Apogee Components

PEAK OF FLIGHT

NEWSLETTER

Rocket Plan: Build The Paradigm-5

A high-efficiency contest design by G. Harry Stine

Red River Rocketry's Merlin Payloader rocket kit:
http://www.apogeerockets.com/RedRiver_Merlin.asp

Apogee Components, Inc. — Your Source For Rocket Supplies That Will Take You To The "Peak-of-Flight"
3355 Filmore Ridge Heights
Colorado Springs, Colorado 80907-9024 USA
www.ApogeeRockets.com e-mail: orders@apogeerockets.com

ISSUE 225 DECEMBER 30, 2008

Rocket Plans: PARADIGM-5 and PARADIGM-5 Sr.

By James Jason Wentworth

Paradigm. This is one of those "ten dollar" words that some academics love to toss about. Economists are fond of talking about how some inventions bring about "paradigm shifts" in the way businesses function, while historians note the way that certain novel ideas bring about "new paradigms" in society and government. But despite all of the lofty connotations that this word has to most people, a paradigm is simply "an example serving as a model."

No doubt that is what the late G. Harry Stine had in mind when he designed the simple yet high-performance model rocket that is the subject of this article. Stine, who was one of the founders of model rocketry, saw the hobby as a wonderful educational tool for teaching young people about aerospace engineering and its mathematical foundations.

He was particularly interested in the ways that model rocketry could be used to demonstrate the principles of aerodynamics. In his *Handbook of Model Rocketry* he described the numerous design trade-offs that a model rocketeer (just like a professional aerospace engineer) is faced with when designing a rocket to achieve the maximum possible performance within its total impulse limit.

As he wrote in his accounts of the early days of model rocketry, the "paradigm for high performance" of that era was to imitate the design features of the full-scale sounding rockets and missiles that were being launched at White Sands, Wallops Island, and Cape Canaveral. Model rocketeers equipped their models with long, sharp-pointed conical (and ogive) nose cones, along with highly-swept fins (as well as delta-shaped fins) that had thin, razor-sharp airfoil sections.

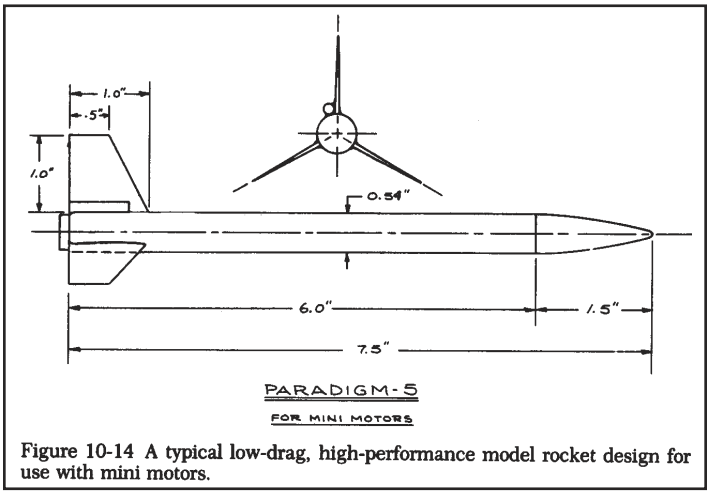


Figure 1: The original design by G. Harry Stine from the "Handbook Of Model Rocketry."

Figure 2: A three dimensional view of the PARADIGM-5 rocket from the RockSim software.

They didn't realize that those sleek shapes, which are ideal for reducing the wave drag at supersonic and hypersonic airspeeds, perform poorly at the subsonic velocities at which most model rockets travel. Aerodynamically, model rockets have much in common with subsonic jet airliners and the specialty subsonic small-arms bullets. Both have rather blunt, gently rounded forms because these shapes produce the least amount of drag at subsonic airspeeds. After several years of theoretical research and flight testing, Stine and other competition-minded model rocketeers came to understand that a paradigm shift in their thinking was needed in order to realize the maximum performance potential of model rockets.

The PARADIGM-5 is G. Harry Stine's optimized design for a low-drag, high-performance mini-motor rocket. A drawing of this rocket has appeared in his "Handbook of Model Rocketry" at least since the fourth edition was published in 1976. It uses a 1.5" long paraboloid nose cone that has a length-to-diameter ratio of approximately 3:1. Its fins have a clipped delta planform, and they are also tapered in thickness from root to tip. The fin planform is of proportions that

Continued on page 3

About this Newsletter

You can subscribe to receive this e-zine FREE at the Apogee Components web site (www.ApogeeRockets.com), or by sending an e-mail to: ezine@apogeeRockets.com with "SUBSCRIBE" as the subject line of the message.

Newsletter Staff

Writer: Tim Van Milligan
Layout / Cover Artist: Tim Van Milligan
Proofreader: Michelle Mason

Continued from page 2

Build the PARADIGM-5 Rocket

he developed as a result of experimentation.

While it is only an issue of concern to the competitor who is trying to wring that last meter of altitude out of the model, this spanwise (root-to-tip) taper of the fin thickness is necessary if the builder wishes to maintain the same airfoil section throughout the entire span of the fin. If the fin is not tapered spanwise, the airfoil section at the fin tip will be "fatter" (thicker as a percentage of the fin's tip chord—the distance from the leading edge to the trailing edge at the fin tip). A thicker airfoil section at the fin tip will often produce less lift and/or generate more drag. Less lift at the fin tip reduces the fin's effectiveness for counter acting any disturbances from wind gusts to the rocket's path. This also increases the rocket's total drag because less effective fins allow the rocket to oscillate (swing) to a greater angle before the fins can bring it back into line with the airstream, which presents more of the rocket's broadside to the air flow.

For ordinary sport flying, however, the PARADIGM-5 will turn in spectacularly high flights even with un-tapered fins. In fact, recent theoretical and experimental results indicate that competition rockets that have un-tapered fins with an un-swept rectangular planform or a slightly swept

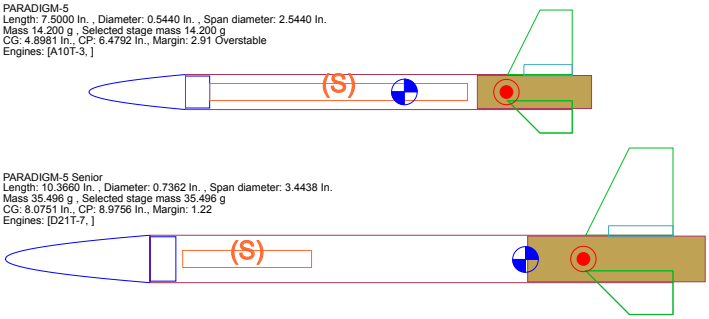


Figure 3: Comparative sizes of the PARADIGM-5 and the PARADIGM-5 Senior. Note that the CP for both rockets is right at the leading edge of the fins.

parallelogram planform perform the best—see Apogee Components Technical Publication #16, "What is the Optimum Fin Shape for Altitude?" www.apogeerockets.com/technical_publication_16.asp

As well as its fins, every aspect of the PARADIGM-5's design was chosen with drag reduction in mind. The launch lug is nestled into a fin/body tube joint in order to reduce its interference drag (the launch lug is often the single largest source of drag on a model rocket), the fins are carefully sanded and sealed to provide efficient airfoils, the body tube spirals are filled with sanding sealer, and the entire

Continued on page 4

Continued from page 3

Build the PARADIGM-5 Rocket

rocket is given a mirror-smooth finish to minimize friction drag.

This high-performance yet simple and easy-to-build rocket would be useful for altitude contests, drag-racing (competing in 2-rocket "heats"), and streamer duration contests. It would also lend itself well to school class projects.

I was inspired to bring this model to the attention of other model rocketeers when I unexpectedly found a source for its 1.5" long paraboloid nose cone. While looking through the Apogee Components web site, I noticed that they offer a 13 mm parabolic nose cone (the PNC-13A) that is precisely the size and shape of the nose cone that G. Harry Stine used for the PARADIGM-5. See: www.ApogeeRockets.com/nose_cones.asp

I also noticed that Apogee Components has an 18 mm nose cone (the PNC-18A) that is a proportionally scaled-up version of the PNC-13A, so I have designed a scaled-up 18 mm motor version of the rocket to use the PNC-18A, which

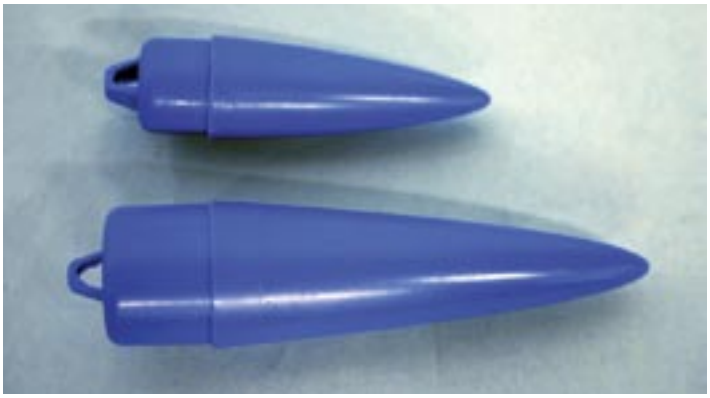


Figure 4: Apogee Components has the perfect nose cones to make the Paradigm rockets. Top: the 13mm PNC-13A (P/N 19700). Bottom: the 13mm PNC-18A (P/N 19800).

I've nicknamed the "PARADIGM-5 Senior." The design data for both rockets is included below.

These would be good "first" competition rockets for

Continued on page 5

How Creative Can Your Designs Get?

Test The Limits Of Your Creativity In The NEW RockSim v9!

RockSim, the leading software for designing and finding out how high rockets will fly, is now even more versatile. You asked for these new features, and we listened:

- *External Pods*
- *Parallel Staging*
- *Attach Fins to Fins*
- *Scale Your Designs Up/Down*
- *Automatic Downloads of New Engine Files*

Authentic images taken from RockSim v9. Just imagine the really cool designs you'll make!

FREE demo version. Download it today.

ROCKSIM

www.RockSim.com

For further information, call Apogee Components at: 719-535-9335.

Mac

LINUX / UNIX coming soon

CERTIFICATION SPACE EDUCATIONAL PRODUCT

Space Foundation certified as an excellent teaching aid.

Continued from page 4

Build the PARADIGM-5 Rocket

model rocketeers who have never built a competition model rocket before. Their simple, low-parts-count design would allow the builder to concentrate on achieving the lightest possible mass (using the minimum amount of glue commensurate with sufficient glue joint strength), sanding the best possible fin airfoil shape, and giving the rockets a mirror-smooth finish for minimum aerodynamic drag. (Apogee Components' epoxy clay would be perfect for optimizing the aerodynamics of these rockets' fin fillets!)

As an alternative to first sanding a spanwise (root to tip) taper into each fin and then sanding them to have "teardrop" airfoil cross-sectional shapes, each tapered fin could be produced using the model airplane-type "built-up" construction, with 1/64" thick sheet balsa skins cemented to an interior balsa spar and two or three balsa ribs. (This type of construction could also be done using styrene sheets and styrene rod stock.)

Unless the builder is planning to launch either of these rockets in an international-level competition, however, untapered fins made from 1/16" or 3/32" thick sheet balsa will work just fine.

I would like to thank Tim Van Milligan, President of Apogee Components, for inviting me to write this article and for creating the PARADIGM - 5 illustration, fin pattern, and RockSim file for this article.

Note: The RockSim files for this design can be downloaded at: http://www.ApogeeRockets.com/Education/ Downloads/paradigm-5.zip

PARADIGM - 5 Specifications:

Length: 7.5"
Diameter: 0.544"
Fin Span: 2.544"

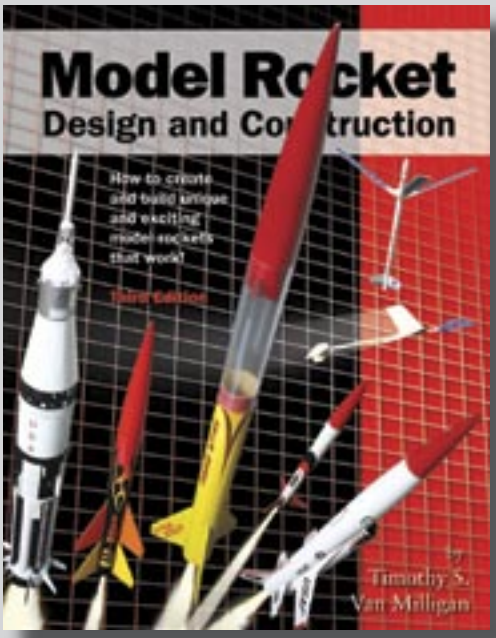
PARADIGM - 5 PARTS LIST

Nose Cone, 1.5" long.....PNC-13A (P/N 19700, parabolic)
Body Tube, 6.0" long.....Airframe Tube 13/18 (P/N 10063, Estes BT-5 size)
Shock Cord, 24.0" long Kevlar braided cord (P/N 30325, 0.063" diameter)
Streamer, 2.0" wide…..Mylar Streamer (P/N 30303)
Engine Block* (Thrust Ring)…..Estes BT-5 size, for 13 mm mini-motors
Launch Lug (0.75" long, for 1/8" launch rod).....LL-1.0 (P/N 13052)
Fins (3), made of 1/16" thick sheet balsa…..Clipped Delta planform
[Fin Dimensions: 1.0" root chord, 0.5" tip chord, 1.0" root-to-tip]

* The Centering Ring 10-13 (P/N 13021) can be used as an Engine Block for mini-motors.

PARADIGM-5 RECOMMENDED MOTORS

Continued on page 6



Model Rocket Design and Construction

By Timothy S. Van Milligan

New 3rd Edition Now Shipping!

This new 328 page guidebook for serious rocket designers contains the most up-to-date information on creating unique and exciting models that really work. With 566 illustrations and 175 photos, it is the ultimate resource if you want to make rockets that will push the edge of the performance envelope. Because of the number of pictures, it is also a great gift to give to beginners to start them on their rocketry future.

For more information, and to order this hefty book, visit the Apogee web site at: www.ApogeeRockets.com/design_book.asp

Apogee Components
3355 Fillmore Ridge Heights
Colorado Springs, Colorado 80907 USA

telephone: 719-535-9335
website: www.ApogeeRockets.com

APOGEE COMPONENTS

Continued from page 5

Build the PARADIGM-5 Rocket

Engine	Altitude (feet)	Altitude (m)
1/4A3T-3	194.5	59.3
1/2A3T-4	471.93	143.84
A3T-4	945.29	288.12
A10T-3	860.78	262.37

PARADIGM-5 Senior Specifications:

Length: 10.368”
Diameter: 0.736”
Fin Span: 3.442”

PARADIGM-5 Senior PARTS LIST

Nose Cone, 2.25” long.....PNC-18A (P/N 19800, parabolic)
Body Tube, 8.118” long.....Airframe Tube 18/18 (P/N 10086, Estes BT-20 size)
Shock Cord, 24.0” long.... Kevlar braided cord (P/N 30325, 0.063” diameter)
Streamer, 2.0” wide.....Mylar Streamer (P/N 30303)
Engine Block* (Thrust Ring).....Estes BT-20 size, for 18 mm standard motors
Launch Lug (1.0” long, for 1/8” launch rod).....LL-1.0 (P/N 13052)
Fins (3), made of 1/16” or 3/32” thick sheet balsa...
Clipped Delta planform
[Fin Dimensions: 1.353” root chord, 0.676” tip chord, 1.353” root-to-tip]

* The Centering Ring 13-18 (P/N 13028) can be used as an Engine Block for 18 mm motors.

PARADIGM-5 SENIOR RECOMMENDED MOTORS

Engine	Manufacturer	Altitude Feet (m)
1/2A6-2	Estes	229.9 (70.09)
A8-5	Estes	620.8 (189.22)
A6-4	Quest	554.7 (169.06)
B4-4	Estes	1093.7 (333.37)
B6-6	Estes	1157.5 (352.81)
B6-4	Quest	1161.3 (353.96)
C6-7	Estes	2037.8 (621.14)
C6-5	Quest	1912.0 (582.76)
D10-7	Apogee	3026.6 (922.51)
D21-7	Aerotech	2810.4 (856.61)

About The Author:

James Jason Wentworth is a rocket modeler living in Alaska. You may recognize the name, as he is the former proprietor of Nova Rocketry.