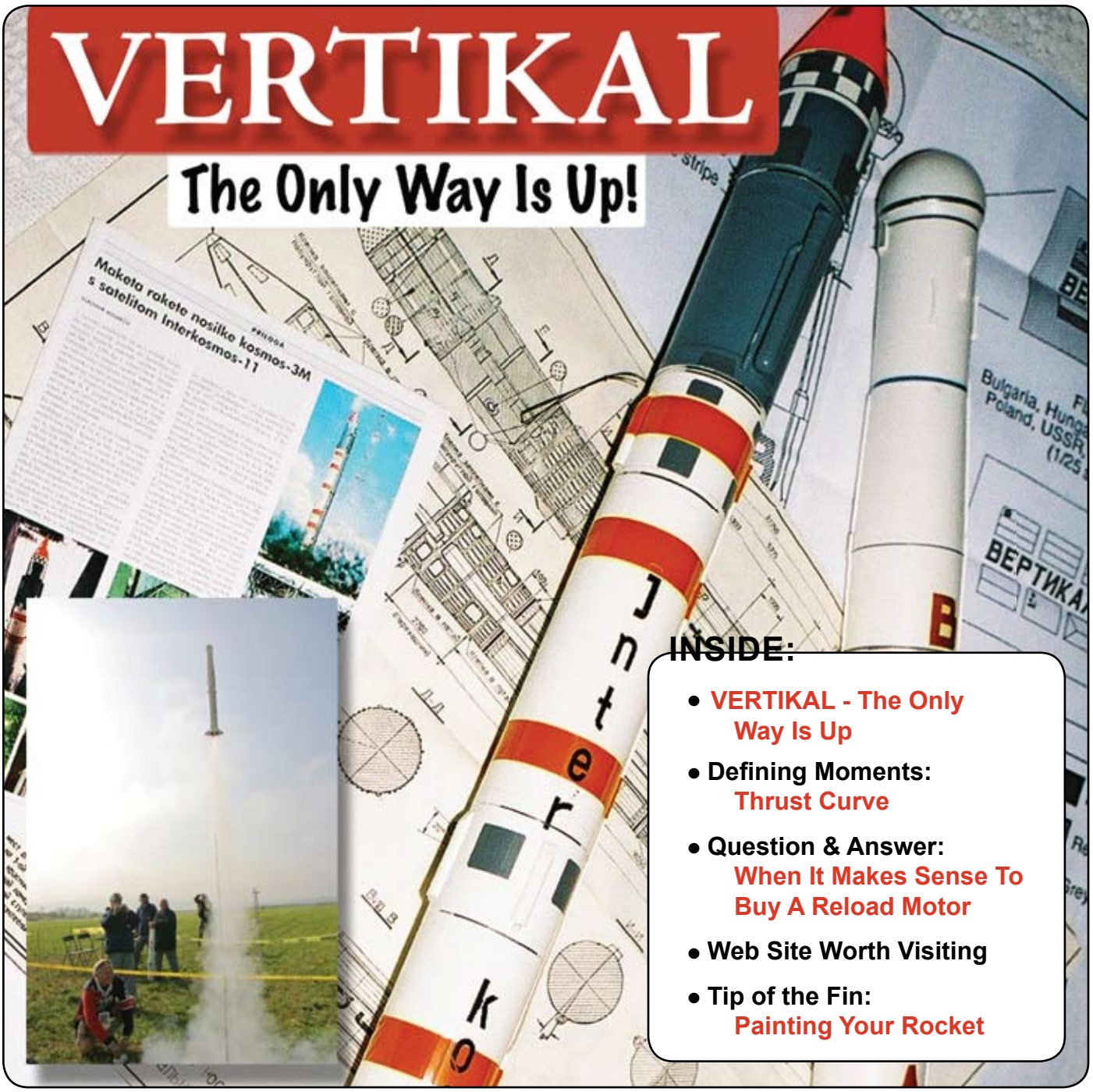
APOGEE PEAK OF FLIGHT NEWSLETTER

VERTIKAL

The Only Way Is Up!



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VERTIKAL...
the only way is up!

By Stuart Lodge

A very simple, very successful, FAI S7-Scale space model...

CCCP – the old Soviet Union - had a pretty exciting space program, dating from the end of World War 2. The major watershed was the 1961 launching of Yuri Gagarin in a Soyuz-based Vostok vehicle, with subsequent manned and woman-ed launches in Soyuz-based rockets. This continues to the present day, with the Soyuz seeming eternal, but backed up by exciting newer delivery systems like Proton and Cyklon. In FAI Space Modeling, Soyuz variants form la doyenne, with NASA Saturn 1Bs and ESA Arianes hot on their heels. However, a number of lesser-known birds were also key to the Soviet Union's Space Program.

One of these was the V-5-A, which made its full-size appearance in 1958, unmanned - albeit sometimes dogged. This prototype formed the delivery system for advanced solar ultra-violet studies, boosting a plethora of payloads ranging from ultra-violet spectrographs, mass spectrometers to live canine loads…all to be recovered safely by parachute! During the 1970s, the prototype was adopted into the Vertikal Project, part of the Soviet Interkosmos program of Eastern Bloc countries. These vehicles - all called Vertikal – carried payloads fabricated by East German & Soviet scientists. These included instrumentation to study the ionosphere and record solar radiation, all housed in a cylindrical housing, topped by a parachute-recoverable spherical capsule.

The first V-5-V Vertikal 1 boosted out of Kapustin Yar, Southern Russia, on 28 November 1970. This prototype was to form the subject of my research. Its success ensured that over the next decade, ten more boosts were undertaken in conjunction with other Eastern Bloc nations. 1981 saw the final shot of this brilliant program.

There endeth the history lesson. In the late 1990s, I needed a bird to contest FAI the World Cup events, but lacked the time and commitment to consider a multi-functional Soyuz. I thus decided upon the V-5-V Vertikal 1! Naturally, no kit was available; naturally, no one I spoke to knew anything about it; naturally, I needed a lot of data! My research was gleaned from the following:

- Alway, Peter; *Rockets of the World*, 2nd Ed, ISBN 0-9627876-5-5.
- Twardowski, M; *Rakieta geofizyczna WERTIKAL 1 ZSRR*, Modelarz nr 5 (401), May 1989. Polish model magazine; super detailed drawings & photos.
- Minakov, Vladimir; Good photos at the works and boosting, from Russia.

The array of sources above is international, and was obtained with the help of friends around the globe. Normally brilliant, Internet surfing was less than productive in this data search.

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Scaling up… How to start ? This article cannot be an exhaustive "cut & shut" analysis of how to build a scale model rocket. This is a project for builders who are past the basic kit stage and have accumulated sufficient skills and knowledge to employ progressive construction techniques. The photographs provide a very effective impression of how the bird was made. In space modelling, the scale factor is normally taken from the major body tube diameter. Estes' catalogue lists a wide range of tube diameters and these are easily available. Estes' body tubes needed are:

- BT-80 - 66.09mm diameter : 2 pieces, with tube couplers, for main body.
- BT-50 - 24.80mm diameter : 2 pieces, with tube couplers, for 24mm motor mount.
- BT-80 - 66.00mm diameter : 1 piece for front nose section, after rolling down.

Two BT-80s were bonded together using an EST 303196 tube coupler to achieve the ~60cm length needed. The front body needed to be 5.57cm in diameter and an Estes' BT-80 tube was sliced and rolled down. Finishing started here. Body tubes possess a depressed helix where the tube was rolled at the mill and this would be clearly visible through any paint job. The helix was filled with a combination of Tippex – painted along it, top to bottom followed by white primer. Rubbing these down between applications left the body sections resembling fluorescent strip lights. Caliper/micrometer measurements double-checked that the diameters of the tubes are as stated and from these, the scaling factor determined to be 1:25.1173. Scale drawings previously obtained were scrutinised and every dimension scaled – then the drawings were xerographically enlarged to the model's finished size.

World Cup needs… This bird was intended for World Cup events – consequently, "special effects" were included into the flight profile at the design stage. Conversely, reliability in all flight segments - boost, coast, and ejection of the recovery systems - was crucial and the following committed to…

- Single stage boosting – either 20Ns Estes D12-3, or 40Ns Aerotech E15-4.
- Main body ..recovered under a single parachute.
- Nose section to recover under a single parachute, cracking open to release.
- Spherical instrument capsule ..also recovering under a parachute.

Prototype Core This is defined as an assembled & primed model, with hatch covers and body stage wraps simulated by sticky paper labels and joint welds made with strips of PVC insulation tape but no major details were added, nor finished paint job. To turn the two partly finished body tubes into this, the following was needed:

- Main body section - needs sizing to 60cm, to include a little "meat" at the tail end for cutting away between the fins and prepared such that a tube coupler does not coincide with the body : nose fit.
- A tapered shoulder - needs to be developed from

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relevant equations and cut from vellum/card to blend the main body into the smaller nose section.

- A spherical instrument capsule - 6.4cm in diameter (the original used a Quickfit chemistry flask) - perfect diameter, very strong and also doubling as nose mass.
- Motor tube assembly - from BT-50 tubing 45cm long, with centering rings cut from 3mm balsa, or thick card.
- Fins – 4 off - to be fitted after finishing. On the full-size, these fins are very small, the rocket having a guidance system. During Vertikal's first competitive outing in Slovakia in 1999, it was apparent that stability and dynamic damping were right on the edge…paradoxically still winning two medals! Consequently, new fins were made with increased area, using 1mm clear polycarbonate sheet at the rear. This was used as the core fin material, with a balsa mid-section and 1mm polystyrene simulating tip steerers.

At this stage, the nose section needed separating from the main body section – this is the part that will be blown off to eject the recovery parachutes of the body and nose. The nose section needs an EST 303196 tube coupler affixing such that the front section locates in the body with a sliding fit. A good time to check the body length..

No specialist tools were needed, except an artist's "Compass Cutter" – a device for precisely cutting circles in card, plastic sheet and balsa. This is particularly useful for making centering rings used to set up the motor tube and nose section, which must be concentric with the main body. Like most of my models, Vertikal was made with scalpels, scissors, steel rulers and abrasive papers…most modelers of a couple of year's standing will be well enough equipped. Vertikal was stuck together with the normal suite of stickies… PVA, cyanoacrylates and fast epoxies. The last lap bell sounded.

The Run in Vertikal entered this final (but vital..) stage as a basic shell – the motor tube prepared but not inserted, enabling the body/cone assembly to be set up horizontally on a Workmate for the spray job. Before this, all surface details – cable conduits, inspection hatches, fins, transponder aerials etc – needed making…lots and lots of them, largely from commercial extruded polystyrene and sheet, the aerials from micropipette needles! When complete, body details were "pasted up" on a board for spraying and these and the prototype core blown over with automotive white primer. Relatively few colour details are needed and a tape and paper job was undertaken to mask virgin areas – checking with the drawings & photos constantly - before spraying with the various other tints. When complete – again with meticulous checking – various details were applied to the core…a good tip is to label the model's fin positions with 1,2,3 & 4, related to the numbering on the drawings; very few real prototypes have symmetrical details. In addition, graphics – numbering and lettering – needed making. My friend Paul Clark, Senior Lecturer in Design at Brighton Art College, undertook to enlarge the A4 drawings and from there produced excellent Cyrillic graphics for the model. The Eastern Bloc flags motif on the nose section was similarly prepared… and the lot now meticulously applied. Body trim stripes were applied using thin slices of blue, grey & brown insulation tape and hi-tack aluminised Mylar.

Before adding the prepared motor tube, a decision was taken to affix the shockline – a length of Kevlar

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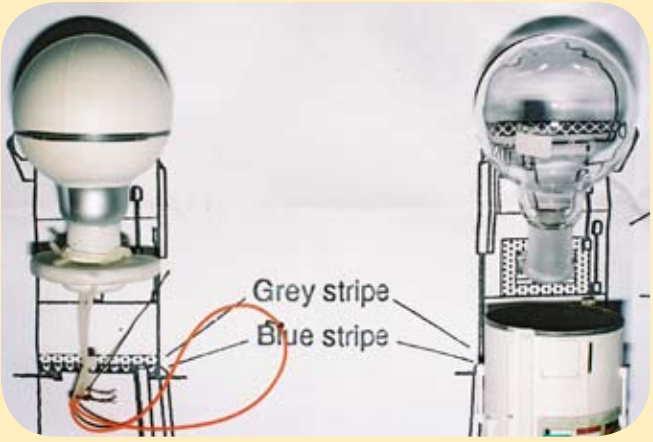

cord, topped with bungee elastic - to the mount. Why? The recovery parachute is attached to the shockline, which must be shockproof, fireproof, idiot proof and very securely mounted. Similar shocklines were applied to the nose section and the spherical instrument capsule. Checked once, then checked again – then the motor tube was located and fixed with epoxy…forever! Fins were then located on the tail section, using thin dowels, initially stuck with fast cyano and reinforced on the inside with epoxy. Fins exist for stability – vital for a nice scale bird - and a synergy of watching a dodgy opening boost, experience and running Vertikal's statistics through the Barrowman Equations and RockSim software – used to determine a rocket's CP position – determined that with the increased fin area the CP was just over one body diameter behind the CG with the beast loaded for bear…on the money, with no ballasting. And subsequent fabulous flying characteristics confirmed it.

Finished But with S7-Scale, that's an oxymoron! The rocket still needed launch lugs to fit a heavy-duty steel rod and provisions for the spherical instrument capsule to be released in flight. The parachute on the nose cone section was set-up in such a way that the opening parachute releases the capsule. Nearly there…I collated together all the scale data, drawings, plans & photos and pasted and bound them into a presentable Scale Documentation Pack for the FAI Judges. Over a period of years, researching and building scale models, definitive data on many prototypes was accumulated.

Track Record Results of *Vertikal* since it was researched and built are shown below:

1999 2nd G. *Mazzaracchio Memorial ~ Liptovsky Mikulas*-Slovakia S7 World Cup 3rd
1999 *Championships of Armady Slovenkej republiky* (same event) S7 Open 2nd
1999 *21st Ljubljana Cup ~ Kamnik* – Slovenia S7 World Cup 5th
2000 *1st World Cup in Plock ~ Plock* – Poland (Serious crash!) S7 World Cup 16th
2001 *2nd Canterbury Cup ~ Charing* – UK port Scale 2nd
2002 *2nd Ruma Cup ~ Ruma* – Serbia S7 World Cup 2nd
2002 *24th Ljubljana Cup ~ Kamnik* – Slovenia S7 World Cup 2nd
2003 *4th Canterbury Cup ~ Charing* - UK Sport Scale 1st
2003 *25th Ljubljana Cup* ~ Kamnik – *Slovenia* S7 World Cup 1st
2004 *4th Sirmium Cup ~ Sremska Mitrovica* – Serbia S7 World Cup 3rd
2004 *British Space Nationals ~ Heckington* – UK Sport Scale 1st
2004 *25th Ljubljana Cup* ~ Kamnik – *Slovenia* S7 World Cup 2nd
2005 *British Space Nationals ~ Barkson Heath* – UK Sport Scale 1st
2005 *4th Belgrade Cup ~ Lisicji Jarak* – Serbia S7 World Cup 1st
2005 *27th Ljubljana Cup ~ Kamnik* – Slovenia S7 World Cup 5th
2006 *6th Sirmium Cup ~ Sremska Mitrovica* – Serbia S7 World Cup 1st
2006 *Cassovia Cup ~ Kosice* – Slovakia S7 World Cup 9th
2006 *28th Ljubljana Cup ~ Kamnik* – Slovenia S7 World Cup 3rd
2006 *FAI S7-Scale World Cup* S7 Bronze medal

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Flying... The dry mass of the bird should be <300g and ~350g ready to go with D12-3 motor, recovery wadding and parachutes. Set up to fly initially using a 20Ns Estes D12-3 motor –which gives a good firm thrust off the launch rod, coasting on up after propellant burn-out for 3 seconds, before ejecting the recovery systems and triggering the special effects. Although not "experts only", some familiarity with launching Space Models is assumed. A wide range of propellants exist for this bird – Estes' D12-3 the most obvious…with Aerotech's E15-4 truly special, if much too fast off the pad! D12-3 is my usual World Cup choice, with E9-4 in the script for 2007…as are other special effects.

Parachutes vital! Flying at the lower impulse level, aluminised Mylar parachutes are perfect – 50cm diameter for the main body, with rigging trained right over the canopy for security; 30cm for the nose section and 25cm for the spherical instrument capsules. The first two reside in the main body section atop several layers of recovery wadding; the capsule's in the gap in the nose section.

Ringpiece... These results are amazing for a simple scale model, constructed from "over the counter" materials. The last entry in the results array defies belief, a podium Bronze in the 2006 FAI S7-Scale World Cup was never even dreamed about…Vertikal is a bit of a Superstar!! To start "serious" S7-Scale at FAI World Cup level, there's not much better. Sport Flying?!? Much of the in-depth researching could be shelved and fine detailing omitted. Crucially, Vertikal is reliable, consistent and FUN! And, does what it says on the tin.

About the Author:

Stuart Lodge is a famous name in rocketry in the United Kingdom and also among competition modelers in Europe. He's written several rocketry books, including "Model Rocketry," "The Model Rocket Handbook" and "Stu's Space... The Gospel According to Stuart Lodge. A Cornucopia of Space Modelling & Model Rocketry: The World Game." He can be contacted at: stuart.lodge1@ntlworld.com. Stuart has also writen for us in the past: http://www.apogeerockets.com/education/downloads/Newsletter83.pdf

Web Site Worth Visiting

This week's web site worth visiting is a hobby portal dedicated to hobby rocketry enthusiasts around the globe. Here you will find everything you're looking for in an online rocketry community.

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Question & Answer

Q: "How do I determine when it makes economic sense to buy a reloadable rocket motor? In other words, how many flights would it take to reach the break-even point and start saving money by switching from single-use motors to reloadable motors?"

A: That is a great question. The advantage of reloadable rocket motors is that if you fly a lot, then it will probably make sense to switch to reloadable motors as soon as possible.

Here is how I would go about determining the break-even point. Start by making an excel worksheet showing the flight number and the cumulative costs to get to that point.

For example, in the chart shown here, I've compared a single-use F42 motor versus the F37 reloadable motor. Before you fly your first rocket, you'll need to purchase the aluminum reloadable casing. The reload case for the F37 motor has a cost of $71.00 – found at: http://www.apogeerockets.com/Rouse-Tech_Motors.asp.

For the first flight, we now compare them; add the cost of the single use motor ($20.11 – the price can be found at: http://www.apogeerockets.com/aero-tech_motors.asp) to the cost of the F37 reload case plus the reloadable propellant kit ($11.60 - http://www.apogeerockets.com/Aerotech_Reload_Motors.asp), which gives us a total of $82.60.

For each subsequent flight, you'll add $20.11 for each single-use flight, and $11.60 for each additional reload flight. Pretty simple huh?

The break-even point is where the cumulative cost for the reloadable flights is less than the cost for the single-use flights. In this particular example, the break-even point occurs at the conclusion of the 9th flight. From then on, you'll be saving money by flying reloadable motors.

Does nine flights sounds like a lot? Let's put that into perspective. Say you fly rockets just once a month with your local club. Furthermore, at that launch you fly just three flights (which isn't a lot). In just three months, that reload casing you bought from Apogee Components has more than paid for itself.

If you fly three rockets per month for just one year, how much money will you have saved? You can extend your Excel spreadsheet out to find the answer. In this particular case, it is whopping $235.36! That could be several mid-power rocket kits to add to your fleet.

	A	B	C	D
1	Flight Number	Single Use F42	Reloadable F37	
2	0	$0.00	$71.00	
3	1	$20.11	$82.60	
4	2	$40.22	$94.20	
5	3	$60.33	$105.80	
6	4	$80.44	$117.40	
7	5	$100.55	$129.00	
8	6	$120.66	$140.60	
9	7	$140.77	$152.20	
10	8	$160.88	$163.80	
11	**9**	**$180.99**	**$175.40**	
12	10	$201.10	$187.00	
13	11	$221.21	$198.60	
14	12	$241.32	$210.20	
15	13	$261.43	$221.80	
16				

In conclusion, I'd like to point out that every motor is going to be different, so I recommend making a table like the one shown here. You'll be surprised at how fast the savings add up.

DEFINING MOMENTS

Thrust Curve

The thrust curve is a graph showing how much thrust a rocket motor produces over the duration of propellant consumption during burn. On the Y-axis, you'll have thrust measured in Newtons, or pounds-force (Aerotech uses pounds-force, while most other manufacturers use Newtons). On the X-axis of the graph, you'll always see burn-time measured in seconds.

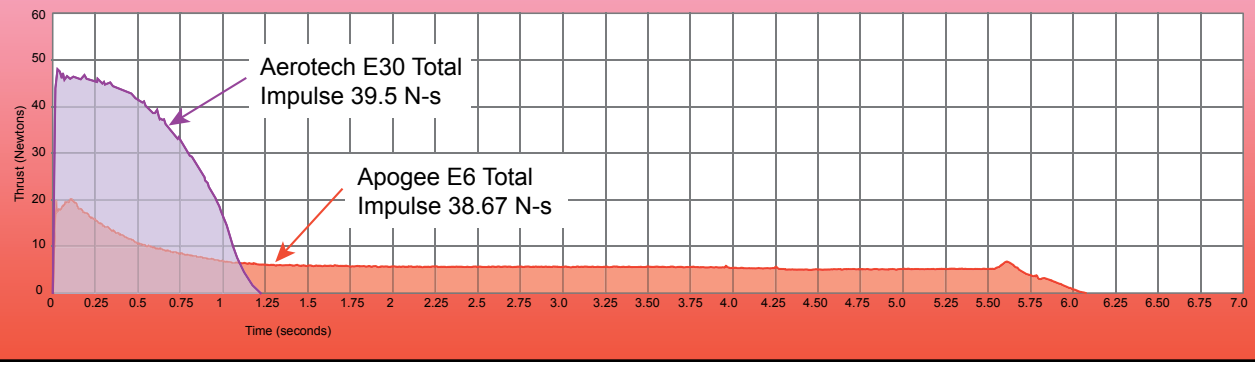
What good are these charts? They tell us how the propellant is being burned inside the rocket case. For example, the chart below compares the Aerotech E30 rocket motor to the Apogee E6. I've pointed out in the charts that the area under the curve, is very similar; the E30 is 39.5 N-s, while the E6 is 38. 67 N-s. It should be noted that they both use the Aerotech Blue Thunder propellant formulations, and the are similar in propellant weight.

The difference is how fast the propellant is consumed. The E30 burns it very fast and produces a lot of thrust over a short time period, while the E6 burns it slow and has relatively low thrust.

They are both great motors that serve a unique purpose. The E30 would be good for heavy rockets or those that have a large diameter. It is also good for windy days, when you want more speed to punch into the sky without weathercocking too much. The E6, on the other hand, is good for skinny rockets that are optimized to fly really high.

For more information on rocket propulsion, check out the book: "Model Rocket Propulsion" at: http://www.apogeerockets.com/mod_rocket_propulsion_bk.asp

We also have a new Flash-animation on our web site showing how a composite propellant rocket motor works. You'll fins it at: http://www.apogeerockets.com/education/how_composites_work.asp



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APOGEE COMPONENTS

TIP OF THE FIN

By Tim Van Milligan

Painting models is the one thing that people always ask me about. How do I get such a smooth finish? You can't see one groove of the tube spiral, nor the tell-tale sign of grain in the balsa wood fins.

There is no super secret "paint." The supplies I use are the same as what they are already using. I use the cheap aerosol paint, sandable paint primer, balsa filler, and a couple of different grits of sandpaper.

The "secret" ingredient is the "how" I apply all the materials to the rocket. In other words, the subtle techniques that I use to assemble and finish a rocket are different from the way a novice modeler would do the same tasks. And you know what, I bet we both spend about the same amount of time building and finishing the rockets.

Learning the techniques only comes through trial-and-error, or by learning from someone that has already gone through the trial-and-error and is willing to show you the process. I would like to be that person for you, since I know what a pain it is to screw up models.

In my video book: Building Skill Level 1 Model Rocket Kits, I'll show you the best and quickest way to finish a rocket so that you'll have something so sleek and smooth that others will be asking you how to do it. I can't begin to tell you about the amount of pride that swells up inside you when someone asks you how you got the rocket so pretty. You'd like that same feeling, right?

To get this $14.78 video book, just make your way over to the Apogee Components web site at: http://www.apogeerockets.com/skill_level_1_video.asp

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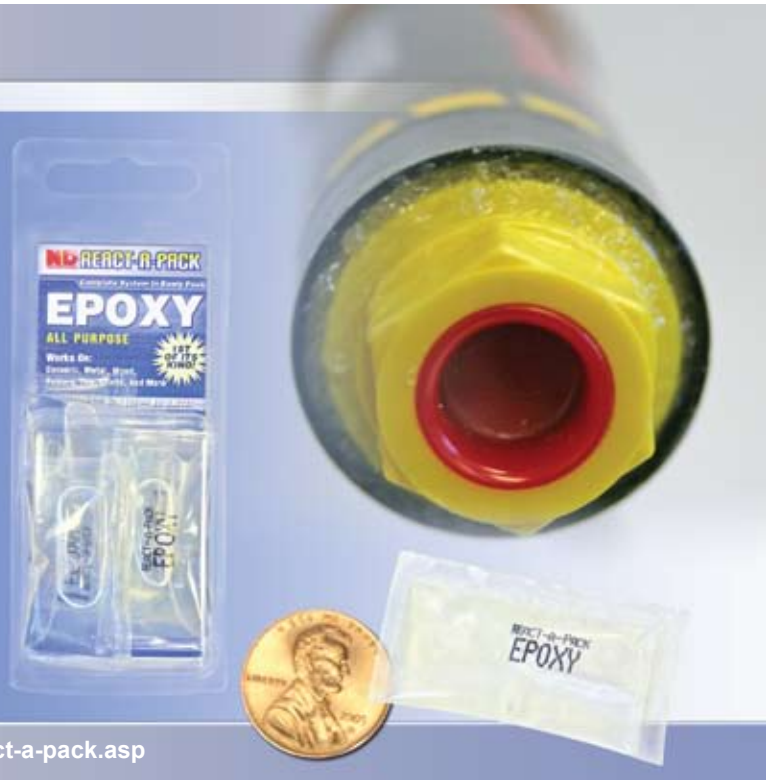

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