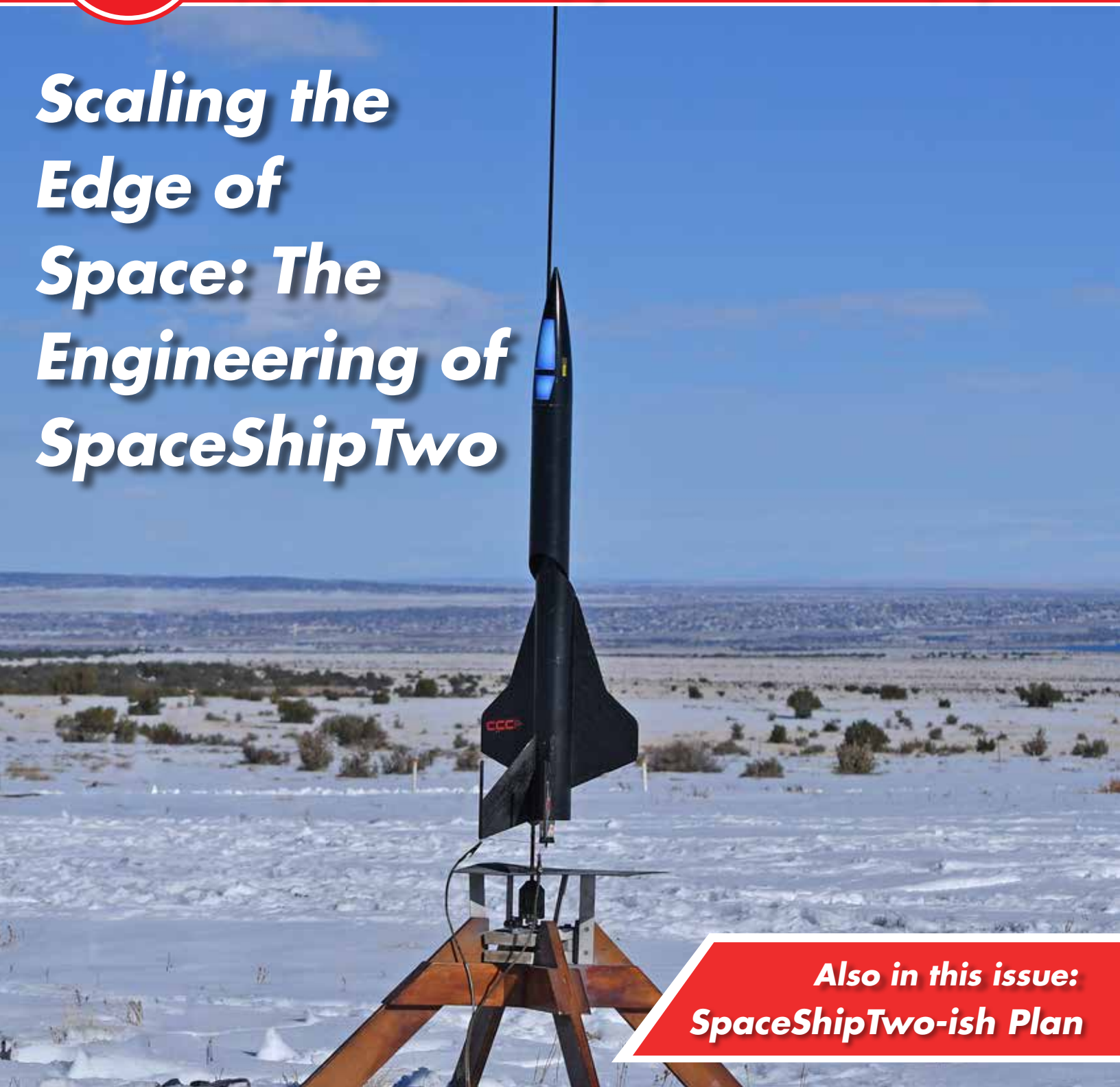
Issue 667 / December 16th, 2025

PEAK OF FLIGHT NEWSLETTER

Apogee Components, Inc. / ApogeeRockets.com / Colorado Springs, CO

Scaling the Edge of Space: The Engineering of SpaceShipTwo



Also in this issue:
SpaceShipTwo-ish Plan

PEAK OF FLIGHT NEWSLETTER

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COVER PHOTO



Firefox SHX Readied for Take-off

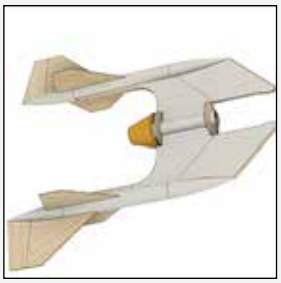
The FireFox SHX rocket sits on the launch pad at the winter launch of SCORE on December 6, 2025.

FEATURED ARTICLES



The Engineering of SpaceShipTwo

The novelty of the SpaceShipTwo rocketship is the subject of this article. Find out what makes it so unique and why it makes space tourism so economical.



Free Plan SpaceShipTwo-ish

Now you can build a rocket that looks very similar to the SpaceShipTwo. While it isn't a scale model, your friends will think it is.

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Managing Editor: Michelle Mason
Content Editor: Martin Jay McKee
Layout Design: Tim Van Milligan

Let 'er Rip!



Would you like to see your launch photo featured in the *Peak-of-Flight* newsletter? Submit your photo at apogeerockets.com.

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Scaling the Edge of Space: Engineering of SpaceShipTwo
by Tim Van Milligan

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Scaling the Edge of Space: The Engineering of SpaceShipTwo

By Tim Van Milligan

In this issue, we are thrilled to feature a profile scale model patterned after one of the most distinctive silhouettes in modern aviation: Virgin Galactic's SpaceShipTwo. With its twin-boom fuselage and sci-fi aesthetics, the vehicle cuts a striking figure on the launch pad, making it an irresistible subject for model rocketeers looking for something different than the standard "three fins and a nose cone." While our balsa-and-cardboard tribute is designed for a fun weekend build and a safe parachute recovery, the vehicle it mimics is a complex, high-stakes machine designed to carry humans to the hostile environment of the upper atmosphere.

The defining characteristic of the real SpaceShipTwo (VSS Unity) is its revolutionary "feathering" reentry system, where the tail booms physically fold upward to stabilize the craft during descent. While reproducing this complex articulation in a small-scale flight model is a massive engineering headache—and consequently, our plan utilizes a standard fixed-tail configuration for stability—it remains one of the most fascinating aerodynamic concepts ever put into practice. To build the model is to appreciate the shape; to understand the ship is to appreciate the genius (and the danger) behind that shape.

For aerospace enthusiasts, SpaceShipTwo represents a gripping case study in stability, control, and the harsh lessons of experimental flight. How do you stabilize a glider that transitions from a vacuum to thick air at supersonic speeds? How does that



Fig. 1 - The WhiteKnightTwo mothership acts as a flying launchpad, carrying SpaceShipTwo above the densest part of the atmosphere before release.



famous feathering system actually work physically? And how did the program recover from a fatal error that played out in the skies above the Mojave? Before you warm up your laser cutter or grab your X-Acto knife to build your own version, join us for a deep dive into the turbulent history and brilliant engineering of the real ship.

The Architecture of a Spaceplane: Breaking the Rocket Equation

Designed by the legendary Burt Rutan and his team at Scaled Composites (and later manufactured by The Spaceship Company), SpaceShipTwo is a scaled-up, commercialized evolution of the X Prize winner from 2004. However, to understand why it looks the way it does, one must understand the tyranny of the "Rocket Equation."

Launching from the ground is energetically expensive. A rocket sitting on a launchpad at sea level must push through the thickest, most drag-heavy layer of the Earth's atmosphere (the troposphere) while fighting maximum gravity. This requires massive amounts of fuel, and because fuel has mass, you need more fuel to lift that fuel. This exponential problem means that for a standard orbital rocket, the payload is often less than 2% of the total vehicle mass.

SpaceShipTwo cheats this equation through its air-launch architecture.

The Mothership: WhiteKnightTwo

The system begins with **WhiteKnightTwo (VMS Eve)**, a massive, dual-fuselage carrier aircraft powered by four Pratt & Whitney PW308 turbofan engines. With a wingspan of 141 feet, it is a marvel of composite engineering in its own right (see Figure 1 on page 3).

By carrying the spacecraft to an altitude of roughly 50,000 feet (15,000 meters) before release, the system bypasses the high-drag lower atmosphere. At this altitude, the air pressure is significantly lower, meaning the rocket engine can be optimized for vacuum performance rather than having to compromise for sea-level operation. This allows the spacecraft to reach the boundary of space (approximately 50 miles or 80 km by US definitions) with significantly less fuel and a smaller engine than a ground-launched vehicle would require.

The airframe of SpaceShipTwo is constructed almost entirely from carbon fiber composites. Unlike aluminum, which expands and contracts significantly with heat and can fatigue over time, carbon composites offer a superior strength-to-weight ratio. This material choice makes the craft incredibly light yet stiff enough to withstand the aerodynamic stresses of supersonic flight and the thermal loads of reentry.





The Hybrid Heart: Rocket Science Simplified

While we modelers rely on Black Powder or Composite Propellant (APCP), the real SpaceShipTwo uses a **Hybrid Rocket Motor.** This engine, known as the RocketMotorTwo, has been a subject of intense engineering iteration and controversy throughout the program's life.

A hybrid motor combines the best characteristics of solid and liquid rockets, attempting to mitigate the dangers of both.

1. **Solid Fuel:** The fuel grain is a solid rubber-like compound cast into a casing. Early versions of the vehicle utilized HTPB (Hydroxyl-terminated polybutadiene—essentially tire rubber). Later iterations experimented with a polyamide (nylon-based) plastic fuel grain to reduce vibration, before eventually returning to HTPB for its predictable burn characteristics.
2. **Liquid Oxidizer:** The oxidizer is liquid Nitrous Oxide (N_2O), commonly known as laughing gas. This is stored in a pressurized tank within the fuselage.

Why Hybrid?

Safety is the primary driver for a passenger vehicle. In a solid rocket motor (like the Shuttle SRBs or a model C6-5), once ignition occurs, the chemical reaction is self-sustaining. It burns until the fuel is gone. You cannot throttle it, and you certainly cannot stop it. In a liquid engine, you need complex, heavy turbopumps and plumbing that introduce hundreds of failure points.

A hybrid offers a "Goldilocks" solution. When the pilot flips the switch, the liquid oxidizer sprays into the hollow core of the solid



Fig 2 - The hybrid rocket motor propels the craft from Mach 0.5 to nearly Mach 3 in under a minute, subjecting passengers to over 3Gs of force.

fuel. The result is a controllable burn. Crucially, if a sensor detects an anomaly—a pressure spike or a temperature fluctuation—the pilot can simply shut the valve on the oxidizer tank. Without the oxidizer, the combustion stops instantly. This "abort-to-glide" capability is a critical safety feature that allows the pilots to turn the spaceship into a glider at a moment's notice.

The "Feather": Genius in Aerodynamics

The most revolutionary feature of the SpaceShip class vehicles—and the aspect that makes modeling it so interesting—is the "Feathering" reentry system.

On a traditional spacecraft, reentry is a violent, high-precision affair. Capsules like Apollo or SpaceX's Dragon use ablative heat shields that burn away to dissipate heat. They must enter the atmosphere at a precise "keyhole" angle. If the angle is too steep, the G-forces will kill the crew and the heat will melt the ship. If the angle is too shallow, the craft will skip off the atmosphere like a stone on a pond and be lost to space.

Burt Rutan's solution was to change the shape of the plane itself to avoid this precision requirement. Once the rocket burn is complete and the craft is coasting in the vacuum of space, the pilots unlock the tail booms. Pneumatic actuators rotate the entire tail section upward by roughly 60 degrees relative to the fuselage.

This transforms the spaceship into a shape resembling a badminton shuttlecock. As the craft falls back into the atmosphere, this shape creates massive drag, but does so in a way that is inherently stable.

The Physics of the Feather:

- **Carefree Stability:** The ship naturally rights itself, belly-down, regardless of how it enters the atmosphere. Whether it is tumbling, spinning, or upside down, the feather forces the ship into a belly-flat orientation. It is aerody-



Fig 3 - The SpaceShipTwo dropped from the WhiteKnight carrier plane. Note the twin tail booms which feather upwards during reentry to stabilize the descent.



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namically stable in this configuration, requiring zero pilot input to keep it oriented correctly.

- **Thermal Management:** Because the feather creates so much drag high in the atmosphere (where the air is thin), the ship decelerates earlier and more gradually. This keeps the thermal loads low enough that the ship does not require heavy ceramic heat tiles. The composite skin is protected by a simple Thermal Protection System (TPS) that is far lighter than traditional shields.

Tragedy over the Mojave: The Loss of VSS Enterprise

The road to commercial spaceflight has not been paved solely with success. The program carries the weight of a devastating tragedy that nearly ended the dream entirely. On October 31, 2014, the program suffered a catastrophic setback that shook the aerospace world.

During a powered test flight of the first SpaceShipTwo, named **VSS Enterprise**, the vehicle broke apart in mid-air just seconds after the rocket motor ignited. The crash resulted in the tragic death of co-pilot Michael Alsbury and serious injuries to pilot Peter Siebold, who miraculously survived the disintegration of the ship at high altitude and a subsequent parachute descent.

The Investigation:

The National Transportation Safety Board (NTSB) launched a comprehensive investigation into the crash. The findings revealed a critical flaw in human-factors engineering. The "feather" system is designed to be unlocked only in the vacuum of space (or very thin air) to prepare for reentry. However, the telemetry data showed that the co-pilot unlocked the feather system while the craft was still accelerating through the transonic regime (around Mach 0.92).

At that specific speed, the aerodynamic forces on the tail are immense. Without the locking mechanism in place, the aerodynamic load overpowered the actuators and forced the tail booms upward into the feather position while the rocket was still firing. The structural loads were immense and instantaneous, shearing the ship apart in a matter of milliseconds.

The Engineering Fix:

The NTSB report criticized Scaled Composites for relying too heavily on pilot training to prevent a catastrophic error, rather than implementing a mechanical fail-safe. The tragedy led to a complete redesign of the safety systems and a transfer of manufacturing to The Spaceship Company (a Virgin Galactic subsidiary).

The second ship, **VSS Unity**, includes a mechanical inhibitor—a computer-controlled lock. This system physically prevents

the pilots from unlocking the feather handle unless the flight computer confirms the aircraft is in the correct flight regime (low dynamic pressure). This "lock-out" ensures that human error cannot repeat the catastrophe of 2014. It was a hard-learned lesson: in safety-critical systems, you must design for the worst day of the best pilot.

Return to Flight: The Rise of VSS Unity

It took two years to mourn, investigate, and rebuild. In 2016, VSS Unity took to the skies, marking the beginning of a rigorous and cautious return-to-flight program.

Unity was built with the lessons of Enterprise in its bones. It moved through a stepped testing program, reminiscent of the early X-plane era:

- **Captive Carry:** Flying attached to the mothership to test avionics and environmental control systems.
- **Glide Flights:** Releasing from the mothership without the engine to test handling qualities, the feather system in a safe environment, and the landing flare.
- **Powered Flights:** Short burns to test the rocket motor ignition and vibration, gradually increasing the duration of the burn.



Fig 4 -The "Feather" in action. By breaking the aerodynamic shape, the craft becomes a stable falling leaf, safely decelerating without the need for heavy heat shields.





Finally, on December 13, 2018, VSS Unity fired its engine for 60 seconds, reaching an altitude of 51.4 miles (82.7 km). For the first time since the Space Shuttle program ended in 2011, a crewed vehicle launched from American soil had reached space.

Since then, Unity has carried company employees, researchers, and eventually founder Richard Branson himself to the edge of space, validating the dream that began nearly two decades prior. These flights provided crucial data on cabin dynamics, passenger experience, and the electromagnetic interference of carrying scientific payloads.

The Future: The Delta Class and the Path to Profitability

While VSS Unity is a triumph of engineering, it is essentially a prototype that was pressed into commercial service. It requires significant maintenance and inspection between flights, limiting the flight cadence to roughly once a month at best. For a business model based on tourism, this is insufficient.

To make space tourism profitable and accessible, Virgin Galactic is currently developing the **Delta Class** spaceships.

The Delta Class represents a shift in philosophy from "experimental aircraft" to "spaceline fleet."

- **Modular Construction:** Unlike Unity, which was hand-built as a single monocoque structure, Delta ships will be built in sub-assemblies. This allows for easier repairs; if a wing is damaged, it can be swapped out rather than grounding the ship for months of patch repairs.
- **Flight Rate:** The engineering goal for the Delta class is to



Fig 5 - The Delta Class spaceship. Virgin Galactic rendering.

fly these ships once a week. With a fleet of multiple ships, this could allow for daily flights from Spaceport America in New Mexico.

- **Materials:** Advanced composites that are more heat-resistant and durable will reduce the inspection time needed after reentry. The thermal protection system is being upgraded to require less refurbishment between flights.

The Delta Class is expected to enter service very soon (the last press release in June 2025 said it would debut around December of this year), marking the transition of the industry from a novelty to a routine transportation sector.

From Blueprint to Balsa: Building the Model

While the real SpaceShipTwo relies on complex feathering mechanics to survive reentry, our featured build for this issue relies on the fundamental principles of rocketry to ensure a safe flight. We are happy to report that despite its unusual, non-traditional geometry, this model is exceptionally stable.

This stability is achieved through careful weight distribution and aerodynamic design. The twin-boom tail fins are positioned very far aft, creating a significant distance between the Center of Pressure and the Center of Gravity. Furthermore, the design mounts the motor well forward of the tail section. This forward motor placement acts as a nose weight of sorts, pulling the Center of Gravity forward and ensuring the rocket flies straight and true, even without the active control systems of its full-sized counterpart.

It is important to note that this is a pure ballistic recovery model, not a glider. While the real ship glides home to a runway, our model is designed to recover via parachute at apogee. For a rocket to transition from a vertical ascent into a glide, the wings or tail

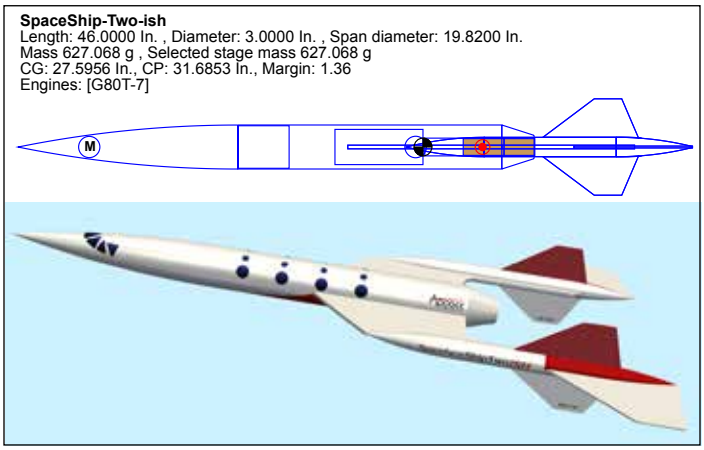
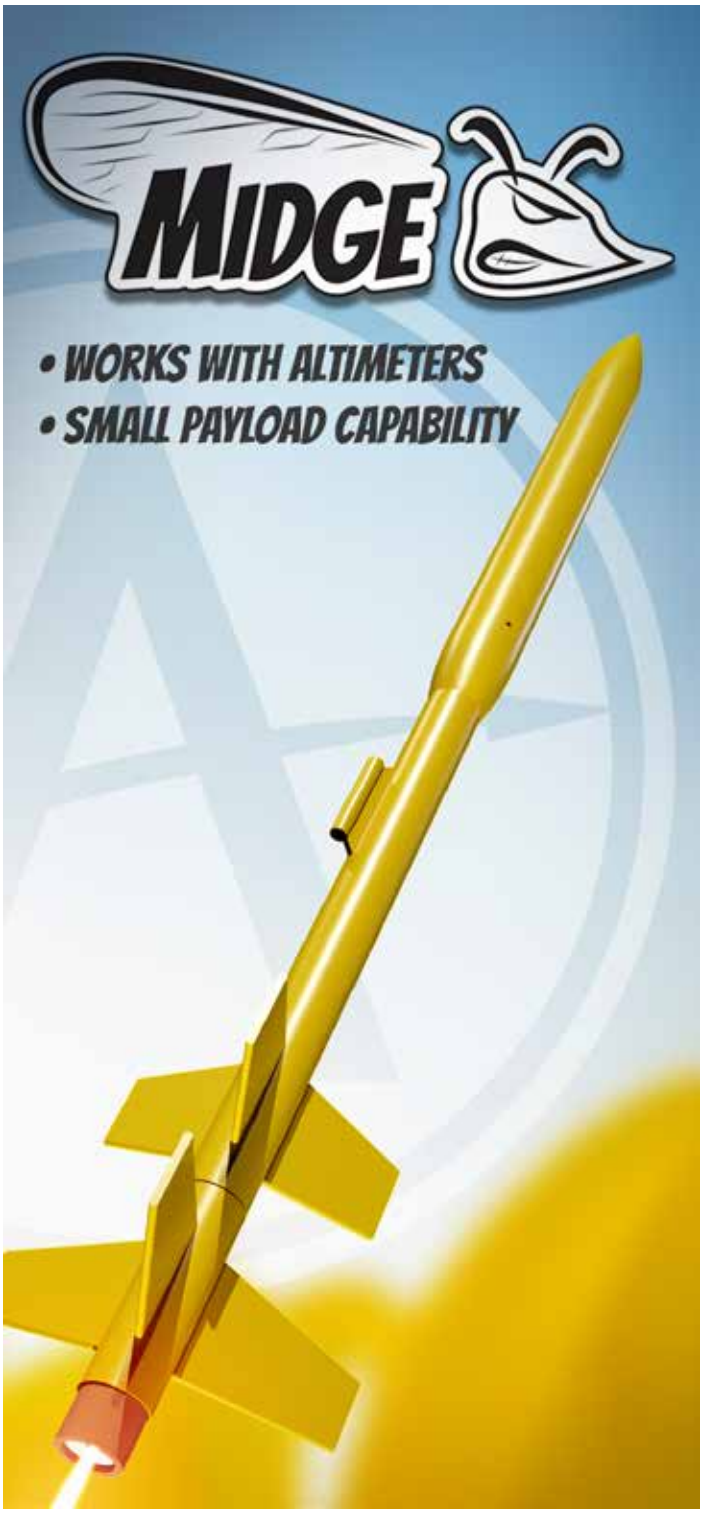


Fig. 6 - The RockSim file shows a healthy static margin of 1.36 with a G80-7T motor loaded.



surfaces would need to mechanically shift to a positive angle of attack to pull the vehicle out of its dive—a complexity we intentionally avoided to keep the build accessible. Instead, you get a high-performance flight on 29mm motors, ranging from F through H impulse, making for spectacular, loud, and high-altitude launches.

Be warned: while it doesn't have moving wings, this is still a builder's kit involving some intricate cutting and alignment. If you are worried about the complexity, don't worry. Our full build-series video is launching alongside this issue. We will walk you through every step of the construction process, helping you level up your fabrication skills to tackle this unique bird.

Get your balsa ready, load up an H-motor, and get ready to put a piece of commercial spaceflight history on the pad.

Get the Plans

Ready to add a piece of commercial spaceflight history to your fleet? The plans included in this month's issue feature:

Download the SpaceShipTwo Plans Here

Whether you are interested in the high-stakes engineering of the real thing or the sawdust-and-glue satisfaction of the model, SpaceShipTwo offers a window into the future of flight. It is a reminder that the edge of space is getting closer every day.

About The Author

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit. He has a B.S. in Aeronautical Engineering from Embry-Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward an M.S. in Space Technology from the Florida Institute of Technology



Fig. 7 - Tim holds the completed, but unpainted model. The unique twin-boom design creates a striking silhouette on the launch pad.

in Melbourne, Florida. Currently, he is the owner of Apogee Components (https://www.apogeerockets.com) and also the author of the books: *Model Rocket Design and Construction*, *69 Simple Science Fair Projects with Model Rockets: Aeronautics* and publisher of the "Peak-of-Flight" newsletter, a FREE ezine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.





SpaceShipTwo-ish Rocket Plan

By Martin Jay McKee

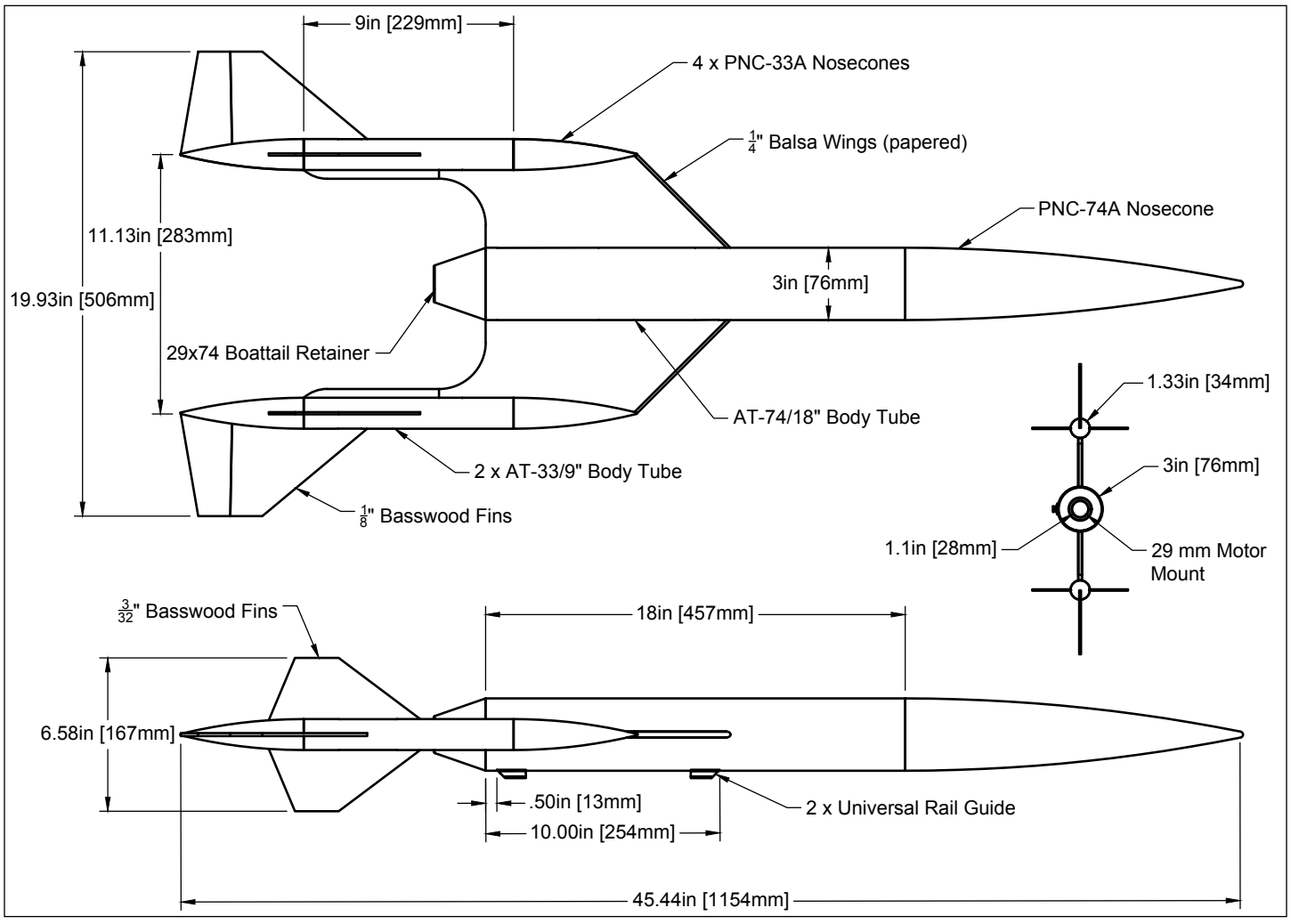
The SpaceShipTwoISH plan was inspired by the real-life spaceplane SpaceShipTwo. It is not, however, scale or even semi-scale. Perhaps it would be better to consider it an impressionistic cartoon of the original space plane. Whatever you consider it, this is a unique and impressive mid-power rocket that will stand out at the next launch.

History of the Inspiration

SpaceShipTwo was a spaceplane developed for the space tourism market. The vehicle was owned and operated by a subsidiary of Virgin Galactic and was designed by Scaled Composites. Originally unveiled on December 7, 2009, the SpaceShipTwo (VSS Unity) made its final flight on June 8, 2024. Originally slated to fly hundreds of private tourists, the craft - which could carry a total of six crew and passengers - only made seven “commercial” flights.

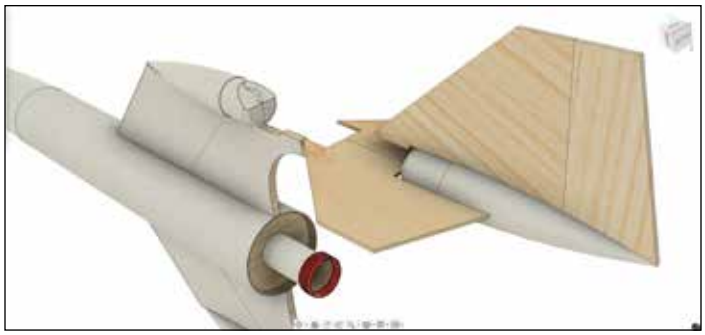
SpaceShipTwo typically flew to altitudes between 80-90 km which made the flights space flights according to US rules (which place the threshold to space at 50mi/80km) but the flights fell short of the internationally recognized Karman Line (60mi/100km).

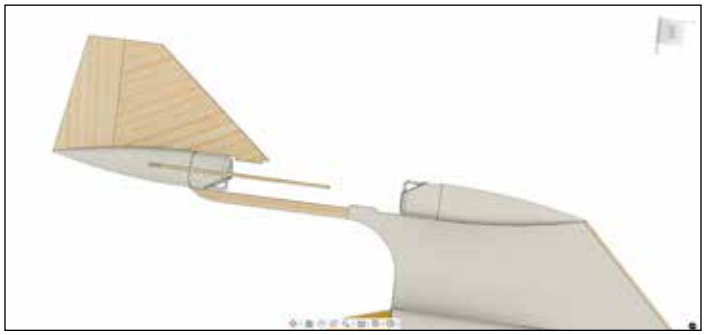
Rather than use rocket propulsion for the entire altitude gain, SpaceShipTwo was lifted to a high altitude first by the White Knight Two carrier aircraft before igniting the onboard hybrid engine to carry the craft up to space. After a couple of minutes in a ballistic (weightless) trajectory in space, the tail-feathering recovery system was triggered and SpaceShipTwo returned to Earth.

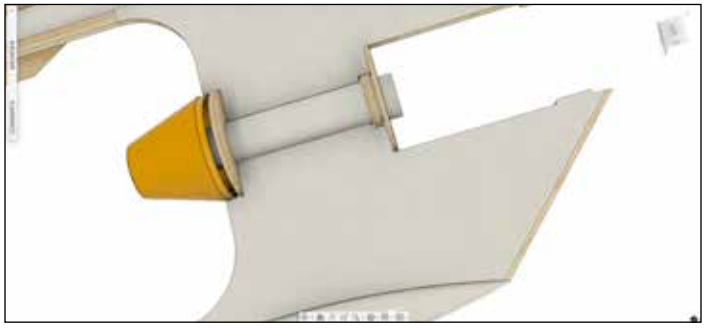


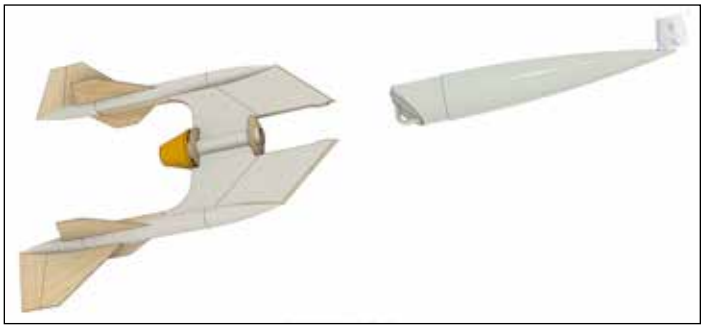
Cutting out and assembling fins

There are lots of fins that go into this rocket and they need to be cut accurately to make assembly easier. Printing out the templates and using a temporary spray adhesive to bond them to the wood can make transferring the shape easier.









Also, due to the limited size of the materials available, once the parts are cut, several of the fins need to be assembled. Fins to be assembled should be glued with wood glue and pressed under weight while the glue dries to ensure a flat assembly. Moreover, the 1/4" balsa main wing should be papered for maximum rigidity.

Tube Slots - for alignment

As with the fins, the tube slots are intended - to a great extent - to provide proper alignment as well as the strength the TTW (through-the-wall) tabs provide. The slot locations should be marked on the tube using the provided marking guides and then cut out using multiple light passes of a sharp hobby knife. Test the fit of the fin tabs in the slots and adjust before committing to building the whole rocket, as it is difficult to correct issues once there is glue racing you to dry!

Mounting the Boattail Retainer

To work correctly, the boattail retainer requires precise extension of the motor mount tube beyond the end of the body tube. While this can be achieved by carefully measuring and alignment, it is suggested to use the alignment card that comes with the boattail retain for installation of the motor mount assembly (motor mount tube, rings, and shock cord) to expedite the alignment at the aft end.

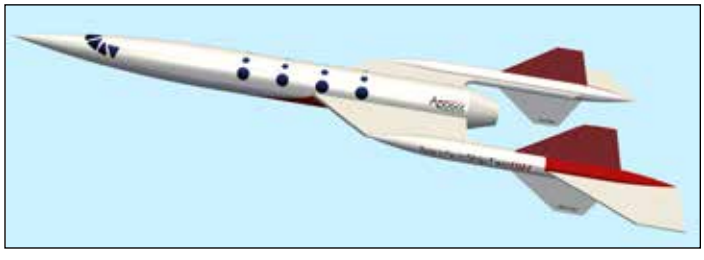
Get the Lay of the Land

The screenshots here were created by Tim for use in his video series on building the rocket. This is a complex layout, and he wanted to see where all the fins were going to end up before he started cutting them out. You'll find that they are beneficial and help make sure you get everything in the right place.

The video series is planned to be released starting December 23, 2025. The first video will be at: https://www.apogeerockets.com/Advanced_Construction_videos/Rocketry_Video_451

RockSim File:

You can download the RockSim file for this rocket at: https://www.apogeerockets.com/Peak-of-Flight-Rocket-Plans



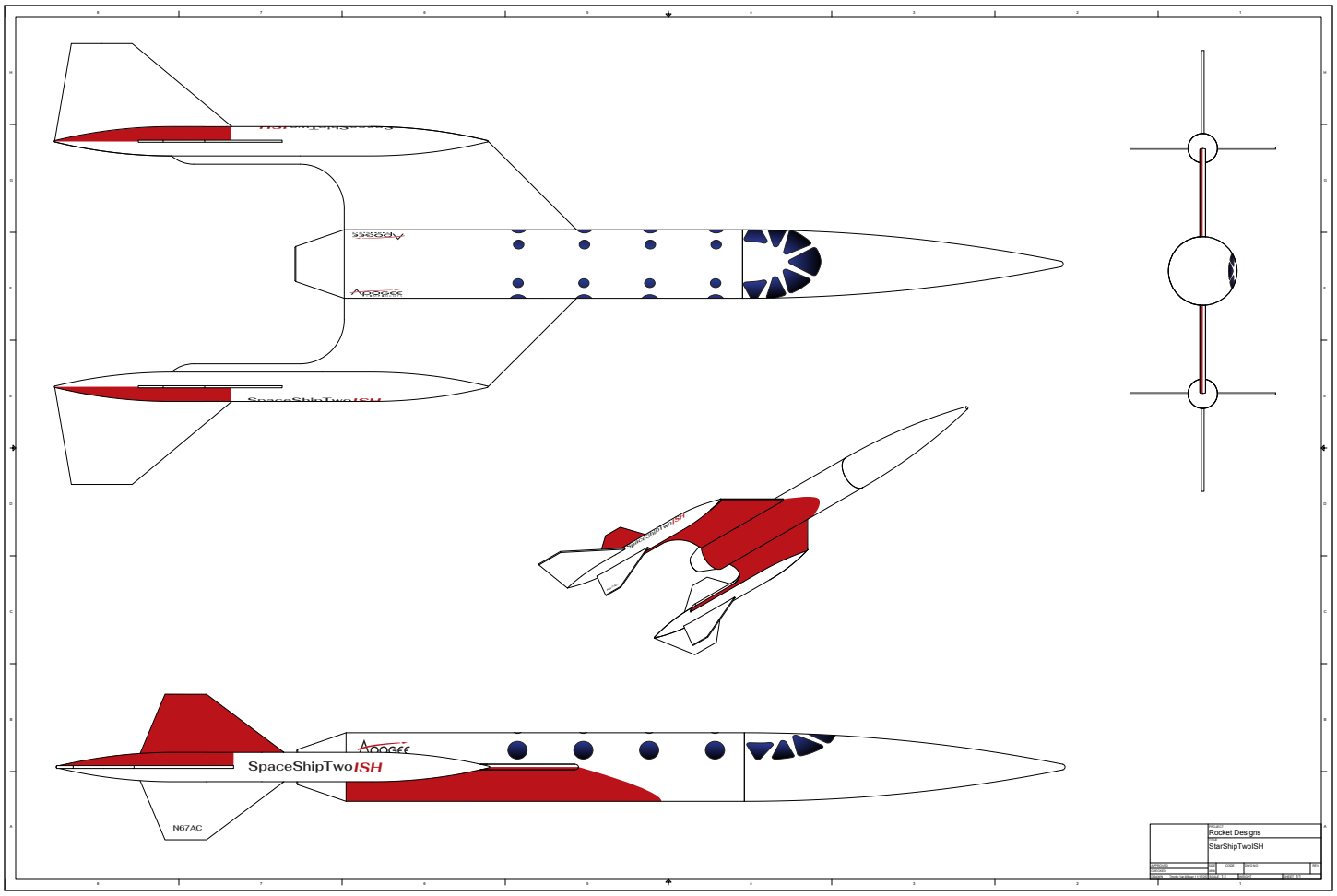
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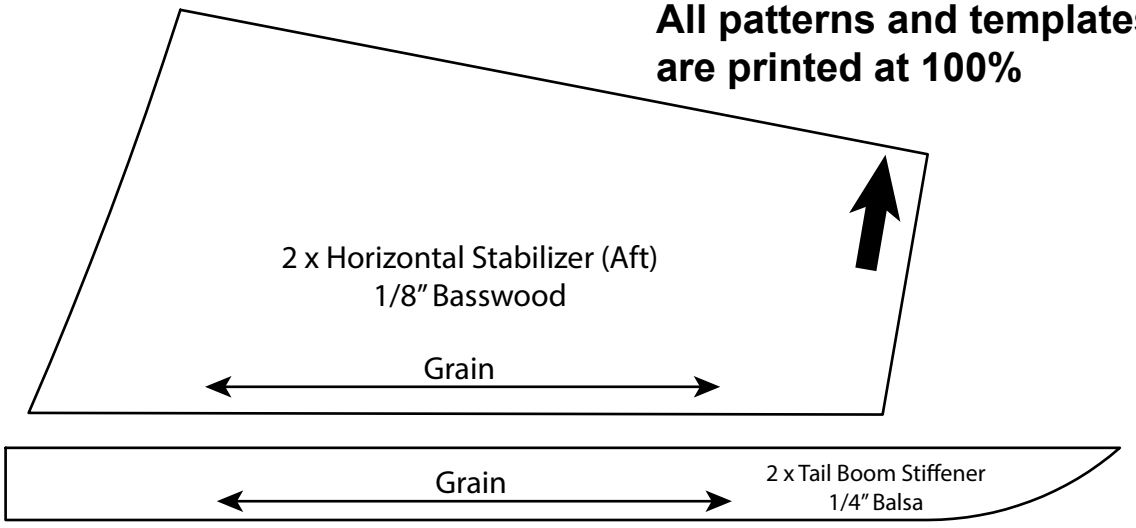
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SpaceShipTwo-ish Plan

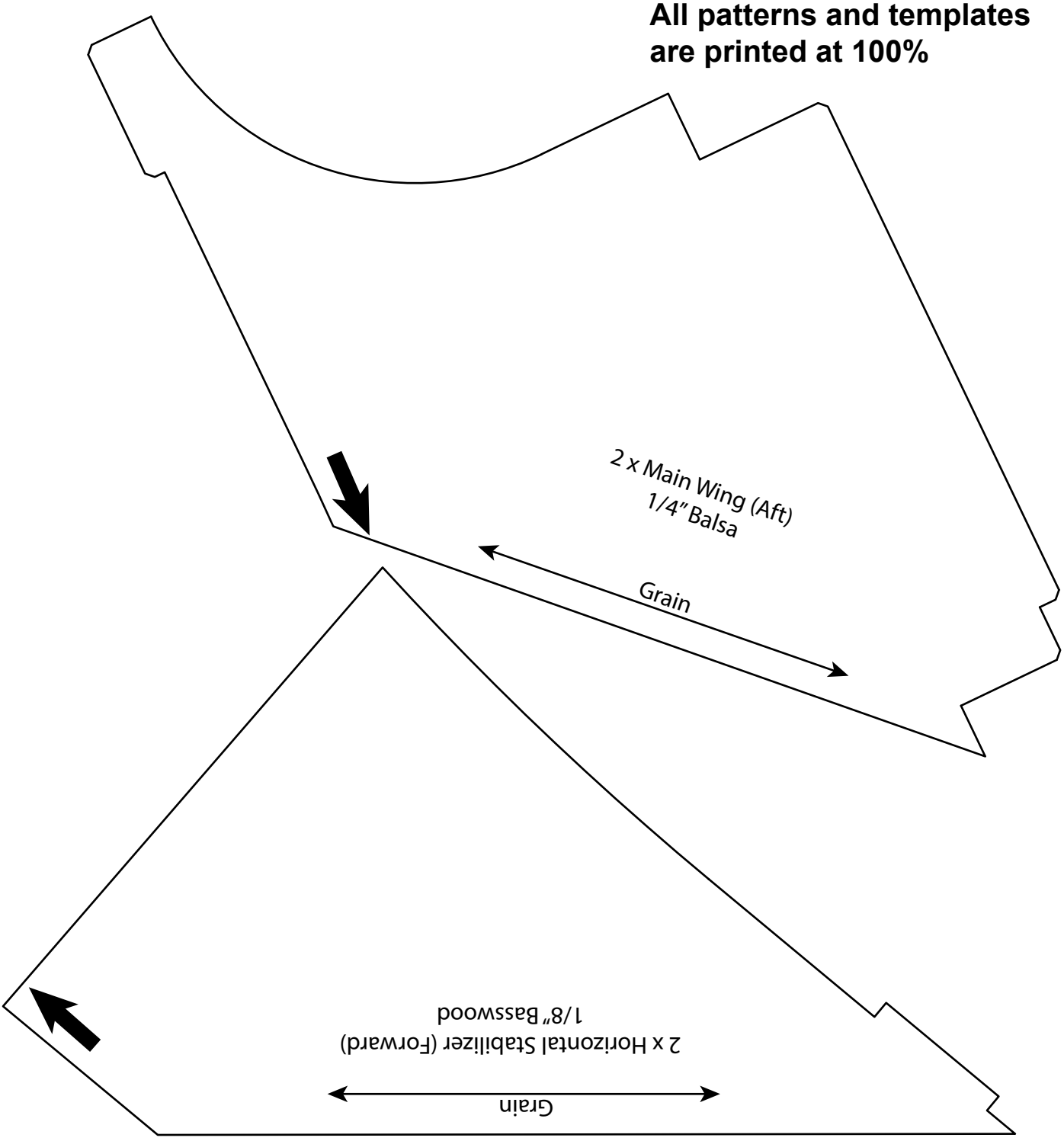
by Martin Jay McKee

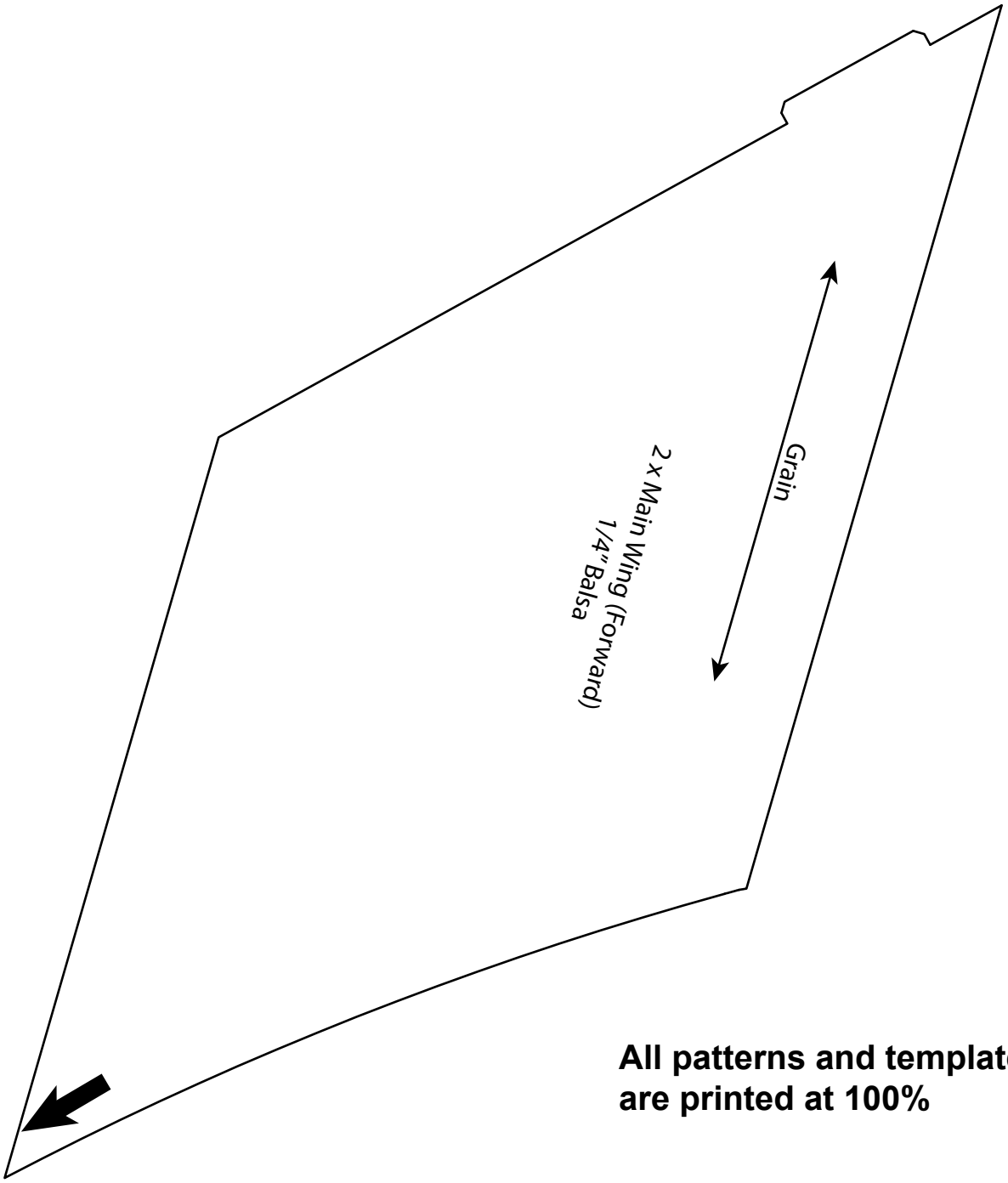


All patterns and templates are printed at 100%

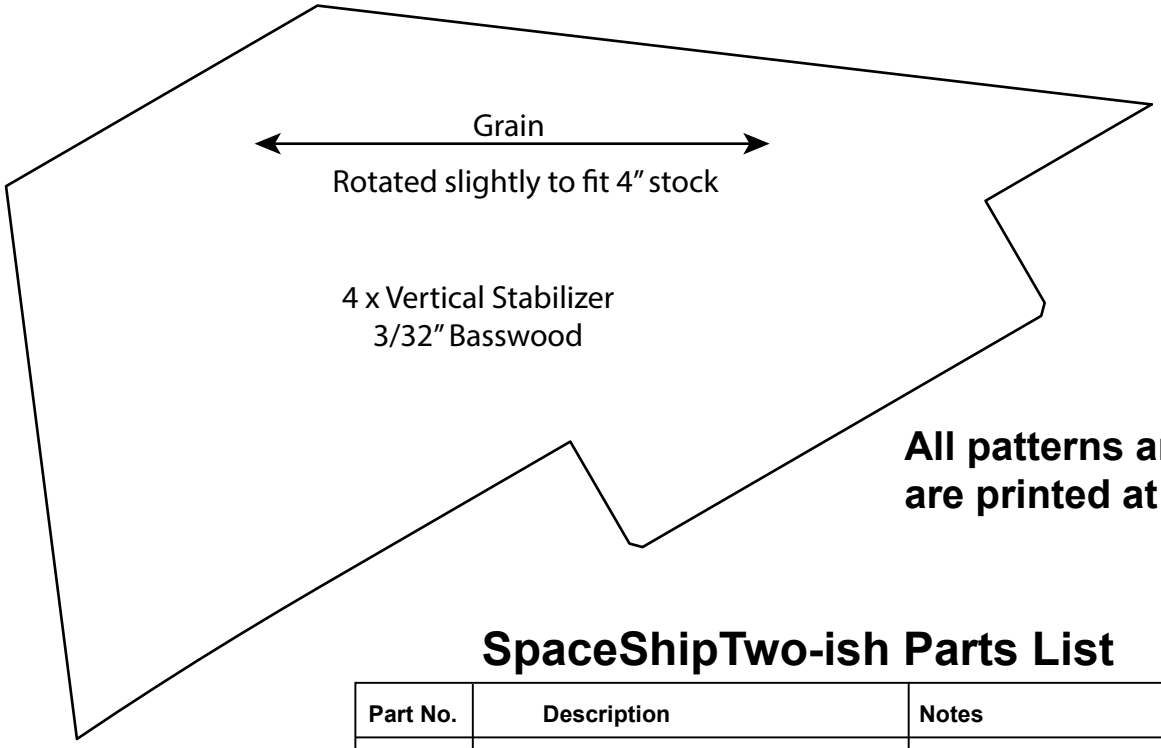


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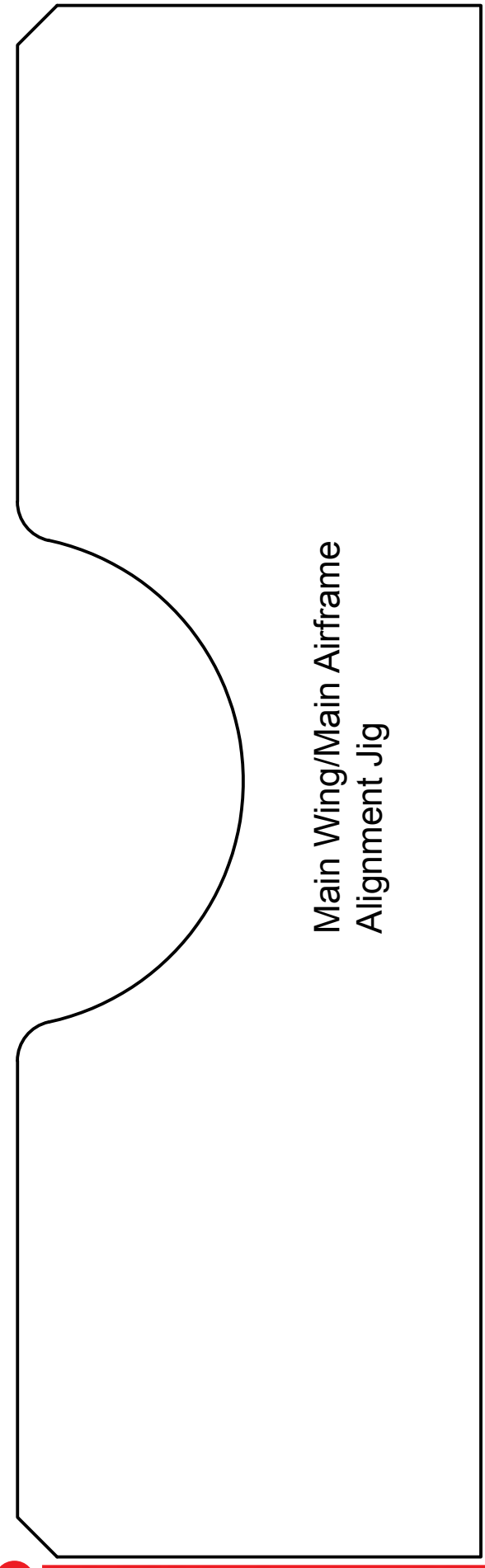
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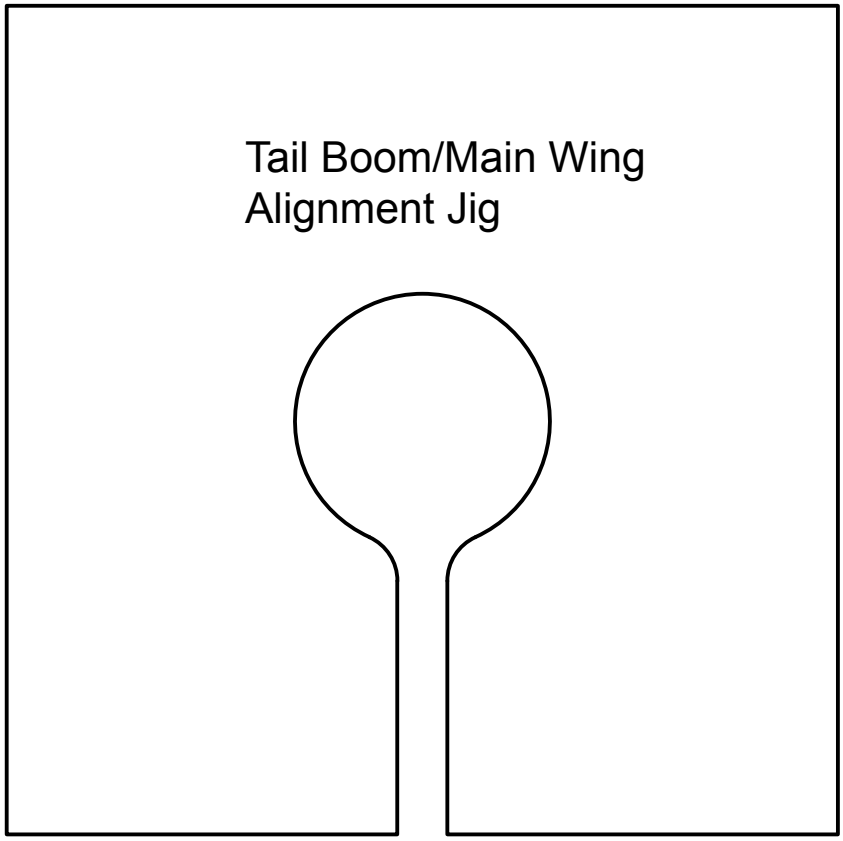
All patterns and templates are printed at 100%

SpaceShipTwo-ish Parts List

Part No.	Description	Notes
10131	1 x AT-33/18" Tube	Use one of six in order
10253	1 x AT-29/7" Motor Mount Tube	Use Twoof six in order
10202	1 x AT-74/18" Tube	Use one of four in order
13427	2xCR-29(thick wall)/7(thin-wall 3")	
13531	Universal Rail Guides	
20068	4 x PNC-33 Nose Cone	Order two packages of two
19490	1 x PNC-74 Nose Cone	
24151	1 x 29/74 Boattail Retainer	
29094	30" Printed Nylon Parachute	
29372	9x9 Parachute Protector	
29507	12' x 750# Kevlar	
	1/4"x4"x18" Balsa	Order two sheets
	1/8"x4"x18" Basswood	Order three sheets
	3/32"x4"x18" Basswood	Order two sheets
	Supplies to paper the main (balsa) fins	

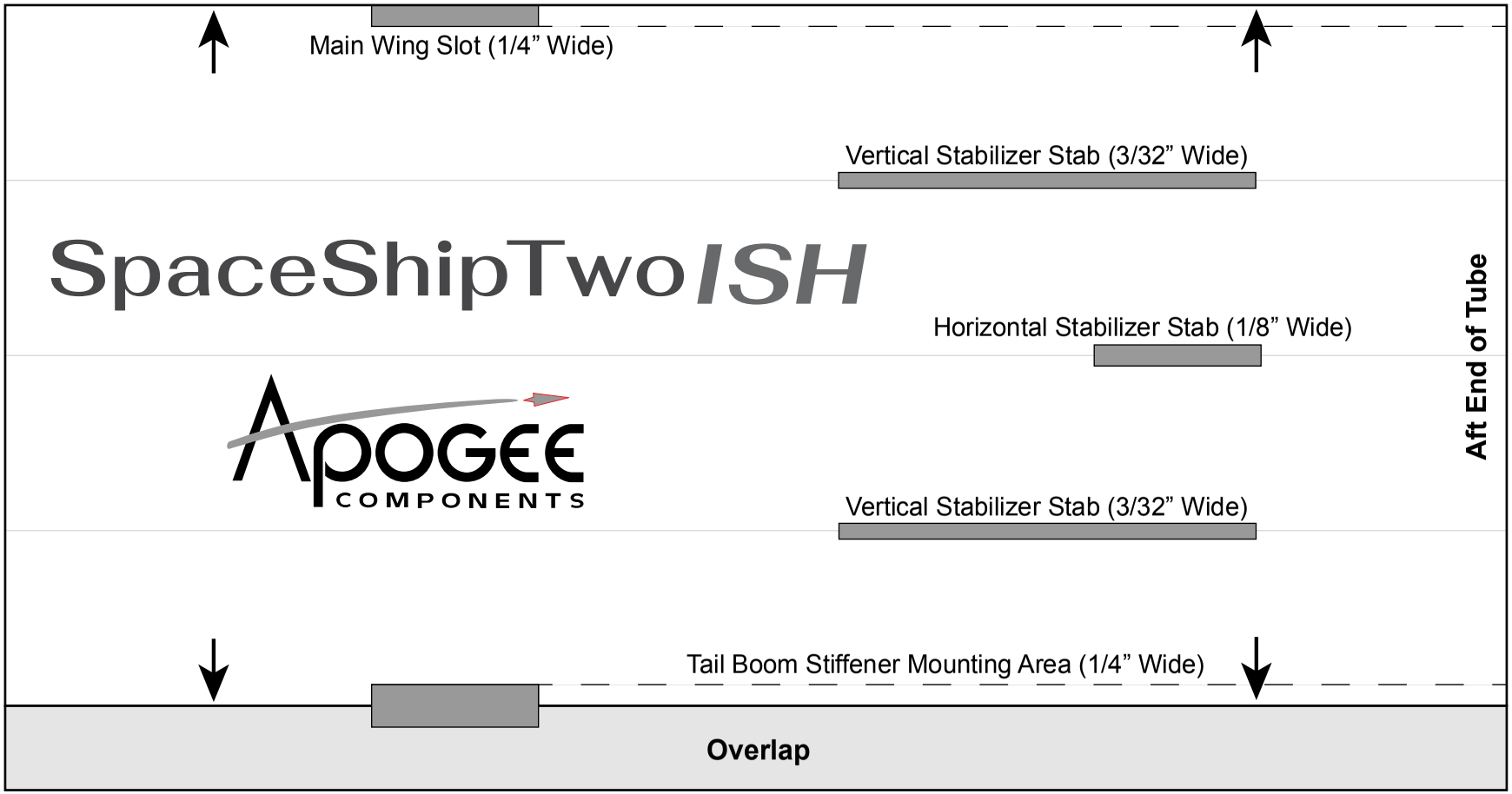


All patterns and templates are printed at 100%

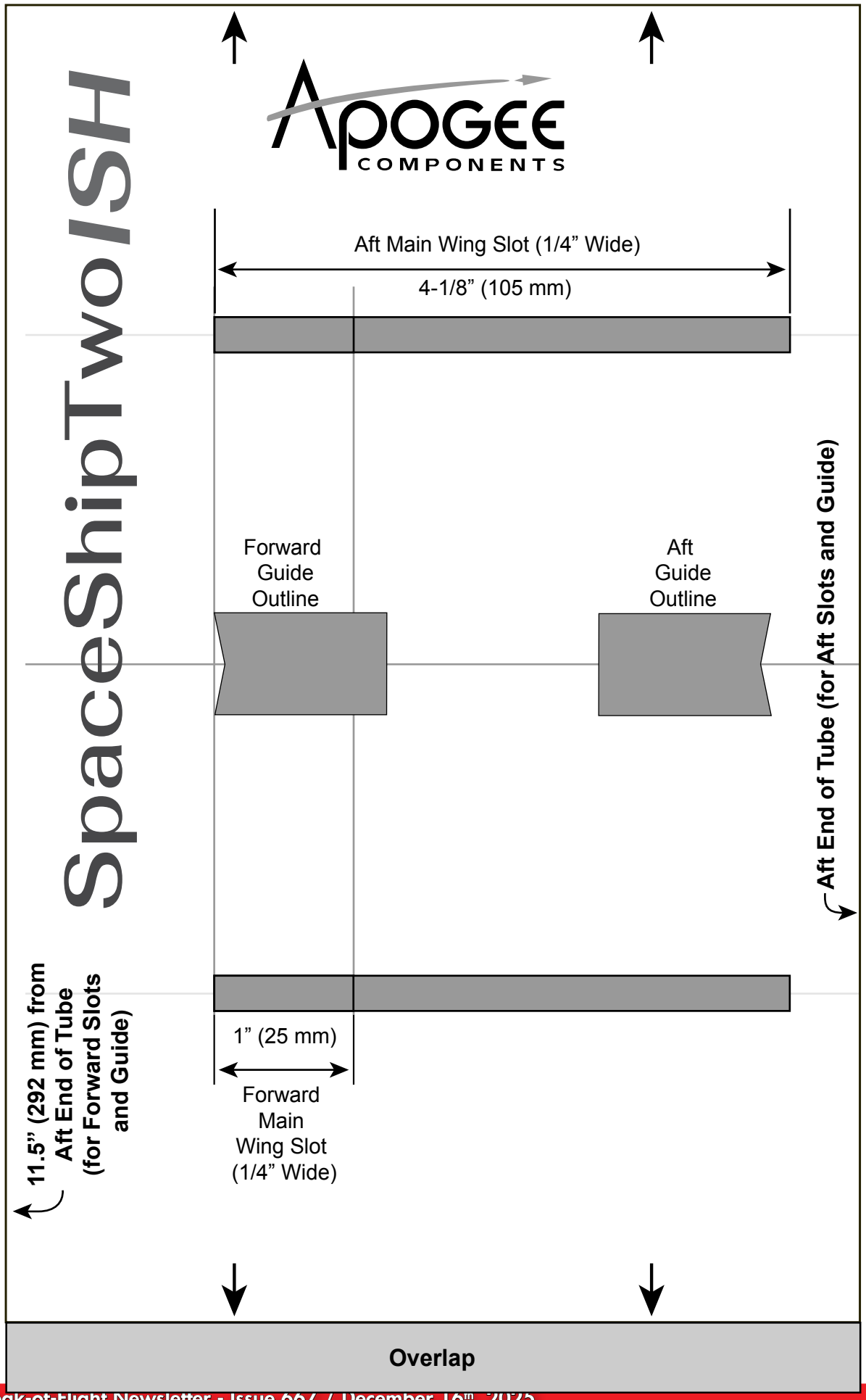


Alignment Tools - Cut from foam-core board or corrugated cardboard. Cut two of each.

Tube Marking Guides - 33mm Tube



All patterns and templates are printed at 100%

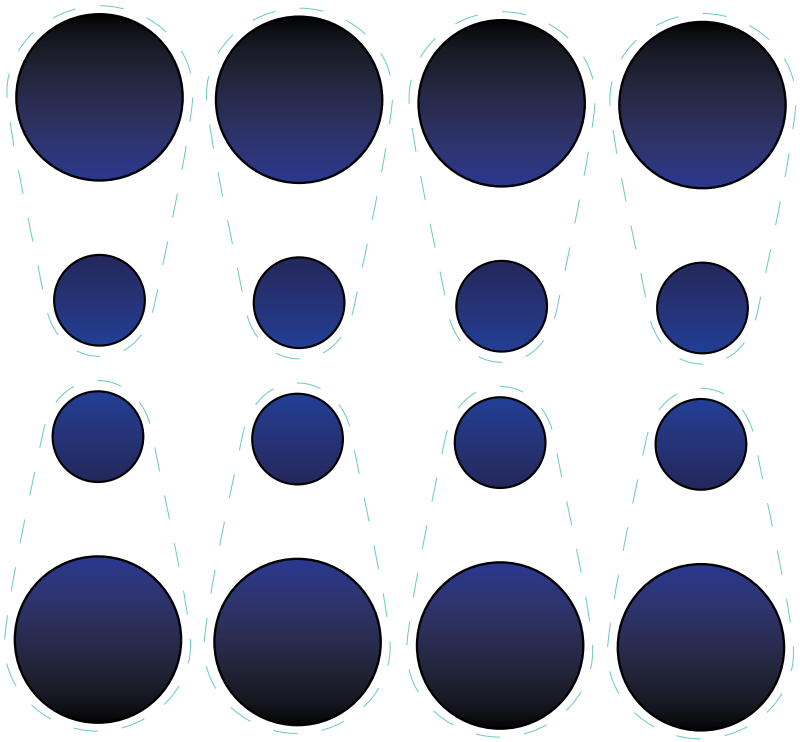


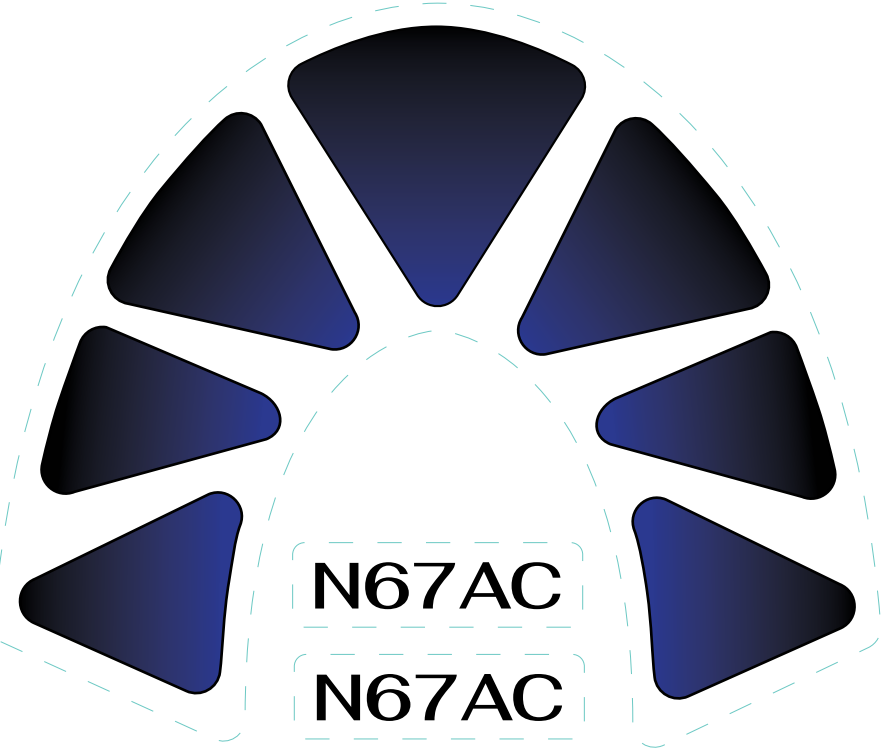
Tube Marking Guides - 74mm Tube

All patterns and templates are printed at 100%

Decal Patterns

All patterns and templates are printed at 100%





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APOGEE COMPONENTS

PEAK OF FLIGHT NEWSLETTER

Issue 667 / December 16th, 2025

www.ApogeeRockets.com

Article Submission Guidelines

SUBMITTING ARTICLES TO APOGEE

We are always looking for quality articles to publish in the *Peak-of-Flight* newsletter. Please submit the "idea" first before you write your article. It will need to be approved first.

When you have an idea for an article you'd like to submit, please use our contact form at **https://www.apogeerockets.com/Contact**. After review, we will be able to tell you if your article idea will be appropriate for our publication.

Always include your name, address, and contact information with all submissions. Including best contact information allows us to conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email or phone.

CONTENT WE ARE LOOKING FOR

We prefer articles that have at least one photo or diagram for every 500 words of text. Total article length should be between 2000-4000 words and no shorter than 1750 words. Articles of a "how-to" nature are preferred (though other types of articles will be considered) and can be on any rocketry topic: design, construction, manufacture, decoration, contest organization, etc. Both model rocket and high-power rocket articles are accepted.

CONTENT WE ARE NOT LOOKING FOR

We don't publish articles like "launch reports." They are nice to read, but if you don't learn anything new from them, then they can get boring pretty quick... Example: "Bob flew a blue rocket on a H120 motor for his certification flight." As mentioned above, we're looking for articles that have an educational component to them, which is why we like "how-to" articles.

You can see what articles and topics we've published before at: **https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education**. You might use this list to give you an idea or two for your topic.

Here are some of the common articles that we reject all the time, because we've published on these topics before:

- How to get a L1, L2, or L3 Cert
- Building cheap rockets and equipment (pads & controllers)
- How to 3D print parts, or a Rocket Kit
- How to Build a cheap Rocket Kit
- Getting Back Into Rocketry After a Long Hiatus

ARTICLE & IMAGES SUBMISSION

Articles may be submitted by emailing them to the editor. Article text can be provided in any standard word processor format, or as plain-text. Graphics should be sent in either a vector format (Adobe Illustrator, SVG, etc.) or a raster format (such as jpg or png) with a width of at least 600 pixels for single column images or 1200 pixels for two-column images. It is preferable for images to be simple enough to be readable in a two-column layout, but special layouts can be used.

Send the images separately via email as well as show where they go by placing them in the word processor document.

ACCEPTANCE

Submitted articles will be evaluated against a rubric (available here on our website). All articles will be evaluated and the results will be sent to the author. In the evaluation process, our goal is to ensure the quality of the content in *Peak-of-Flight*, but we want to publish your article! Resubmission of articles that do not meet the required standard are heavily encouraged.

ORIGINALITY

All articles submitted to Peak-of-Flight must not run in another publication before inclusion in the *POF* newsletter, but it may be based on another work such as a prior article, R&D report, etc. After we have published and paid for an article, you are free to submit them to other publications.

RATES

Apogee Components offers **$300** for a quality-written article over 2,000 words in length. Payment is pro-rated for shorter articles.

WHERE WILL IT APPEAR?

These articles will mainly be published in our free newsletter, *Peak-of-Flight*. Occasionally some of the higher-quality articles could potentially appear in one of Tim Van Milligan's books that he publishes from time to time.





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