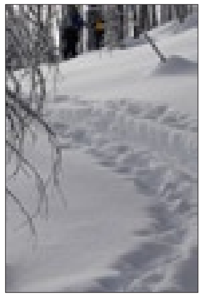

Uphill Float

An Exploration of Lightweight Splitboard Design

A creative work submitted to the faculty of San Francisco State University in partial fulfillment of the requirements for the degree Master of Arts in Industrial Arts.

by Melody dos Santos
San Francisco, California
May, 2006

Certification of Approval

I certify that I have read *Uphill Float: An Exploration of Lightweight Splitboard Design* by Melody dos Santos, and that in my opinion this work meets the criteria for approving a creative work submitted in partial fulfillment of the requirements for the degree: Master of Arts in Industrial Arts at San Francisco State University.

Ricardo Gomes

Professor & Department Chair

Martin Linder

Professor & Advisor

Acknowledgements

This creative work would not have been possible without generous support from loved ones, committee members and industry professionals. While I am thankful to all of those helped me through the past two years, I would specifically like to extend my gratitude to those individuals without whom this project could not have met such success.

First and foremost, I thank Sati Shah, my mentor, confidante, lamination support team and boyfriend. Unable to stand by and watch me struggle for one more season on snowshoes at a time when no one made small splitboards, he decided we would make one. Sati stood by me during epoxy disasters, crooked holes, delaminations, bent tools, bubbled surfaces, and graphite powder meltdowns. His enthusiasm and positivity, often surpassing my own, was undeniable.

I am grateful to Professors Ricardo Gomes, Department Chair, and Martin Linder, my advisor, for their continued support of this creative work. They provided ideas, insights and cautions that kept this project on track. Their encouragement for exploration outside the realm of the classroom opened the door for free pursuit of a subject I love.

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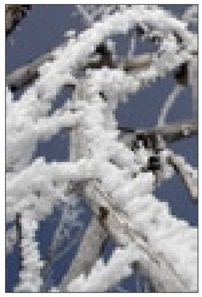

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Abstract

Because of the increase in the number of backcountry snowboarders, recent innovations in backcountry travel gear are numerous. A lighter splitboard could be designed to meet the needs of lightweight, over-snow travel. In this creative work materials, techniques and compositions are explored in order to optimize the strength and weight of a splitboard. Overviews of splitboarding regarding the sport itself, the physics involved, anatomy of the boards and composite design offer an understanding of the subject. Next, three rounds of prototyping are discussed. The first prototype exhibits materials research as well as the manufacturing process. Observational and experiential data are discussed and solutions are offered in the second prototype. Observation, interviews and survey data inform the design of the final three prototypes. The process of their manufacture is discussed. Finally, photographic documentation of the entire creative work is offered.

1 Overview

1.1 Into the Backcountry

"We measure the mountains by the gear we bring. The distances and descents, danger and delight, are all tempered by our tools, given structure by the skis and snowboards we ride, the packs we carry, the transceivers we wear and the skins we climb. Part hardware, part wingspan, our gear gives gravity its form. Gear creates and harnesses our ideas of backcountry bliss, and makes art out of the simple pursuit of hiking and sliding" (Gear Hall of Fame, 2002).

How can a splitboard be redesigned to reduce weight without compromising strength or integrity?

Tremendous advances in the backcountry travel gear have allowed snowboarders deeper into the wilderness. The most notable advance is the backcountry snowboard or "splitboard" which can be separated along its length and used as skis for uphill travel and then reassembled for downhill snowboarding. This innovation has opened deep wilderness exploration to snowboarders.

While the use of splitboards varies from their traditional snowboard counterparts, they employ similar composite construction design. The use of splitboards as uphill skis demands more rigidity along the center edges. Traditional snowboards are designed for resort riding where conditions are quite different from those in the backcountry. Away from resorts, the surface snow is often deeper, having never been groomed by machines or skied on day in and day out. Splitboarders often ride among the trees and require the agility of a lighter board, but the float of a long board. The weight of the splitboard is as much a factor in the backcountry as that of a snowboarder's pack. The currently available splitboards do not meet these demands. This was explored in this creative work: How can a splitboard be redesigned to reduce weight without compromising strength or integrity?

Throughout the research, secondary questions became important. What lighter materials could be used? What changes to the structural design could reduce the weight? Could a lighter board maintain flex, strength and camber? How would different materials or construction react to extreme temperature and changes in altitude? What compromises would have to be made in order to achieve a weight savings? Could the shape of a long board allow for a short board feel, while maintaining float?

1.2 Assumptions

Some weight-saving materials and methods that were beyond the budget and scope of this creative work could not be employed. For example, a the use of a heated press to laminate snowboards allows for the use of pre-empregnated glass, but requires a refrigeration unit. While these materials and the processes to utilize them could have further optimized the weight savings in this project, they were cost prohibitive. Information about these materials and techniques is nonetheless included in this research because there is great value in understanding them. However, an assumption that must be made is that the weight of a splitboard made with a vacuum molding process at between 24 - 26Hg is greater than the weight of the same board if made with a commercial manufacturing process. It is not possible to estimate the potential weight savings in commercial manufacture of splitboards over the manufacture of the boards in this project. Therefore, the direct weight comparisons here can be considered with this assumption in mind.

A Voile Split Decision 153 Splitboard will stand as the point of comparison. Voile has established itself as the standard in splitboard design and produces a board of the same size as the prototypes in this paper.

Prototype testing was conducted in locations near Lake Tahoe, the East Side of the High Sierra and the Wallowa Range in Eastern Oregon. These locations were used to simulate variable conditions found elsewhere.

1.3 Overview

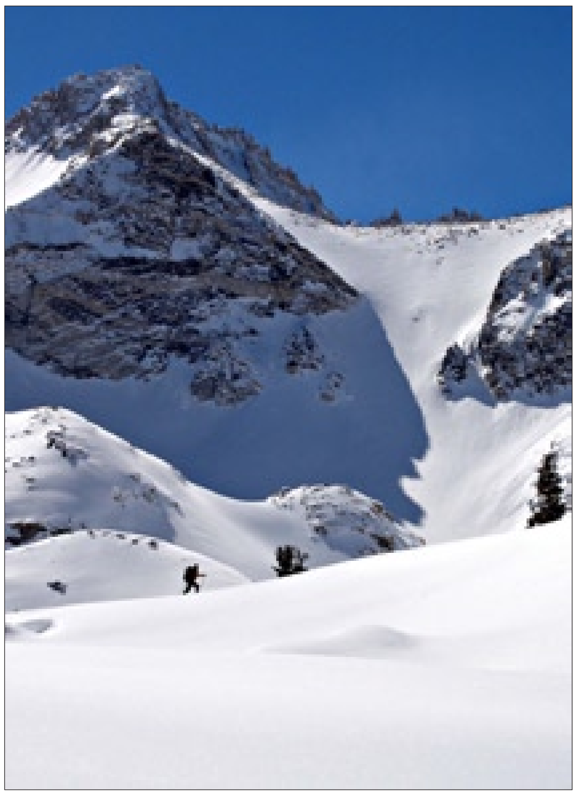
Years of experience riding a snowboard, teaching snowboarding and exploring the backcountry provided a substantial groundwork for the inception of this project, but contributed little to the reality of designing, much less building, lightweight splitboards. Designing and constructing the series of Float splitboards for this work drew forth an wealth of knowledge and skills in composite design from a recent novice.

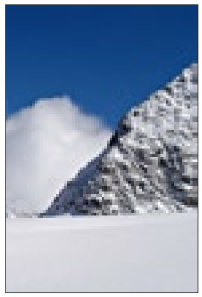
The process employed followed a cycle of discovery, implementation, observation and interpretation. “Discovery” included the history of the sport, the physics of snowboarding, materials science, composite design and information gathering tools such as surveys and interviews. During the “implementation” phases, skills were gained in procurement, computer aided design, woodworking and vacuum bagging. Prototypes were tested in the studio and on the snow. Observations of the prototypes as well as commercially available splitboards in action led to interpretations that informed the subsequent designs. The design process was intensely enlightening and led to greater successes with each cycle.

Five full-size prototypes were completed during this creative work. The Float I prototype served as a lesson in splitboard anatomy and composite design. With bonds failing in the lamination on its first trip to the snow, its weaknesses were apparent from the start. Riding this board provided a deep understanding of the reasoning and effects of snowboard shape design from which I had strayed. Subsequently, the Float II board solved many of the design dilemmas of the first prototype. The aesthetics and ride of this board dwarfed those of its predecessor. Yet, several design issues had yet to be solved. Most importantly, the next designs provided more stiffness for the rider in order to increase stability and reduce chatter, the vibrations of the components of the board due to friction on the snow. Three versions of the Float III board were developed to answer these questions. Finall, success was met on this last attempt.

1.4 Project Outcomes

This project concludes with several lightweight splitboard prototypes that improve the experiences of backcountry snowboarders. The boards have stood up to initial user experience testing as well as flex and camber comparisons. Innovations in these splitboard design include outer cap construction and custom insert patterns. The project also sprouted a network of splitboard enthusiasts and designers. The research has also given forth ideas for future examination in materials technology and lightweight board design.





2
Literature Review

2.1 History

Access to the backcountry dates back thousands of years. Petroglyphs over 5000 years old found in Norway depict the use of skis by hunters. Early skis, dating back to 2500 BC have been uncovered in bogs in Sweden and other parts of Scandinavia. The ease of transportation over snow was a great advantage for hunters in these northern climates.

Skiing began to progress from a utilitarian necessity to a sport around 1000 AD. Viking king Harald Hadrade, became renowned in Iceland for his “fast skiing” as he raced and wagered, skiing for fun. Other northern Scandinavians became renowned for fast skiing and the sport spread across the cold, wintry land. Stick-riding was a early form of ski racing in which people would ride long skis with toe-strap bindings and steer with a long stick that they held with both hands. Ski racing had been born.

By the mid 1800s, farmers in the mountain plateau of Telemark in Norway had developed a style of skiing that employed controlled speed and dynamic turns. They gave up sticks for steering and discovered the importance of the ski base angle and changing the skis’ direction with respect to the fall line. Potato farmer Sondre Norheim made skis and bindings for the people of his village and kept skiing a people’s sport, rather than the aristocratic sport it was in other parts of Scandinavia. Seeing the need for better control through better bindings, he developed a binding that incorporated a birch root tendril heel strap. The stretchy, tough straps allowed him to jump off of the surface of the snow. Today, the same basic equipment design is used by telemark skiers world wide. The two turns he perfected, the “telemark” and the “christiania” or “Christie,” are still the basis of telemark skiing as well. These turns and the telemark bindings revolutionized skiing (Lund, 1996).

Backcountry skiing came to the United States with Scandanavians who flocked to California's Sierra Nevada in pursuit of gold. The only form of communication between mining towns in the mountains was by mail. John A. "Snowshoe" Thompson and other Scandinavian immigrants carried mail by skis, then called snow shoes, across the Sierra on a 90 mile route from Placerville to the Nevada border. These backcountry mail carriers made many rescues of people trapped in the harsh environment without a mode of over snow travel, like skis. Thompson developed bindings to attach the two skis for downhill riding. This was the first splitboard. Thus, backcountry skiing in the Sierra Nevada was born (Adler, 2001).

World War II brought attention to backcountry mountaineering in the Sierra Nevada, the Rocky Mountains and other ranges in the States. After the deaths of more than 25,000 Italian soldiers in Albania, the US Army saw reason to train soldiers in mountain and winter warfare. Three weeks before the attack on Pearl Harbor, the 87th Infantry Mountain Regiment was created. The Army also recruited over 2000 people from the newly formed National Ski Patrol as soldiers in this new regiment. The Regiment established a team of experts to develop equipment for winter mountaineering and combat. These experts embellished the ski equipment designs of the time. They designed bindings with variable heel cables for the varying conditions. They also developed more effective swiveling toe pieces. The improvements that the army made in ski binding can still be seen in designs used today.

After WWII, advances in materials and technology changed the design of skiing equipment. Heel-and-toe release bindings and step-in bindings became the norm for downhill skiers in the 1950s. Aluminum and wood core aluminum skis replaced the wood skis and soon there after, plastic skis were invented. Fiberglass skis finally appeared in the 1960s and once again revolutionized the gear (Kokotele, 1999).

Snowboarding has deep roots in this country. A 1939 film shows a man named Vern Wicklund riding a snowboard with foot straps and a curved nose. He held patents for this design, but never pushed it into production. In 1965, Sherman Poppen created another early precursor to the snowboard. He strapped two skis together for his daughter so she could ride downhill. They dubbed the sport “snurfing” as a combination of snow and surfing. Little did they know that they had started a far-reaching trend. The Snurfer was produced and marketed as a toy and sold over a million units in a few years. Riders held on to a rope in the front and stood on the board without bindings. As the sport developed, no one could have imagined that the design would come back so close to its origin as two skis stuck together (Kokotele, 1999).

Snowboard manufacturers sprouted up across the US in the 1970s and 80s. The first surf board shaped snowboard with metal edges was introduced by Dimitrije Milovich in 1970 (Crane, 2003). He patented the design, but decided not to enforce the patent. He began the company “Winterstick” in Utah, where the powder is deep. Because of the fluffy conditions, Milovich removed the unnecessary metal edges from his designs. In the mid-1970s, Winterstick gained fame in Newsweek Magazine, bringing the sport of snowboarding into the spotlight. Around the same time, a man named Bob Webber developed a skiboard patent and later sold it to Jake Burton. Jake Burton Carpenter started Burton Snowboards, which would become a sport empire (Burton, 2004). He started the National Snowboarding Championships in 1983. The same year, Tom Sims, owner of Sims Snowboards, ran the World Snowboarding Championships at Lake Tahoe. Two years later, both companies introduced metal edges into their fiberglass board laminations and the designers never looked back.

In 1979, Tahoe City, California became home to the world’s first snowboarding half pipe. This new form of snowboarding would change the sport. More than a decade later, Vail ski area opened the first snowboarding terrain park to accommodate the new population of boarders. Park riding has become a huge part of recreational and competitive snowboarding and has pushed innovations in binding design because of the high demand on performance.

By the 1990s, snowboarding finally gained international recognition and albeit reluctant acceptance as a legitimate sport by the ski industry and sports fans. More than 50 different companies had jumped into the game of marketing snowboards and gear. In 1994, Ride Snowboards became the first snowboard company to go public. Snowboarding became an Olympic sport in the 1998 Nagano Winter Olympic Games. Today, most ski resorts welcome snowboarders.

Only three of the 325 resorts in The National Ski Areas Association still ban snowboarding: New Mexico's Taos and Utah's Alta and Deer Valley (Sloan, 2005). Snowboarding has become a religion.

2.2 Snowboarding Styles

Since its inception, the sport of snowboarding branched into several distinct styles. Like skiing, there are many options for sliding downhill on a snowboard. Freeride, freestyle, alpine and splitboard are the main choices for a snowboarder. Each style demands equipment specific to its uses.

Freeride snowboarding, also known as all-mountain riding, is the most popular snowboarding style. Freeriders take chairlifts, gondolas or occasionally and unfortunately, a poma, T-bar or rope tow up a slope. Then they ride groomed runs and the terrain just outside of groomed runs at commercial resorts. A freerider might jump off kickers or natural features, ride among trees or down steep terrain. The snowboards for freeriding are long for speed, stability and float in powder. They are directional with a longer nose, shorter tail and set back stance. Freeriders generally prefer a stiff board for spring and speed. The stance is adjusted depending on the snow and terrain features. For powder riding, snowboarders put their stance far back on the board to weight the back of the board and allow the nose to float above the snow. Most freeriders have a slightly forward angled stance with the front foot between 10 and 20 degrees and the back foot between 0 and 15 degrees. Freeriders generally have a preferred stance; either a regular (left foot forward) or goofie (right foot forward) stance, although they occasionally ride fakie with their opposite foot forward. Freeriders encounter a wide variety of riding styles, conditions and terrain at resorts.

Freestyle snowboarding is an aggressive snowboarding style in which people ride man-made terrain features like half pipes, quarter pipes, kickers, table tops, gaps, straight and arc rails and other jibs. Freeriders pull tricks like frontside or backside 180, 360 or 720 spins, inversions and grabs. The XGames and the Winter Olympic Games highlight this sport and have propelled it into the mainstream. Freestyle boards are shorter than freeride boards to lighten the load when riders are spinning and to allow for more freedom in the half pipe. Freestyle riders are comfortable in both goofy and regular positions and can take off or land "switch" with the opposite foot forward. Therefore, their stance is different than that of freeriders. Freestyle riders often ride duck foot, with the front foot angled slightly toward the nose and the back foot angled slightly toward the tail. Their bindings are situated close to center on the board and the boards are usually twin tip with the same nose and tail tip shapes. They are typically durable polycarbonate to withstand the tremendous forces from freestyle snowboarders taking huge jumps.

Alpine snowboarding has gained strength as a sport with the entrance into the Olympics. Snowboard racers and carvers use narrow, asymmetrical boards and hard boots in a diagonal stance to ride only the effective edge in smooth sweeping motions. The equipment for alpine snowboarding is quite different from freeride and freestyle boards.

2.3 Splitboarding

The quest for a lighter load is one shared by all backcountry enthusiasts. For multiple day wilderness snow tours, essential survival items include a backpack, food, water, map, compass, extra layers of clothing, flashlight or headlamp, sunscreen, repair kit, duct tape, spare screws, screwdriver, matches or lighter, rope, a first aid kit, a knife, goggles or sunglasses, shovel, avalanche beacon, avalanche probe, tent, sleeping bag, stove, fuel, cup and poles. All this equipment becomes a burden, especially in deep snow, so people have to get creative with how they lighten their load. A total pack weight of no more than 25% of the hiker's weight can make for a successful and enjoyable trip. With a twelve-pound snowboard on a backpack, the amount of gear that can be carried safely is greatly diminished. As renowned backpacker Ray Jardine says, "The heavy load subtracts from the safety by increasing the person's chances of injury, and by reducing his or her ability to descend expediently to lower and more protected terrain in the event of a sudden storm" (Jardine, 2001). Lightweight backpackers are committed to scrutinizing the necessity and function of each piece of gear and seeking out the lightest weight and highest quality gear to suit each need (Charles, 1996).

The great surface area of a snowboard floats its rider high on the surface of the snow with a grace and rush of surfing a smooth barrel wave. Snowboarders don't want to give up this feeling when they turn away from ski resorts and head out into the backcountry, but to ride this big stick downhill, they must first carry it up. It is generally accepted that "one pound on the foot is seven on the back" (Van Tilburg, 2002). Backcountry skiing and snowboarding becomes more popular every year. Backcountry.com, the leading online retailer of avalanche transceivers and other backcountry gear has seen a 84% year-over-year sales increase each year between 2002 and 2004 (Backcountry.com Blames the Weather, 2005). The backcountry has opened wide to snowboarders.

Before the recent development of the splitboard, snowboarders had two options for travel in the backcountry. Hiking in snowboarding boots and carrying a snowboard is known as "post holing" because of the depths to which a snowboarder sinks in the snow. This method is ineffective, strenuous and therefore, often unsafe. Snowshoes are a better option. With snowshoes, a person can walk close to the surface of the snow because of the increased surface area of their footprint. Despite their benefits, snowshoes can be cumbersome in deep, light snow which is the preferred condition for snowboarding. A snowshoeing snowboarder also still has the significant burden of the snowboard. Backcountry etiquette dictates that snowshoers not walk in the skin track because they leave large, messy footprints that freeze and render the track unusable by people who are skinning. For snowboarders traveling in the backcountry these options are undesirable.

Brett "Cowboy" Kobernick, a guide for Exum Mountain Guides, was the first snowboarder to cut a board down the middle in orderd to ski tour uphill and snowboard downhill. Inspired by this idea, Voile developed the Split Decision, the first commercially available splitboard (Chorlton, 2003). Getting the board off people's backs and onto their feet reduces their load significantly and propels snowboarders farther into the backcountry than ever before.

Today, splitboards are widely accepted as the preferred method of travel for the backcountry snowboarder. In ski or "tour" mode, the wide bases of the splitboard keep a rider from sinking as deep into the snow as on snowshoes. The ability to slide on flat and downhill terrain is also an enormous advantage. In board mode, the ride is identical to that of a normal snowboard. Snowboarders are taking the natural next step from resort riding to earning their turns in the wilderness with the use of splitboards.

2.4 Safety

As technology advances, the backcountry becomes more accessible to winter adventurers. Without quick access to patrol or emergency rescue, backcountry snowboarders must rely on their own planning, survival skills and gear for safe passage. Snowboarders make up about 14% of avalanche fatalities in the United States backcountry (U.S. Avalanche Fatalities, 2002). Avalanches typically release on slopes between 30 and 45 degrees (Fesler, 1999). These slopes are prime snowboarding pitches because they are steep and hold snow well. Splitboarders sit on the slope transitioning gear before dropping in. Backcountry gear must provide optimal performance in the varying climates, conditions, terrain and situations that face its users. The functionality of high performance technical gear is imperative to the experience and well being of backcountry users.

2.5 The Anatomy of a Splitboard

At first glance, a splitboard looks much like a traditional snowboard that has been cut in half. The board has a rounded and curved front tip, or "nose," and rear tip, or "tail." The narrowest point in the board is called the waist. The sidecut radius is the radius of the circle that makes up the arc along the side of the snowboard. Snowboards are curved along their running length, from the point where the nose tip curves up to the point where the tail tip curves up. This bend is known as camber and provides the rider with spring to pop out of a turn. Camber gives a board its life. In profile, the camber is obvious. This point of view also reveals the core profile. The thickness of the core is a determining factor in the longitudinal flex of the board. Cores are thickest under and between the rider's feet and they taper toward the nose and tail. These elements are customized for particular riding styles (graf, 2006).

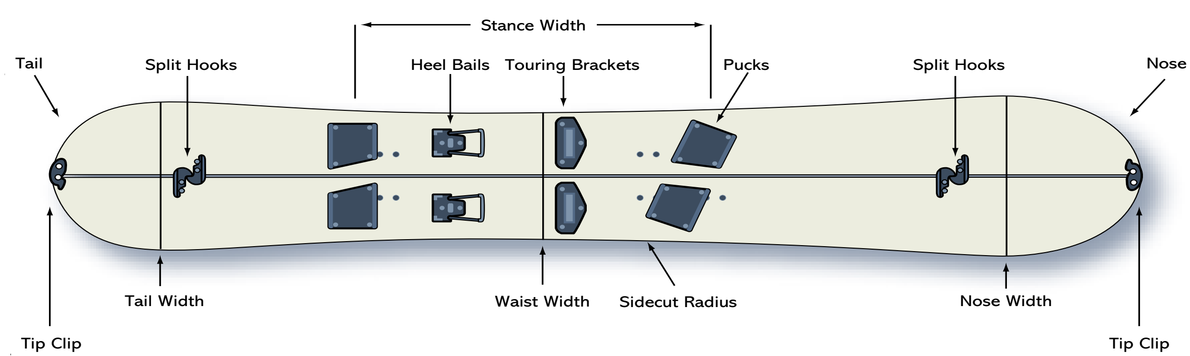


Figure 1. Anatomy of a splitboard.

The splitboard diverges from the snowboard in edges, hardware and insert pattern. In board mode, splitboarders require precision toe-heel edge control to carve, jump turn, slide and otherwise maneuver in all manner of backcountry conditions. Splitboarding requires side-to-side as well as toe-heel edge control. In tour mode, users often need to edge into hardpack or icy slopes when traversing. Efficiency is key when traveling in the backcountry. This is why splitboards have inner steel rails in addition to the outer edges of a traditional snowboard.

The insert pattern for a splitboard is determined by the stance as well as the interface system. The stance on a splitboard is similar to that of a freeride board although it may be set back even further because of the greater chance of deep snow in the backcountry than at resorts. Bindings on a splitboard must work in two separate positions on the board. The 2005-2006 winter season saw the end of the Burton interface system design with their new boards utilizing Voile's system. Both designs rely on a simple pivot point in ski mode, but the ride modes are quite different. Burton splitboard bindings used a metal disc and clamp design. Two aluminum discs came together to support the interface while the clamp's "active design" provided force to aid in the torsional rigidity of the board. The transition with Burton's interface system could be horrendous in wet or sticky snow conditions. Since Burton's retreat from the market, Voile "Slider Track" system is the only remaining option in splitboard interface design. The Voile insert pattern places ride inserts one inch apart at their centers and 1 5/8 inches from the center of the board. With this "Slider Track" interface, a user slides a metal plate over reinforced nylon pucks mounted to the board. The slider track provides a self-cleaning action over the pucks reducing the problem of sticky snow in the transitions. Over all, this is has always been the preferred binding interface system and now is the only option (Gallardo, 2004).

Snowboards are composite laminations of several components sandwiched together with

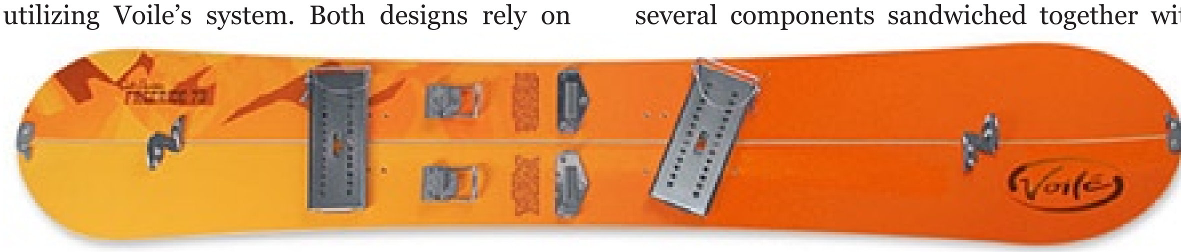


Figure 2. Voile Freeride 173 splitboard.

resin to create a strong and flexible over-snow tool. The main components from top to bottom are the topsheet, reinforcement layers, core with inserts, tips spacers and sidewall, reinforcement layers, damping foil, edges and base. Each component is chosen or designed for specific needs of the particular board (graf, 2006).

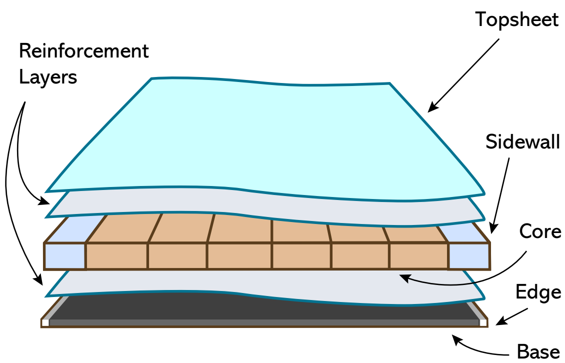


Figure 3. Cross-section of a snowboard laminate.

A topsheet is a thin layer of polyethylene, nylon or polyester or can be a blend or composite. Because UV light breaks down epoxy over time, the topsheet is instrumental in protecting the board. Topsheets can also be dye sublimated to hold graphics.

Reinforcement materials bond with epoxy to create a fiber reinforced plastic structure. These reinforcement layers, or skins, are strong along the length of their fibers, but weak in the opposite direction. The directional nature of reinforcements creates a challenge for designing snowboards, and especially splitboards, because the forces are so intense and varied. Fiberglass is the main reinforcement layer in snowboards because of its resiliency. It may lose strength slowly over quite a long time, but is not inclined toward catastrophic failure. Fiberglass is available in many configurations and weights and is an inexpensive resource. Carbon fiber is lighter and stronger than fiberglass, but has distinct disadvantages. Because of the use of carbon fiber in the current war on terrorism, the industry is experiencing a shortage. Prices have soared to as much as $48 per yard. More importantly, though, is the violent breakage that can occur when carbon fiber is pushed beyond its capabilities. For this reason primarily, if carbon fiber is utilized in a snowboard, it is usually done so in addition to fiberglass layers. Pre-impregnated reinforcement layers (pre-pregs) can be used with a heated press to optimize the glass to resin ratio for the best strength to weight characteristics. Pre-pregs must be kept refrigerated and defrosted before use. The reinforcement layers form a solid, yet flexible, component with extraordinary strength (Graf, 2006).

The function of a snowboard core is to create a distance between the reinforcement layers and to resist the crushing forces applied by a snowboarder. Wood provides a high tensile strength and therefore, a stiff board. Irregularities in wood destabilize the performance of wood cores, so a lamination of wood strips is preferred. Smaller strips decrease the tortional flex but also increase the weight of the glue. Hard and soft woods can be laminated together to optimize the strength and weight characteristics. Honeycomb structures can be used to create strong, light cores. Both aramid and aluminum honeycomb cores can only be used in a heated press with pre-pregs. Also they cannot be profiled with simple machines and inserts cannot be used normally with these cores. Additionally, the sides of the honeycomb need to be reinforced to prevent the core from crushing. For many reasons, honeycomb cores were not an option for this project. Polymer foam is used by some manufacturers as a lightweight core material. The benefit of light weight is countered by the poor durability of foam cores. They lose their shape over time. A board with a foam core will relax more quickly than those with wood cores. Snowboard manufacturers have many options in the makeup of cores and many patents are held in these designs.

Sidewalls give a snowboard its strength along the edges. They can be omitted if the design utilizes a cap construction, which is discussed later in this paper. Strips of ABS or ultra-high molecular weight polyethylene (UHMWPE) are laminated to the edges of the core and profiled with the flex pattern along with the core material. ABS plastic is strong and hard, but can become brittle in extremely cold temperatures (Milenski, 2006). UHMWPE is resilient and flexible, but can make bonding quite challenging. Because of their resiliency, both make quite good sidewall materials.

Cores for hand layup usually end at the widest points of the board. The board curves upward at that point and would requires pre-bending of full-length cores. This process is difficult to achieve without specialized machinery. For cores that end before the tips, a plastic or fiber tip spacer is used to add durability to the tips of the board.

A steel edge rings the perimeter of each half of a splitboard. This tempered steel provides impact protection for the board as a well sharp edge to cut into snow or ice. Edges are 1.5mm square on cross section and have flat T-shaped teeth that protrude to one side. These teeth hold the edges into the composite. The edges are standard for snowboards and are treated for bonding and sized for different base material thicknesses.

Base material is made from UHMWPE and is treated for bonding. This material is low friction and can absorb wax. Snowboard bases can be extruded or sintered. Extruded bases are less expensive and slower than sintered bases but can be more durable and longer lasting. Some base material contains graphite to reduce the friction on the snow. Bass material can be dye sublimated to hold graphics, but this is a costly venture.

2.6 The Physics of Snowboarding

The forces applied on a splitboard are tremendous and varied. Depending on snow conditions and riding style, these forces vary greatly throughout the anatomy of a splitboard. As with normal snowboarding, the rider exerts forces at the bindings in many directions. These forces can be seen in Figure #**. The twisting, tilting, pushing and pulling motions work in concert to initiate and execute a turn (Williams, 2002).

As a snowboarder carves a turn, the snowboard rides along its edge. The ability to hold an edge, or maintain a smooth motion throughout the turn, is known as the stability of the board. Stability is important for a snowboarder because there is only one edge in use at a time, unlike

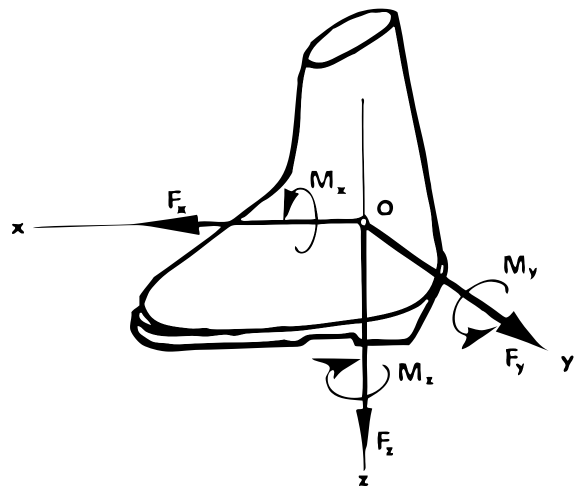


Figure 4. Loads transmitted by a snowboard binding, from (Bally, 1996)

the two edges employed in a turn on skis. The longitudinal stiffness and the torsional rigidity of the board determine its stability (Renshaw, 1989) during the turn. Longitudinal stiffness can be a product of the core materials, the thickness of the core or the makeup of the skins in the lamination. A stiff board will resist single point pressure along an edge. Similarly, torsional rigidity, or resistance to twisting flex, ensures that a snowboard does not twist so much as to allow the board to ride on one part of one edge, but rather distributes that pressure along the edge. Due to leverage along the flat plane of the board, torsional forces are greatest along the edges toward the tips. The physics of turning on a snowboard dictate that stability of the ride is determined by the flex pattern of the board.

Another intense force is applied on a snowboard when landing from the air. Depending on rider's center of gravity upon landing as well as the slope angle of the landing transition, the point of impact can be anywhere along the running length of the board. Ideally, the rider is centered on the board and the slope angle is steep enough that the snowboard hits the snow evenly and continues to decelerate upon further travel downhill. If balance is off during takeoff, however, the board can land at the nose or tail tip, exerting a huge force on that area.

Crushing forces are also a factor in the physics of snowboarding. If the snowboarder either comes up short, landing before the slope steepens, or lands flat, hitting the slope after the steep landing transition, the weight of the rider and the momentum of their fall tests the crush strength of the snowboard.

In addition to all the forces related to traditional snowboarding, splitboards also must stand up to the forces exerted during tour mode. Splitboarders typically swap the two sides of their snowboard when they ski, the right half of the board goes on the left foot and vice versa. This is done so that the outer edge of each ski is the straight edge of the snowboard for optimal edging while traversing or kick-stepping. Phenomenal pressure is applied to this straight edge when the skis are traversing icy slopes because it can be the single point of contact to the snow which the person has when taking a step with the downhill ski.

2.7 Sandwich Composite Structures

Glass reinforced plastics have advantageous properties over many conventional, natural materials. They are light, strong, predictable, resilient, flexible and resistant to denting and corrosion (Gaylord, 1974). While processes for glass reinforced plastics tend to be slow, they are gaining speed as newer machines, materials and techniques are developed.

Since the 1940s, the innovations in composite design have been countless. Progress in materials science have propelled composite design into many industries. For decades, composites have been used in boats, surfboards, skis, automobiles, buildings and airplanes. The aerospace industry has also seen major breakthroughs in composite design.

Sandwich composite structures are designed to optimize the thickness of the skins and core to create the strongest laminate possible. The sandwich theory is applied in dealing with core and skins. The skins and core correspond to the flanges and web of an I-beam (Lubin, 1975). Leaving aside for the moment the crushing forces applied during jumps, the core in a lamination could just be air separating the two skins. The main function of the core is to create a curved space between the layers of glass. This distance and the pattern of the profiling that creates this space determines the longitudinal stiffness of the board. The upper skin is in compression while the lower skin is in tension. In a splitboard, the crushing forces are great. Wood, foam or a honeycomb material acts as a filler for this space and provides structural support across the entire facing.

In a sandwich construction, the bond between layers must be strong. This bond gives the components of the laminate the physical reaction of a single unit under deflection, or bending. The bond also holds the part together under forces exerted from different directions on the composite. In addition, the bond must allow flexibility of the materials, without the possibility of their movement away from one another (Lubin, 1975).

As new materials and techniques are developed the field of composite design changes. However, these simple ideas remain the same.

2.8 Wet Hand Layup & Vacuum Bagging

Wet hand layup was chosen as a manufacturing method for this project for its accessibility, low cost and minimum space requirements. While more sophisticated techniques and materials could improve the weight savings of the splitboards, the processes involve tools, machines and other costs that were out of the scope of this project. Informaton about discovery and explanation of these methods are in the conclusions of the project. Wet hand layup and vacuum bagging provided the learning that was sought in this creative work.

Information about these hand layup and vacuum bagging came from many sources, most notably the “How to Build Snowboards” video series by Lindsay Rogers as well as the Graf Snowboards website. Wet hand layup is the process of laminating all of the components of a composite with epoxy or another resin. When building a snowboard, the order of materials to be laid in the mold is as follows: the base with edges already bent and attached, the damping material, the first skin, the core with sidewalls and inserts as well as tip spacers, the second skin and finally, the topsheet. Each layer is wet out with epoxy before the next layer is added.

Once layup is complete, pressure must be added to pull excess epoxy out of the composite and to press the board down onto the mold. A polyethylene film is then spread out over the board because it will not bond to the epoxy. A fibrous material called breather fabric sits above the plastic film to aid in even distribution of vacuum pressure. Vacuum film is laid down onto the mold and sealant tape seals the film to the mold. Valves in the film are attached to a vacuum pump and to a pressure gauge (Rogers, 2004). Once the seal is formed, the pump begins to pull a vacuum. Perfect vacuum at sea level is -30in. Hg. and any level beyond -24 is acceptible. To reach the best resin to glass ratio, the pressure must be optimized, the ambient tempurature must be warm and the entire lamination process must take no longer than one hour.

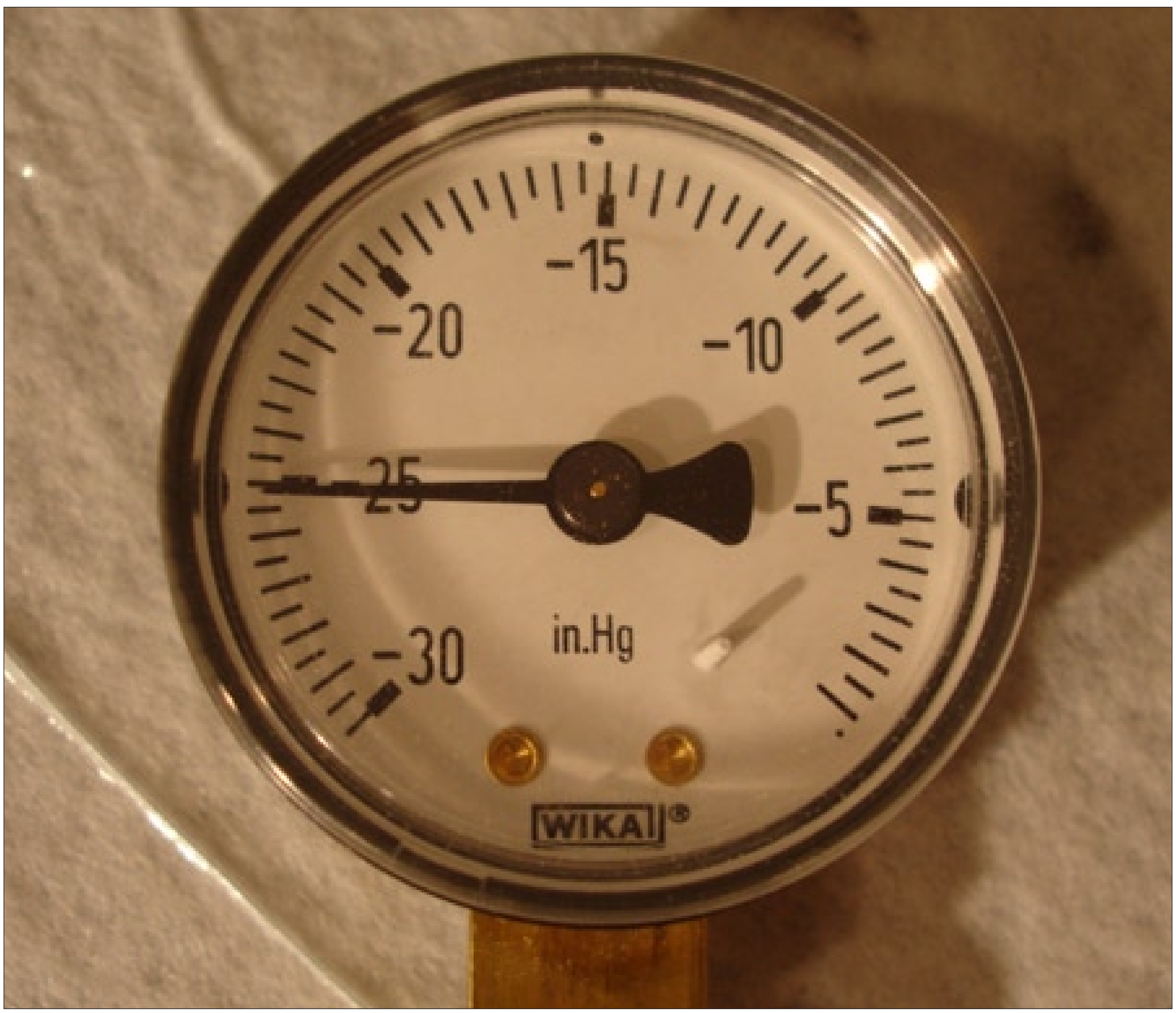
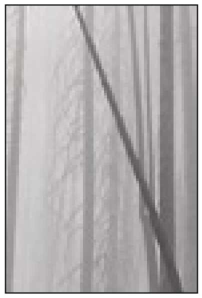


Figure 5. Vacuum pressure gauge.



3
Design and Production

3.1 Float I – Exploration

Float I, the initial prototype, was designed and built to gain knowledge about material properties, materials procurement, snoCAD, composite design, CNC routing, woodworking, hand layup and finishing. Information gleened from Roger's videos, the Graf website and several online forums paved the way for the first prototype.

Before the lamination could happen, some tools were built or acquired. A mold was built to govern the profiled shape of the snowboard. In this case, once the board was designed in snoCAD, the profile of the board was exported to Adobe Illustrator. This profile was extended to exist as the top of each rib for the mold. This rib profile was sent to a CNC router and the result was a set of identical ribs made of MDF. These ribs were aligned on an MDF board and spaced with blocks. An aluminum sheet was bent and drill-mounted onto the ribs to create the mold surface. The mold was designed with a sheet surface of 18 by 72 inches for the lamination of one half of the snowboard at a time. Due to gel time of about one hour, the epoxy is only good for hand layup for a relatively short amount of time for the complex layup of a splitboard. The finished mold was marked up for alignment and prepped with a wax release agent. Completion of the mold was the first step toward manufacture of a snowboard.

Next, a profiling tool was built to shape the cores. A pair of square steel tubing was drilled screw-mounted to a portable table surface. A second pair of drilled square steel tubing was attached by screws and t-nuts to the first pair and to the board. The screws allowed the top tubes to be raised and lowered by the fraction of an inch. Two aluminum square tubes were mounted to the surface of the table in the opposite direction to serve as clamps for the cores. A router jig was built out of T-shaped aluminum bars. This jig sat along the square steel bars so that the router could make horizontal passes across a core. As the jig was pushed up along the sloped bars, the router would be raised and the next pass would cut a higher part of the core profile. The cores, with sidewalls already tacked on with cyanoacrylate, were marked with profile specification indicators, fed onto the table and clamped for profiling. The profiling tool was rebuilt more than once with alterations until the cores could be accurately profiled.

The Float I board was comprised of both light and heavy weight materials. The core was 100% balsa. Triaxial woven E-glass was chosen for its directional weaving pattern and low 20 ounce weight. Biaxial +45°/-45° woven carbon fiber was difficult to find, but was perfect for torsional rigidity benefits at a very low nine ounce weight. The sidewalls on both the outer and inner edges were one half inch wide and the tip inserts were one eighth inch thick UHMWPE. The steel inserts for the touring brackets were six and a half millimeters tall. A sintered base was chosen for its speed on snow and a standard Polybutylene Terephthalate (PBT) thermoplastic polyester for its dimensional stability.

All of the materials were then cut to size and

Figure 6. Profiling tool.

Figure 7. Bending steel edges around base.

Figure 8. Graphics being laminated onto the underside of the topsheet.

otherwise prepped for bonding. The cores were sanded and the insert holes for the touring brackets were drilled with a hand drill and countersunk with a utility knife because a countersink bit chewed up the balsa on test pieces. UHMWPE is notorious for its poor bonding properties. Therefore, the plastic sidewalls and tip spacers had to be sanded and flame treated in preparation for bonding. Base material was routed by hand using a template cut on the CNC machine. A base was cut for each half of the board and the steel edges were annealed with flame and bent around the base material. This process was difficult and the edges did experience some deformation. The edges were then adhered to the base material with cyanoacrylate. Breather fabric, plastic film, glass and carbon fiber were cut to size. Rubber damping foil was cut to be placed over the edges to alleviate vibrations in the board. Graphics were printed with a laser printer on silver cardstock and then laminated onto the underside of the topsheets. The topsheets were taped to protect the surface from epoxy residue. Finally, all of the components were laminated into one half of the board at a time over a two day period.

When the parts were removed from the mold, the finishing process began. The flash was cut off of each board half with a jigsaw. The jigsaw blade could ride along the steel rail smoothly, leaving a relatively good finish. The sidewalls and tip spacers did not cut as well as the other components, though, so a hand planer was employed to cut the plastic walls. A flap wheel drill bit then cleaned epoxy along the rails for a clean finish. Epoxy had to be removed from the base by sanding. Hours were spent sanding epoxy with a sand block. Rogers discourages the use of a belt sander because uneven pressure can cause a deep scar in the base material, rendering the new snowboard useless. Therefore, hand sanding was the painstaking solution (Rogers, 2004).

After the sanding was complete, the hardware

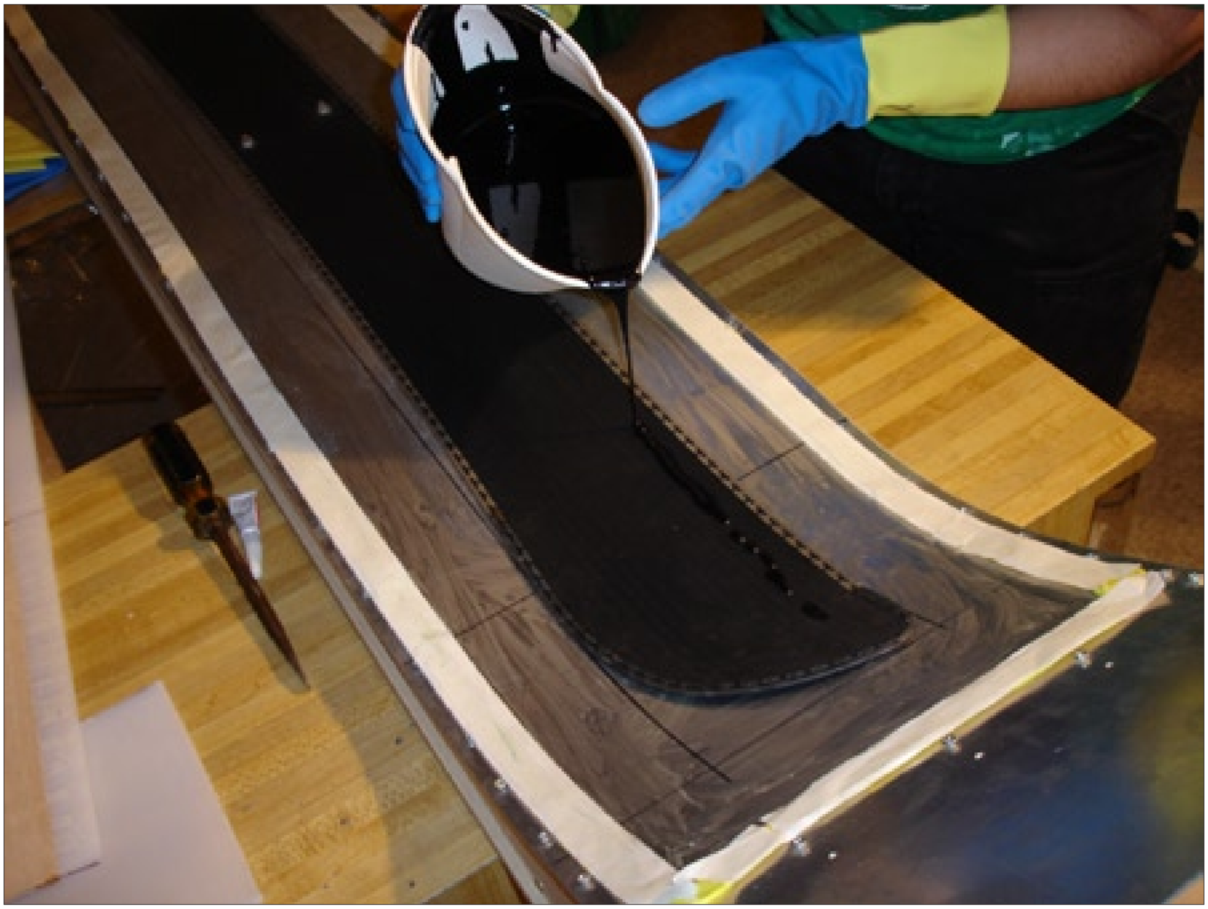


Figure 9. Lamination of the right half of the Float I board.

was installed. The steel inserts were located with a drawn template of the insert pattern. A small drill bit located the hole and plunged down through the wax in the insert. Then, a larger drill bit was used to clear the hole. Next a tap cleared the threads of the inserts and created a clean finish inside. Tip and tail clips as well as hooks, heel pads and pucks were screw-mounted. Finally the board was complete and the tape could be removed from the topsheets.

Lamination problems arose quickly. Bubbles had appeared beneath the clear topsheet. Small bubbles could be seen throughout the area of the board, but large holes had opened over the graphics. More epoxy was injected into these areas to seal the holes and keep water out of the core of the board. This remedy solved immediate problems, but the extent of the laminations problems ran deeper than the surface.

On the first trial run of the Float I board, the sidewalls delaminated from the rails next to the touring bracket. The UHMWPE hadn't bonded well enough. Delamination plagued this board from then on.

Figure 10. Float I board.

In addition to the lamination problems, the board profile was compromised by relaxation out of the mold. The camber lost half of its height and the nose and tail sunk some as well.

3.2 Splitboarder Interviews

The Float I board was ridden with four other commercially available splitboards, three Burton and one Voile, over one week at Rock Creek Canyon in California's High Sierra in the spring of 2005. The conditions were deep powder snow every day but one when the snow had turned to breakable crust over mashed potatoes.

During this week, observational data was collected and interviews were given to five split-boarders. The interviews included the following questions:

- Brand, Size, Year of Split Board
- Have you ridden this board before?
- If so can you approximate the number of days?
- Do you have any problems with your board?.
- What about with any part of your setup (boots, bindings, edges, length)?
- Does the board feel stable in variable conditions?
- In skin mode, does your board edge well on steep traverses?
- If you have difficulty regarding gear in the backcountry is it likely to be your board, your hardware (bindings, etc), your boots other gear or the load you are carrying?
- Do you carry a heavy pack on this board?
- Is the weight of your burden a concern in the backcountry?
- Could benefit from a lighter board?
- Which is the most satisfying aspect of riding this board:
  a. Carving
  b. Pointing it straight and riding fast
  c. Jumping off terrain features
  d. Tree riding
- Do you consider your board to be a good stiffness for you?
- Does it carve well?
- Does snow stick to your board in skin mode?
- Board mode?
- The base?
- If you could snap your fingers and change something about your board and related gear, what would it be?

In addition to the obvious dissatisfaction the Burton riders had with their interface systems, some valuable learning came from these observational interviews. All four participants indicated that they carry a heavy pack on this board, they are concerned about the weight of their burden in the backcountry and that they could benefit from a lighter board. They all agreed that snow sticking to the board is problematic. Also similar among the splitboarders was that three of them felt that their board was not appropriate for their size or riding style.

Although it toured very well, holding its edges on steep, icy terrain, the Float's ride was notably insufficient. Turning the board on hardpack could be done smoothly and with ease. However, in deep snow, whether light or thick, the board was very difficult to turn. The nose of the board dove very often as well. These conclusions and the comparisons to the other riders fed the next round of discovery.

3.3 Test Laminations

Four laminations were created in order to explore: cap construction, laminating without a topsheet, laminating a combination of hardwood, utilizing thinner sidewalls, graphics applications and steel insert sizes. The prototype testing yielded significant results. The findings are broken down in Figure 11. Graphics were used for both identification and testing purposes.

Wood

Basswood on edges of cap construction added average of 2.6% weight over Balsa. The added strength of basswood at the edges is worth the weight. The edges over the caps take on a huge amount of pressure from the force of the rider carving on an edge. Extra strength in this area is valid weight expenditure. The basswood samples looked smoother at the caps.

Cap Construction

Seems to have worked very well. The cap is well bonded and aligned perfectly with rail. The 45 degree angle causes epoxy to well over rail and this looks like a real strength for this type of construction.

Surface

Topsheets added an average of 6% to the weight of the prototypes. The topsheet doesn't provide anything worthwhile to the board for all its weight other than UV protection for the epoxy. Graphite powder was added to diminish the degradation of the epoxy in UV light. The Fish and Hummingbird samples with no topsheet and with a graphite additive have an amazing smooth matte finish. The samples with topsheets look smoother, but they feel like they have more fric-

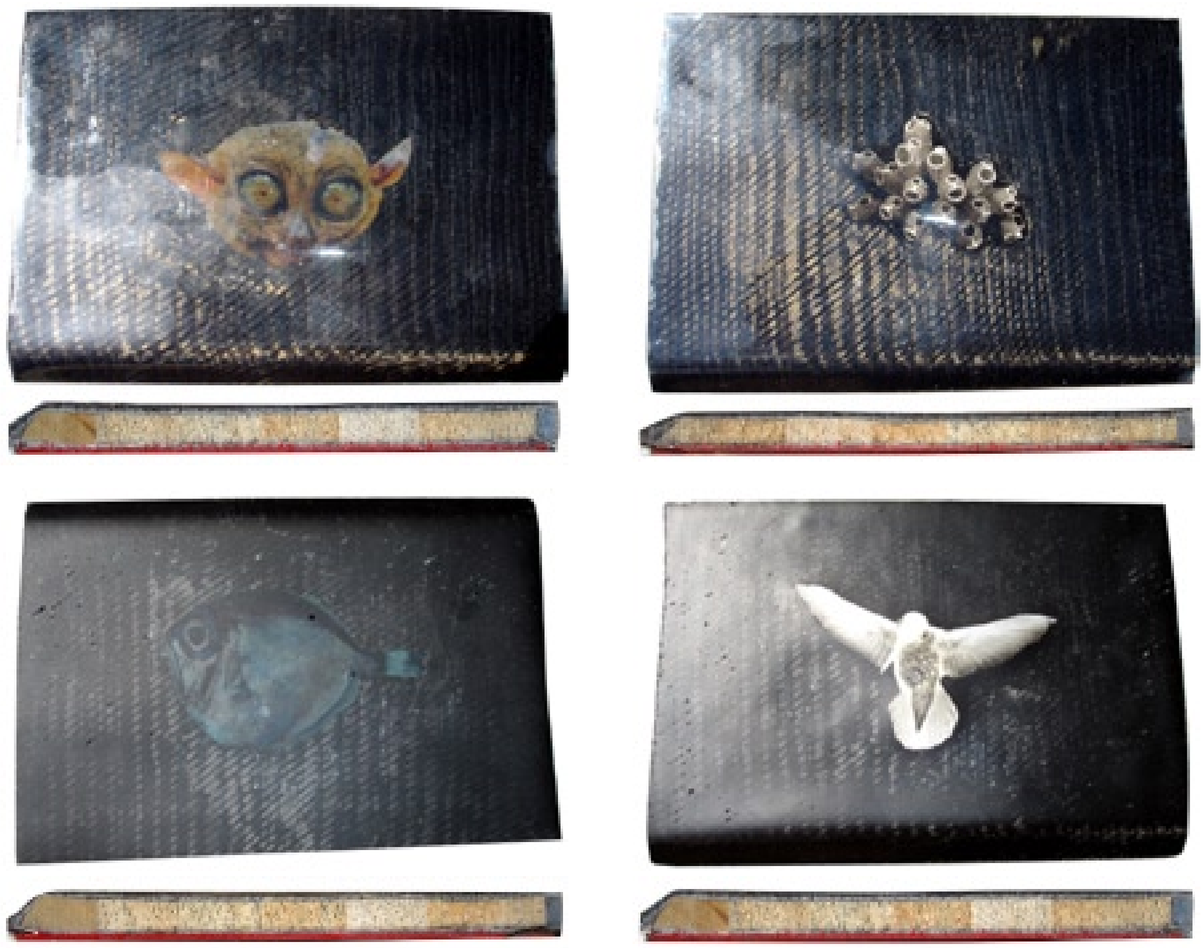


Figure 11. Test laminations (clockwise, from top left): Lemur, Coral, Fish and Hummingbird.

tion. The graphite finish feels fast. The flat black surface also absorbs more heat than the smooth topsheet finish. This would be better at melting snow. Bubbles were still present on the surface of the epoxy, under the topsheet and on the surface of samples without topsheets. Research on this problem reveals that air often gets trapped between layers even when they appear to be wet out well. The air bubbles surface during curing. A bristle roller brush may be able to alleviate this. If the bubbles could not be eliminated with the bristle roller, then topsheets would be necessary. Otherwise, omission of the topsheet would be a huge weight savings.

Sidewalls

The sidewalls came out to between 2mm and 5mm across all samples. This was fine, but less than 2mm could cause problems. For example, if alignment was slightly off, the core could be exposed. In the final board, the sidewalls will end with the core at 1/8” thick and fiberglass will

#1 Lemur	#2 Fish	#3 Coral	#4 Hummingbird
			
Balsa, Topsheet	Balsa, No Topsheet	Bass, Topsheet	Bass, No Topsheet
205.6g	192.7g	210.4g	198.4g
Lemur 6.3% heavier than Fish		Coral 5.7% heavier than Hummingbird	

Figure 12 Test lamination results.

take the place of the tip spacers from the Float I board. Weight reduction with thin sidewalls will be huge. Sidewalls didn't tip as much under pressure as big sidewalls did in Float I board. The thinner sidewalls didn't strain on the bond with the core as much as the thicker sidewalls had. Base material scraps could be placed next to rail to ensure prevention of this problem.

.3 vs. 0.015 HDPE

The thinner HDPE film was much easier to work with. It didn't bend up as much while working with graphics or laying in the mold. Weights were used with the thick film in the layup process and that could spell trouble on the real board. Also, the vacuum pressure pulled more epoxy out of the sample with the thinner film. A lower resin to reinforcement ratio is ideal and a great reason to use the thin HDPE.

Graphics

Bubbles appeared above the Hummingbird and Lemur graphics, one cardstock and one paper. Therefore, the bubbles weren't caused by thickness of graphics. The paper became quite transparent with the black epoxy showing through the graphic. The silver cardstock looks great both under a topsheet and with no topsheet.

Inserts

There is no visible difference between the 7mm and 6.5mm inserts. The longer the better for inserts because more core and reinforcement material is in contact with the insert making for a stronger connection to the binding.

3.4 Float II – Implementation

The Float II board was designed taking into consideration the results of the Float I board testing as well as the findings of the lamination prototypes. The board was a 153 with a balsa and basswood core, 1/8 inch thick sidewalls, a thinner epoxy called Aeropoxy, no topsheet and graphite powder.

The board incorporated an inner sidewall and an outer cap construction which existed entirely in the basswood zone. This was an innovation in splitboard design. The UHMWPE tip spacers were eliminated and replaced with an extra layer of carbon fiber in the tips. The topsheet was not used in this board initially. The hardware would still be screw mounted onto the board.

The Float II board was a far superior board to its predecessor in both form and function. The basswood along the outer edges allowed for a smooth cap construction which solved the turning problem. The thinner sidewalls bonded well and no delamination occurred. Although a bristle roller was utilized during lamination, bubbles still emerged in the epoxy finish. A topsheet was subsequently added to the board at a later time. The board weighed 8.9% less than the Voile 153.

3.5 User Experience

Two snowboarders were observed comparing

Figure 13 Float II board during testing, Rose Knob Peak, Tahoe National Forest.

the Float II with the Voile Split Decision boards over a one week period in the Wallowa Range in Eastern Oregon in February, 2006. According to these riders, these two boards were comparable in both tour and ride mode. Findings indicated some true success in the design of the Float II board.

Subjects were asked to rate both boards in ride mode for torsional rigidity, flex, carve, float, chatter resistance, maneuverability onto toe, maneuverability onto heel and stability at high speed. In tour mode, they rated edge control, nose float, stamina and kick turns. The stiffness, stability and chatter resistance of the Float II board rated lower than the Voile. The boards rated similarly on torsional rigidity, edge control and kick turns. The Float II was rated higher than the Voile on float in both modes. Results of the questionnaire spoke to possibilities for design changes in the next round of design chnages.

3.6 Splitboarder Survey

A survey was conducted on a splitboarding community website called splitboard.com. The site is run by Chris Gallardo, an accomplished snowboarder based at Lake Tahoe, California. Seven hundred eight-three members as well as countless unregistered users are a part of the splitboard.com community. The forum on the website is voluminous with nearly 14,000 articles posted as of April, 2006. The aim of the ten question survey was to learn about the experiences and preferences of a larger splitboard audience and gain insights into the audience as a whole.

As an incentive for survey participants to respond quickly and thoroughly, a splitboard.com sticker was developed and designed with Gallardo. The sticker was the first identity piece for splitboard.com other than its logo.

Figure 14. Incentive sticker designed for splitboard.com

The design was approved and stickers were paid for, in part, by the site owner. Two stickers were mailed to each of the fifty respondants. Gallardo also created t-shirts of the design for sale on the website and sought additional design work which was completed that month. For all of this design work, Gallardo provided discounts on other materials for the project.

The survey consisted of the following questions:

1. How many years have you been snowboarding?
2. Approximate the number of tours you have completed on a splitboard. a. 1-5 b. 6-20 c. 21+
3. Please list the brand, model, year and length of your splitboard.
4. Rate the appropriate stiffness of a splitboard for backcountry riding on a scale of 1-5, 1 being the most flexible and 5 being the most stiff.
5. Is lightweight gear important to you? Yes or No.
6. List the order of importance of the following characteristics when you consider a splitboard: brand, camber, core material, graphics, reinforcement materials (glass/carbon), stiffness, tip shapes, weight.
7. Is stability at high speeds more important than agility in turns in backcountry snowboarding? Yes or No.
8. Do you move your stance more than one insert forward or back? Often, Sometimes or Never.
9. Is the ability to move your stance more than one insert forward or back important to you? Yes or No.
10. How many tours out of every 10 you take, do you ride on non-breakable crust or hardpack?

The survey yielded impressive data from fifty conclusive sets. Most notably, all but two respondents agreed that lightweight gear is important to them. Twenty people rated weight in the top three most important characteristics *and* claimed that they never move their stance. More than half of the subjects noted that it is not important to be able to move their stance. This opened the possibility of custom insert patterns for weight reduction.

Twenty-three people listed stiffness as their number one priority and the average preferred stiffness was 3.6 (out of five), with twenty-seven people listing four as their ideal stiffness. Nearly even were the answers about which was more important; stability at high speeds or agility in turns.

3.7 Stiffness / Camber Tests

Because the stiffness of a splitboard is a priority among advanced riders, further research was conducted into the mechanics of board stiffness. According to snowboard dynamics engineer, Keith W. Buffinton, high quality snowboards for advanced riders are considered to be stiffer than medium quality boards for beginners. In his study, “Laboratory, Computational and Field studies of Snowboard Dynamics,” he offers quantitative and qualitative correlations between the “soft” and “stiff” characterizations given by manufacturers and snowboarders. Buffinton calculated the effective stiffness of eight snowboards using simple beam theory. By clamping the boards at their widest point at the nose or tail and hanging weights from the board, he was able to measure the deflection of the center of the widest point at the opposite end of the board.

The following formula can be utilized to determine the uniform cantilever beam stiffness of a structure:

$$EI=PL^3/3y$$

Here, P is the applied load, L is the distance from the support to the load application point and y is the deflection at the load point (Buffinton, 2003). A similar test was performed on the Voile and Float II boards. The boards were clamped across their widest points under a narrow board and the height of the tail width was noted. A half pound weight was applied to the boards 110 centimeters from the clamps. The deflection at the tail width was noted. The deflection on the Voile was approximately 7.3 centimeters. The Float registered 16.51 centimeters of deflection. A comparison of this deflection illlustrated that the Voile's stiffness was significantly greater than that of the Float II board.

In addition, camber measurements were made of the Voile and Float II boards. The Float II board's camber was compared to the camber designed into the mold. This disparity was considered in subsequent designs. At the rear of the touring brackets, the Voile 153 had a 17mm camber. The Float II had a 6mm camber although the snoCAD file had a 10mm camber. Four milimeters were lost to relaxation.

3.8 Interview with Composites Expert

A contextual telephone interview was conducted with composites expert Barrett Milenski, who is the composites consultant and designer for Scotty Bob Skis as well as a composites engineer for ATK, an advanced weapons and space systems company. While many of his suggestions revolved around equipment and techniques that were outside the scope or budget of this project, he did provide insight into basic composites mechanics. Milenski supported the direction of making lighter splitboards. As a splitboarder, he knew first hand the importance of lightweight gear for backcountry travel. He reinforced much of the thinking behind this work and provided ideas that informed the next round of design.

His most valuable point was that the longitudinal stiffness of the board, and therefore much of its strength, is a product of the thickness of the core rather than the intricacies of the skins. It was his view that snowboard manufacturers concentrate so much on the latest fiber technology, forgetting that simple I-Beam physics provides some of the strongest composites. According to this expert, a core up to 3/8 inch thick, sandwiched between two layers of fiberglass could create a strong, stiff light board. This thinking was adopted by a later prototype.

He also explained that designers often make the mistake of adding regional stiffness to the board by utilizing small pieces of glass or carbon fiber in key locations on the board. Fiberglass and carbon fiber are strong along the length of their fibers. If the fibers are broken, the strength is greatly compromised. While small pieces of glass may reinforce an area, they will not add to the stiffness of the board.

Milenski is a wealth of knowledge in materials. He favors of the use of balsa for the core material, especially when laminated with stringers of harder wood. He suggested hua birch, which was researched and found only in China. Milenski believed that the UHMWPE sidewalls chosen for these boards was a far better option than ABS for its flexibility and durability. He supported the choices in skins for this project and shared the understanding that carbon fiber on top of the core provides greater compressive strength while carbon below the core increases the tensile strength of the board. This information on materials was invaluable to the understanding of composite design.

Further, Milenski explained the advantages in lightweight design possible with advanced equipment. The use of a heated press allows for pre-preg skins. These resin rich reinforcement layers provide a 60:40 glass to resin ratio, greatly optimizing the strength to weight of the composite. Additionally, adhesive film can be used over porous wood like balsa to diminish the epoxy penetration into the core. Fibers that have been previously cured under tension provide excellent longitudinal stiffness and longevity of the camber of the board. These materials, however, must be used in a heated press. Although these materials and techniques could not be utilized in this creative work, the information will likely become valuable on future projects.

3.9 Float III – Culmination of Learning

Based on analyses from literature, observation, interviews, design and manufacture of prototypes as well as survey data, three different splitboards were designed. While the Float II board rode quite well, it was determined that several characteristics could be improved to answer the needs of the typical backcountry user. The next round of prototypes saw increased longitudinal stiffness. In addition, steel inserts were added to the lamination so that binding pucks could be screw-mounted rather than drill-mounted. This

Figure 15. Some of the inserts are glued to the base.

allowed both goofy and regular riders to use the new boards. A custom insert pattern was also be designed to accommodate moving the stance forward or back one insert. This pattern also allowed for a deeply angled stance.

For consistency, one shape design provided the layout of the last round of boards. All three boards had an increased nose width and height. Shorter, narrower tails where designed to optimize the float and the sidecut radius was increased. These Float III board designs had twice the camber as the earlier prototypes to add pop to turning as well as to account for relaxation out of the mold. These constant design elements provided controls for the stiffness comparisons in the Float III boards.

With the Float III boards, three approaches to optimizing stiffness were tested. One board retained the composite design elements from the Float II board with the addition of a two inch carbon fiber tape along the length of each half of the board. This board was called the "Tallac." The new specifications and insert pattern were applied to the same materials and lamination structure as the previous prototype.

Another prototype, the "Wallowa," incorporated 1/8 inch spruce stringers throughout the length of the core. Three stringers were laminated into the core, alternating with the softer wood. Basswood strips still remained on the

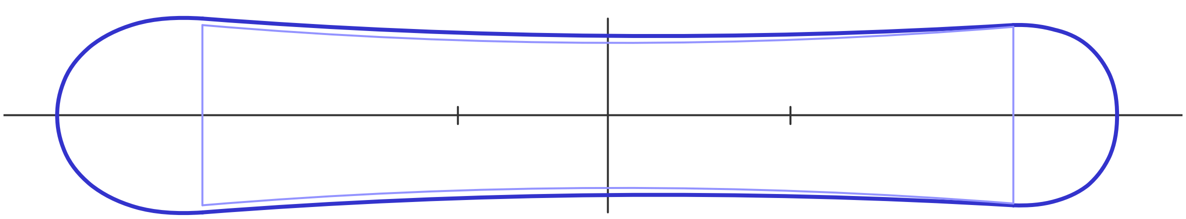


Figure 16. Float III shape.

Figure 17. A foam cutter running along MDF jigs.

angled caps.

Third, a 3/8 inch core was designed for the "Rock Creek" board. This design required longer inserts and thicker sidewall materials which had to be sourced separately from other previously tested materials. This board was created with only one layer of glass above and below the core material. The three boards were built to test the differences in stiffness and camber.

Several new tools and techniques were employed in the manufacture of the Float III boards. A new mold was built to accommodate the width of an entire splitboard, rather than only one half at a time. Because space was a constraint, the design of this mold was developed to allow for ease of mobility and storage. Once MDF jigs were shaped with the CNC router, the mold ribs were cut with a hot wire through Styrofoam and laminated with white glue. Snowboard base material was used as the surface of the mold because it was already prepped for bonding. The surface had a seam which was sealed with epoxy and plastic tape. The mold was well formed with a full surface of ribbing unlike the previous mold with spacers between the MDF ribs.

However, problems arose. The foam mold had problems in bonding and in strength. First the foam soaked in epoxy when the surface was laid on. This problem was obvious along the seam and the edges of the mold. Air pockets formed and the bond around them was weak. At any air pocket the material could be peeled up. A syringe was employed to wet out the pockets with epoxy and further bonding happened on two occasions.

Once the surface was bonded, a dry test was run. Strips of balsa were placed on the mold and breather fabric was laid over them. Rather than expensive vacuum film and sealant tape, polyethylene sheet and duct tape served as the vacuum

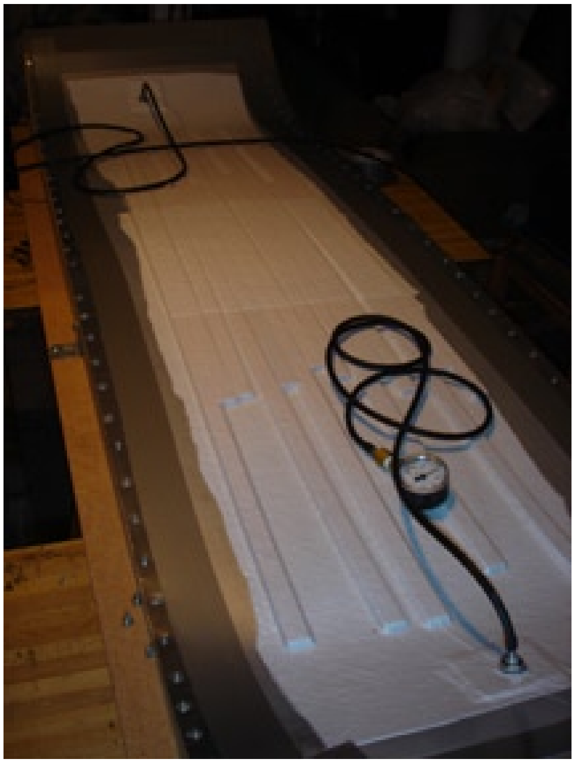


Figure 18. Dry test on the new mold.

bag for the test. The pressure climbed steadily for a minute and then the surface began to separate from the ribs. The test was disassembled and the seam was sealed further with duct tape. During a second test, small leaks appeared after four minutes and the pressure dropped slowly, but steadily.

A envelope bagging test was conducted in which a tube of plastic encircled the mold entirely. As pressure rose inside the envelope, the foam of the mold began to deform. The surface of the mold took on a lateral curve. The ribs of the mold began to separate at the top as well. Clearly, this mold had failed.

The solution was a return to an aluminum surface. The same aluminum was not available from known local sources, so the 0.032 inch thick 6061 material was replaced with 0.025 inch thick 5052. The MDF ribs were secured with brackets onto a board with the foam mold in between. By securing the metal sheet along the edges of the ribs, the surface could sit on the plastic surface beneath. This mold was tested with polyethylene sheet and duct tape over wood and breather fabric. The pump pulled 24Hz and the new mold was a success.

Each half of a board core was laminated onto the center sidewall. This way, the entire board

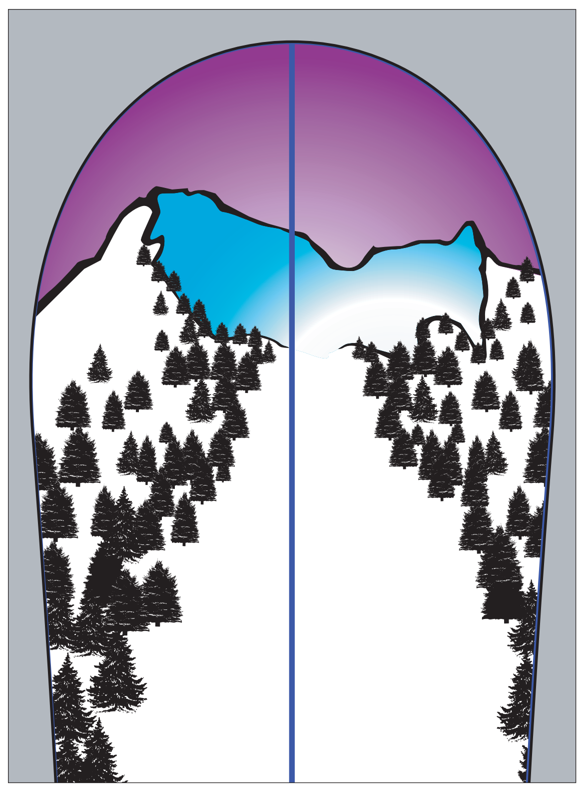


Figure 19. "Tallac" graphics.

core would be profiled and laminated as one piece. A drill press was utilized for the insert pattern. Precision was increased greatly over the hand drill process from previous rounds. Base material was taped prior to lamination to save time in finishing. Previously, most of the time in finishing was spent sanding epoxy from the base. The tape proved quite difficult to remove. It was faster, however than the sanding.

Graphics were designed to exemplify the essence of splitboarding; the journey into the wilderness where the society does not matter. Each board exhibits one of three backcountry destinations where the Float boards had been tested; Mount Tallac at Lake Tahoe, Rock Creek Canyon in the High Sierra and the Wallowa in Eastern Oregon. The graphics also elude to the allegory between the city and the mountains, with skyscrapers and port cranes toward the tail.

Dye sublimation printing onto prepped PBT material is a specialized process and not one that is easily sourced. With dye sub machines broken at two vendors, the possibility of attaining high quality graphics for the Float III boards was slim. However, Greg Pronko, founder of Glis-

Figure 20. Testing in Rock Creek Canyon, High Sierra.

Figure 21. Testing in the Wallowa Range, Eastern Oregon.

sade Snowboards of San Francisco, provided dye sub printing, a service that his company does not normally provide.

3.11 Weight and Camber Comparison

Results were surprising in the last round of prototyping with a wide range of weights. The Rock Creek board championed a weight savings of 11.6% over the Voile and was 2.9% lighter than the Float II board. The weight savings of the Tallac and Wallowa boards were quite a bit smaller at 2.2% and 1.9% respectively. The The Rock Creek design with a thicker core and fewer reinforcement layers was by far the leader in lightweight design.

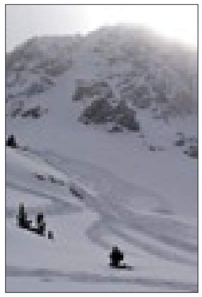
Board	Weight	Savings
Voile	3466g	--
Float II	3156.6	8.9%
Rock Creek	3066.1	11.6%
Tallac	3389.9	2.2%
Wallowa	3402.7	1.9%

An observation during lamination spoke to this potential. The layup was completed in less than 45 minutes and almost 250mL of epoxy remained unused. This was an obvious improvement in the glass:resin ratio in this layp.

This Rock Creek board also tested at a higher stiffness than the Voile and its camber was 15mm. The camber of Tallac equalled the Voile at 17mm and the Wallowa had 15mm as well.

The initial weight analysis was completed although the boards would lose a bit more weight in base grinding, to be done professionally. However, it was clear from these findings that the Rock Creek design exhibited the best relationship between lightweight materials and a design for stiffness. The savings in resin and reinforcement weight more than make up for the additional sidewall material. This may not be the case with traditional double sidewall construction, rather than the outer cap design implemented here.

Figure 22. Rock Creek board.



4
Analysis of Insights

4.1 Design Research

Meandering through the exploration of the field of splitboarding, this project employed a successful design methodology. While some challenges put the project off schedule at times, the awareness and application of a set of steps provided a path for solutions.

The qualitative and quantitative data collection for this project was guided by techniques exemplified by the graduate program in the Department of Design and Industry. Emphasis on conclusive observational and survey data was a recommendation that strengthened the conclusions that could drawn. These answers provided thought for subsequent designs. Expert interviews further solidified the research. The design research methodology developed for this creative work was the foundation for successful problem identification, data collection, ideation and implementation.

The design research process included intense testing of several prototypes. It was this iterative, problem-solving process that accounted for the high quality of the final outcome. Many tests were conducted on prototype samples as well as on full-sized prototypes. While these procedures were time-consuming and at times disappointing, their value is obvious when comparing the first and fifth completed splitboards. The difference is clear.

4.2 Materials Procurement

The difficulty of materials procurement was a sticking point for this project. Many of the materials for snowboard manufacture are used in composite construction in the aircraft, space and nautical industries. Because of the current military build-up, a carbon fiber shortage is in full swing. Additionally, suppliers for some materials such as steel edges and base material only exist

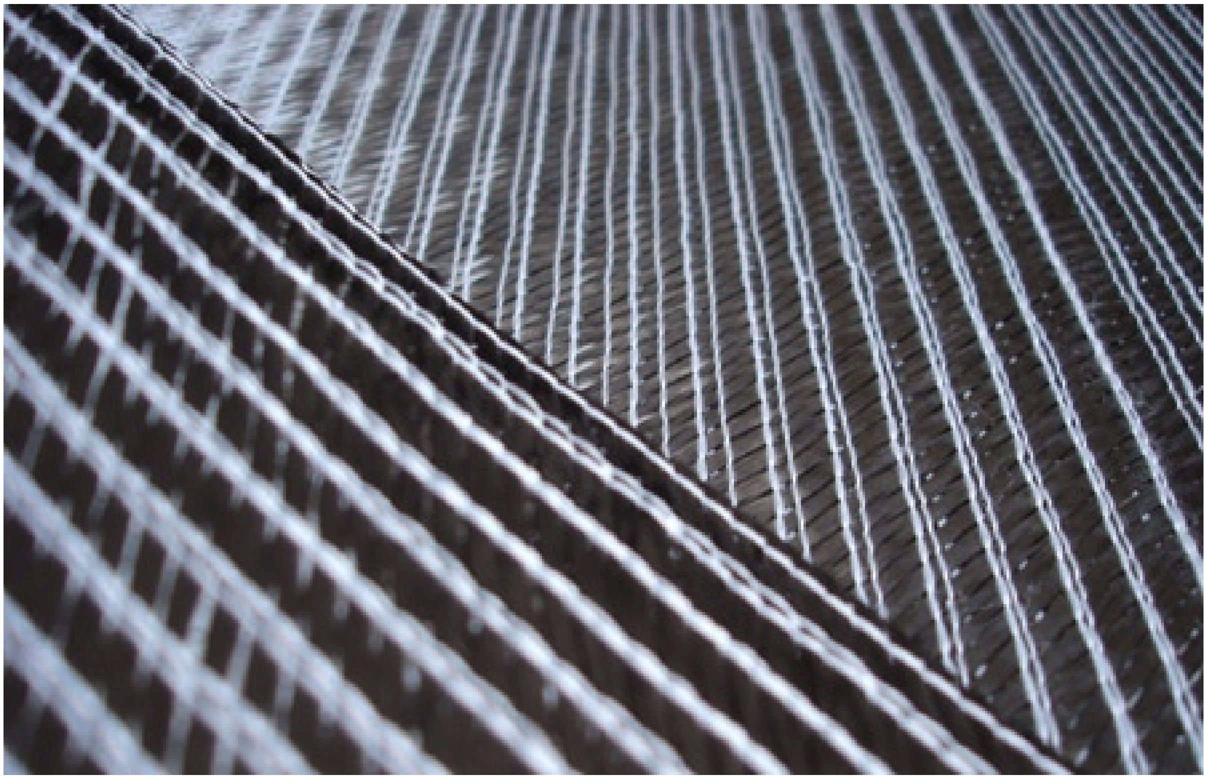


Figure 23. Biaxial woven carbon fiber, (+45 / -45).

outside of the United States. For these reasons, future projects of this nature would require early and well-planned procurement. As the design solutions (and therefore the materials chosen) resulted from information gleened throughout the rest of the process, materials could not be ordered as early as would have been ideal.

Materials procurement was also made difficult by the small quantities required by this project. Suppliers accustomed to dealing with aircraft manufacturers are not eager to sell three yards of carbon fiber to a student. Similarly, orders for small quantities would often take a surprisingly long time to arrive.

4.3 Graphic Design

Inspiration for the topsheet graphics were not in short supply. Throughout the research and development process, many days and nights were spent in snowy locations throughout the mountains of California as well as Eastern Oregon. The imagery and ideas were rich and plentiful.

Some difficulty arose in the layout design with regard to the composition. The graphics on a splitboard pose quite a challenge to a graphic designer because the graphics are seen from five different points of view. When touring, the rider sees the graphics from the touring brackets forward, looking longitudinally at the board. In ride mode, a goofy rider stands with the right foot forward, sideways on the board. A regular rider is just the opposite, looking at the board from the other perspective. Either rider sometimes switches feet and and rides with their opposite foot forward, now seeing the tail of the board in front of them. Another design driver was the hardware placement necessary on a splitboard. It was imperitive to design graphics that could speak to each of these five points of view in a sensible way.

The design direction spanning a landscape from the city to the mountains was chosen for its appropriateness to the subject matter and for its appeal to backcountry enthusiasts. The horizontal layout design only considered the ride mode of a goofy rider. It then became apparent why many commercially available splitboards have simple graphics. The challenge was great.

The final solution spoke to all five perspectives. The nose and tail graphics were composed to be viewed from the center of the board. The sky reaches out toward both tips. A sweeping curve connected the tips across the middle of the board and provided visual equality for both goofy and regular riders.

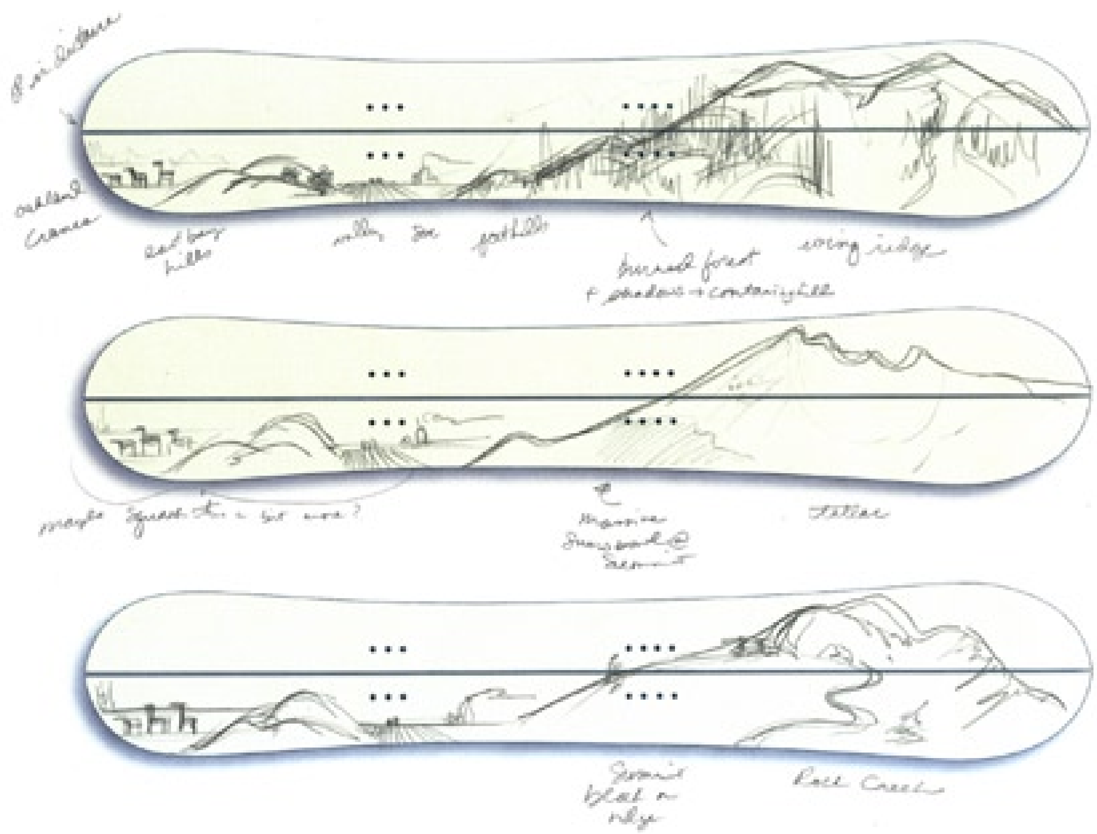


Figure 24. Early sketches for Float III boards.

4.4 Manufacturing

The exploration of splitboard design provided a wealth of learning about user needs, shape design and composite structures. These insights and their application into the design were discussed throughout this paper. Additionally, the knowledge that was gained about materials preparation and the manufacture of composite structures, and specifically splitboards, was voluminous. Observations of these processes were recorded throughout the project and are analyzed here.

The intricacies of core lamination and profiling were imperative for high quality splitboards. Strength could have be added to core laminations by using more strips of wood. However, this would have added weight in the presence of more glue. Depending on the nose width, seven or eight strips of balsa or basswood were laminated together for each half of a board. Two pieces of basswood on the curved edge of board allowed the entire cap to sit in hard wood. The offset of laminated wood was the same across both cores. This required considerable planning.

Figure 25. Balsa and basswood, bound to prevent warping.

Sidewalls, while entirely different material than the core, were thought of as part of the core. They were bonded during core lamination and were shaped along with the core. UHMWPE sidewalls must be treated for bonding. Bleaching or other chemical etching methods are possible. Sanding and flame treatment worked well as long as the flame was applied just before layup. The flame should not melt down the fuzzy character of the sanded sidewall as these grooves are important for better bonding.

Core shaping is an art. Large snowboard manufacturers machine shape their cores for precision tapers. To achieve the best results in core shaping, center lines were marked on each core for consistency. Extra balsa strips were placed next to the core on the profiling table in order to test routing depths prior to cutting each. Both halves of the cores were profiled at one time to achieve even shape across the width of the board. On profiling table, the router was zeroed out before the slope angles were set. Next, the router bit was set on the ¼ inch mark first and the bars were lowered on that side until the bit hit the wood. Then the smaller end depths were set. The taper was carried out further than the end of the core to accommodate the base of the router for trimming the ends off of the cores. A print of a digital template was created to align the insert pattern on the cores. These techniques, gained from research and experience improved the process and the core product.

Base material routed more smoothly with the smooth (bottom) side facing up. However, taping the bottom side of the base material saved hours in finishing time. While the tape added a gum residue when routed, this was be easily trimmed before the rails were tacked on. Many sources suggested annealing the steel edges before bending them. This caused deformation of the edges and was unacceptable. The initial board design

Figure 26. Vernier calipers and profiling tool.

had curved tips on each ski and edges were annealed and bent around the curves. The tight curves were difficult achieve in hand-bent steel. Therefore an extra MDF template was CNC routed and utilized as a jig for bending edges. With this shape to bend against, smooth curves could be achieved. Plastic tape on the tacking template prevented the cyanoacrylate from bonding the edges and bases to the template. Violent separation of the edges from the base material occurred when pressing the bases onto the mold for layup. In once instance, the epoxy had been mixed and the problem had to be remedied quickly. This situation was avoided on subsequent bases by bending the edges at the tips before tacking them to the base material.

Materials preparation was a key step in the success of the subsequent boards. Fiberglass was cut last after all other materials were cut. This minimized the contact with tiny irritant fibers on hands as well as on other materials. Reinforcements had to be cut wider for boards with cap construction as the angled cap required more material. Every piece of material for the laminations had to be cut with precision prior to lamination. The valves were installed onto the vacuum film before laminating as well. Only pin prick holes were made in the vacuum film as even the slightest tear in this material could impede the vacuum pressure. The mold was marked up with indicators to aid in alignment during lamination. Inserts were affixed to the base material with a gel cyanoacrylate for exact placement. Alignment became difficult during lamination. Mate-

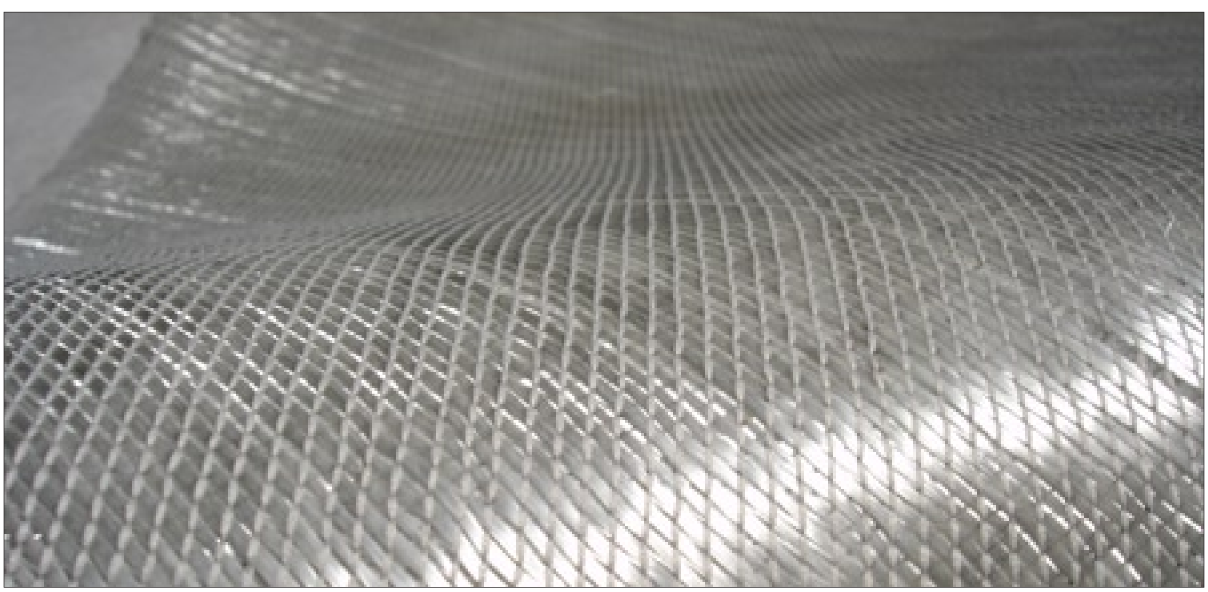


Figure 27. Triaxial woven fiberglass.

rials had to be cut and assembled precisely to sit perfectly in the composite. Bases were cut two millimeters smaller than final board on each side to accommodate the rail. Sidewalls were aligned three millimeters from final board edge and one millimeter from base material edge. Meticulously prepared materials were vital for lamination.

The lamination processes throughout the project offered insights into challenges as well as solutions. Epoxy can be a difficult material to use. Aeropoxy worked well as the resin because of its thin, fluid nature. It wetted out the glass better than other epoxies. Epoxy should never come into contact with skin, vacuum valves, or dry materials at all. The hour-long gel time was shortened dramatically with the addition of graphite powder on one full-size prototype. Graphite powder caused an exothermic reaction that generated an impressive increase in heat. The temperature got hot enough to melt containers and mixing tools. Graphite powder should be added as late in the process as possible. The composite lamination process demands attention to detail. The knowledge gained through the repeated experience and implementation of new techniques throughout this creative work provided a deep understanding of one of today's most exciting manufacturing processes.

Figure 28. Materials preparation.

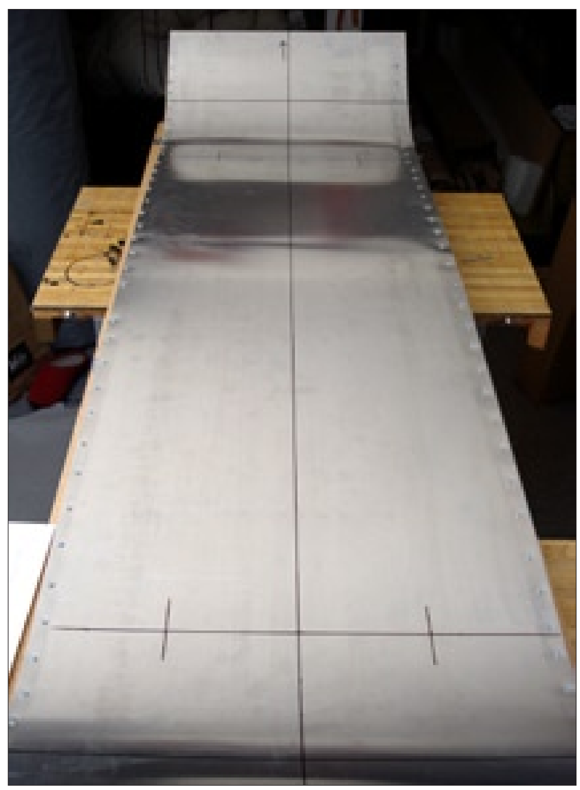
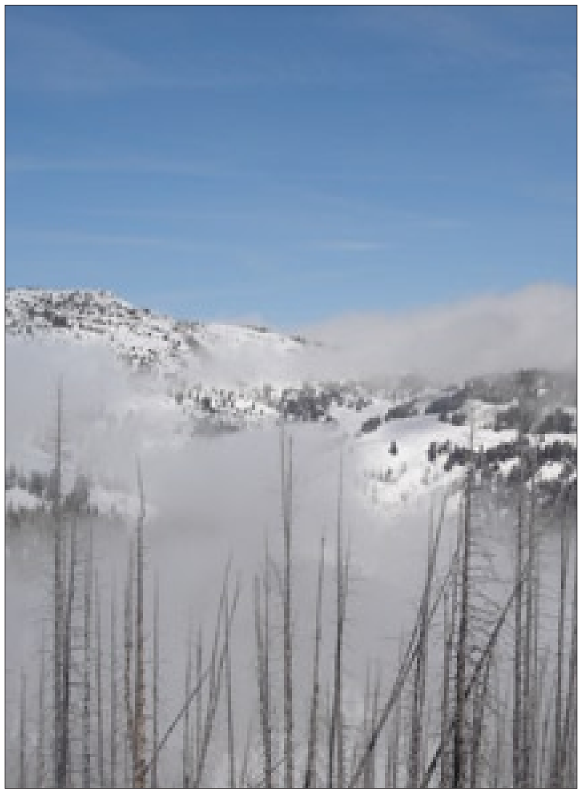


Figure 29. Mold mark-up.



5
Creative Work in Pictures

Figure 30. Float I board in testing.

Figure 32. Float I board, Rock Creek Canyon.

Figure 31. Float I board, Rock Creek Canyon.

Figure 33. Float I board, with hard boots.

Figure 34. Float II board in testing, Tahoe National Forest.

Figure 35. Float II board in testing, Wallowa Range.

Figure 36. Rock Creek board, thick core cap construction.

Figure 37. Touring brackets.

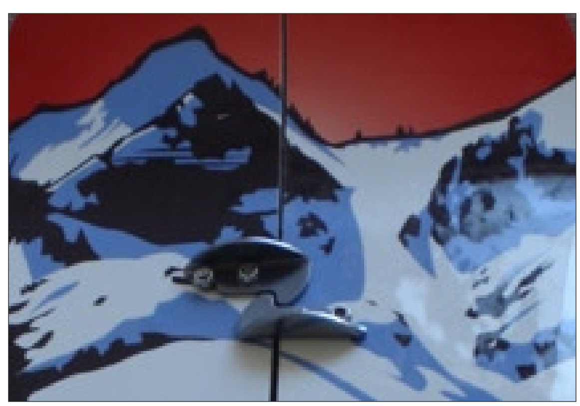


Figure 38. Rock Creek graphics and split hooks.

Figure 39. Tallac splitbaord.

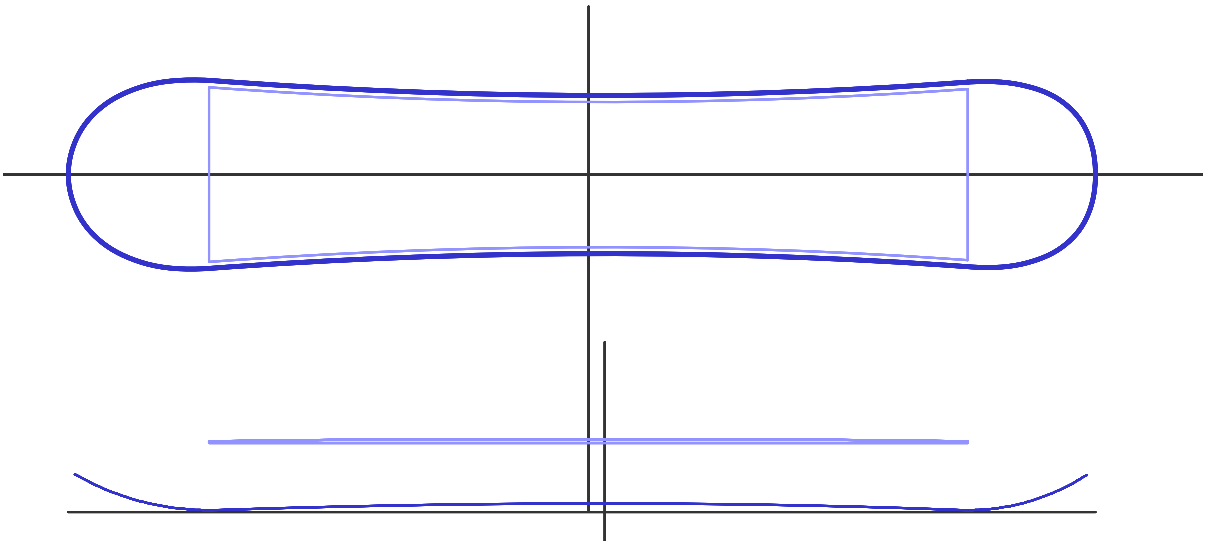
Figure 40. Tallac logo and board title.

Figure 41. Tallac cityscape.


Figure 42. Wallowa cityscape, close-up.


Figure 43. Wallowa, burnt forest landscape.


Figure 44. Tapping inserts on Wallowa board.



board length	1530	running length	1130	nose tip radius	400	nose 3D length	200
nose width	280	sidecut radius	7700	tail tip radius	325	nose 3D width	250
se length	210	sidecut bias	6	nose height	54	tail 3D length	200
tail length	190	waist width	235.986	tail height	54	tail 3D width	250
tail width	275	sidecut type	Quadratic	camber	10		

snoCAD²
all dimensions in millimetres
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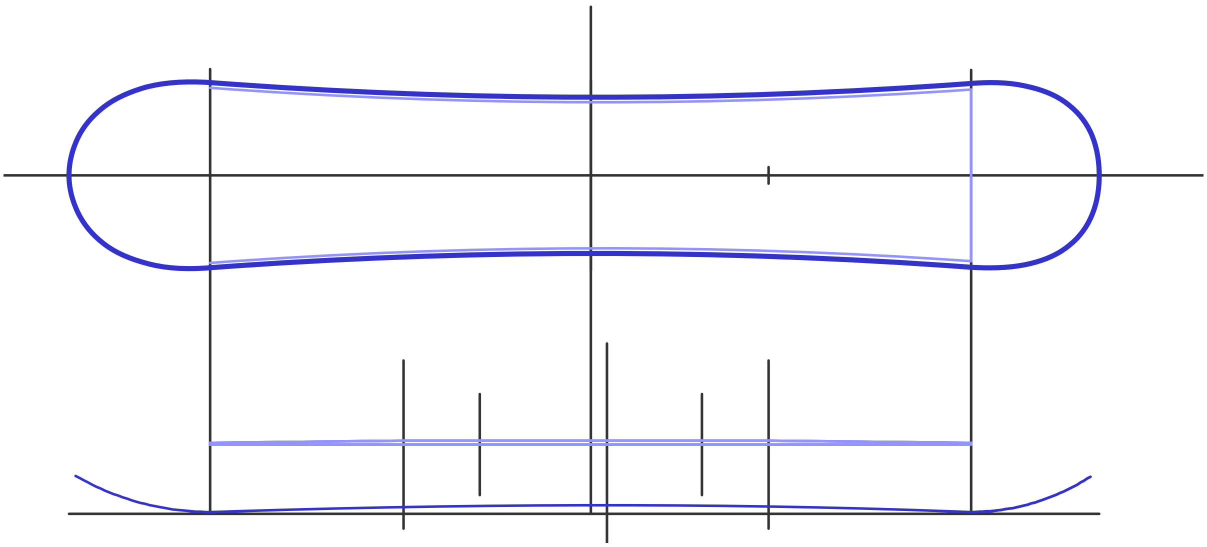
www.grafsnowboards.com

Figure 45. SnoCAD drawing for Float I.



board length	1530	running length	1130	nose tip radius	400	nose 3D length	200
nose width	275	sidecut radius	7600	tail tip radius	325	nose 3D width	250
nose length	210	sidecut bias	0	nose height	54	tail 3D length	200
tail length	190	waist width	231.938	tail height	54	tail 3D width	250
tail width	273	sidecut type	Radial	camber	10		

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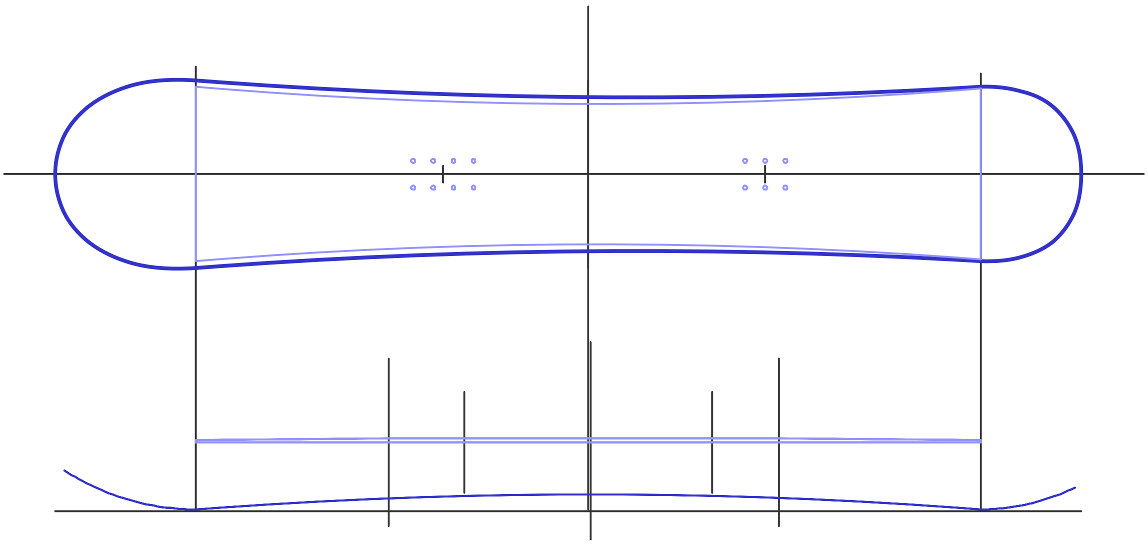
www.grafsnowboards.com

Figure 46. SnoCAD drawing for Float II.



board length	1530	running length	1170	nose tip radius	360	nose 3D length	200
nose width	280	sidecut radius	8500	tail tip radius	320	nose 3D width	250
nose length	210	sidecut bias	0	nose height	60	tail 3D length	200
tail length	150	waist width	229.690	tail height	35	tail 3D width	250
tail width	260	sidecut type	Radial	camber	22.5		

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Figure 47. SnoCAD drawing for Float III.

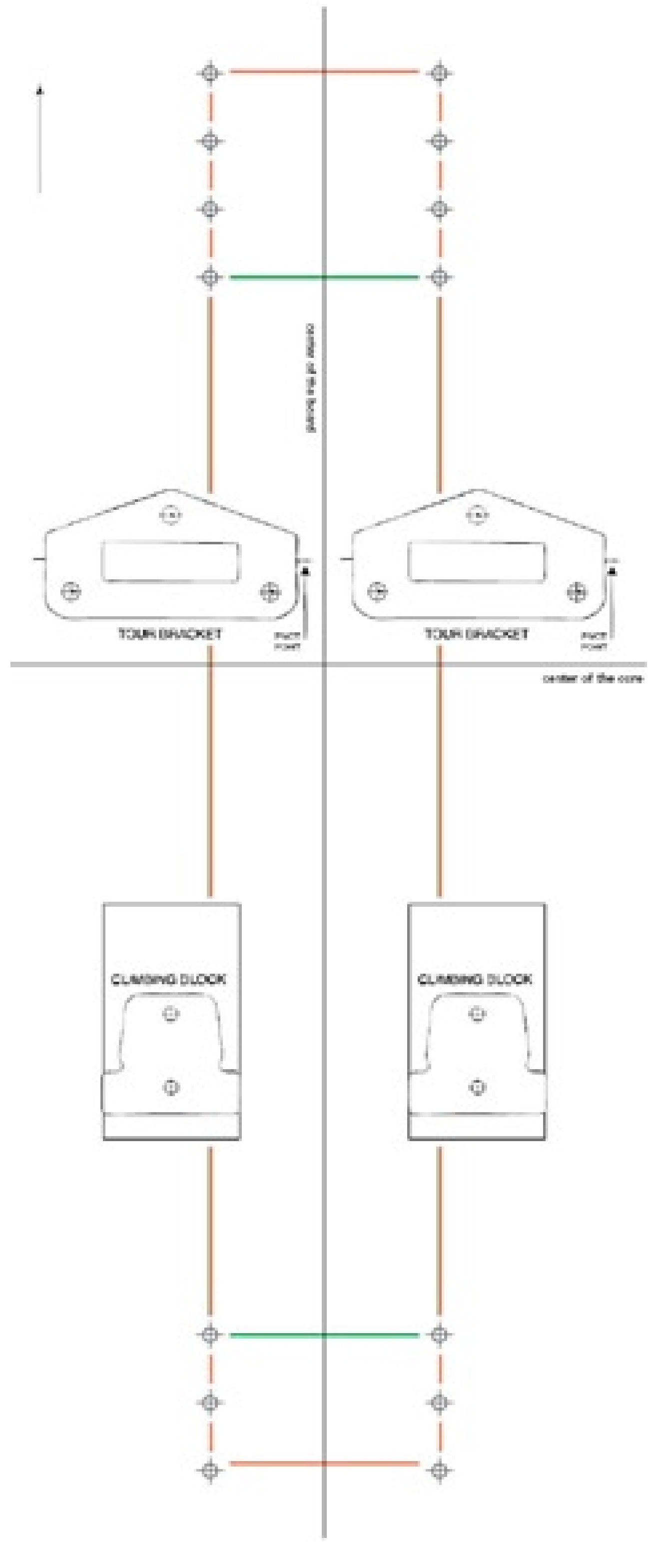
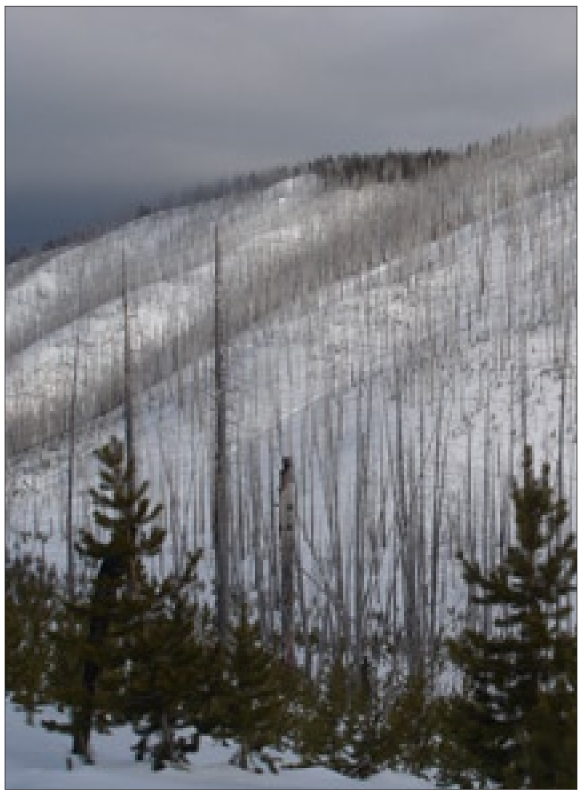


Figure 48. Hardware Template.



Glossary

Alpine Touring (AT). Skiing with free heel bindings that can lock down for downhill skiing.

Avalanche Beacon. A portable signal transmitter and receiver worn by backcountry users as standard avalanche safety equipment for location of burial victims.

Backcountry. Wilderness.

Binding Interface. The hardware that secures bindings to a splitboard.

Binding. Fastenings that secure boots to skis or a snowboard.

Camber. The degree of arch across the length of a snowboard causing a space between a flat surface and the middle of a snowboard.

Cant. Side-to-side angle of bindings on an alpine snowboard.

Chatter. Vibrations caused by the friction of a snowboard on snow that in turn cause slippage of the edge of the board.

Effective Edge. The length of the steel edge that touches the snow and therefore effects the turns.

Fakie. To snowboard with the opposite foot forward to the natural stance.

Forward Lean. The degree to which a highback is set to hold the lower leg toward the toe edge.

Gas Pedals. Risers that fit into the base plate of snowboard bindings under the toe to provide lift to the toe of the boot.

Goofy. The snowboard stance in which the right foot is the front foot.

Grab. A freestyle trick in which the rider reaches down and holds the toe or heel side of their board while they fly through the air.

Hard Boot. Mountaineering, snowboarding or touring boot with a hard plastic exterior shell.

Hardpack. Consolidated snow condition resulting in a dense surface and underlying layers.

Heel Edge. The metal that runs down the side of a snowboard nearest the snowboarder's heels.

Highback. The part of a snowboard binding that is a hinged plastic plate that cradles the back the boot.

Inversion. A freestyle trick in which the rider flips upside-down during a jump.

Jib. A terrain park obstacle such as a garbage can or picnic table that isn't normally intended as a snowboarding tool.

Lift. Toe or heel angles added to the bindings of an alpine snowboard.

Mountaineering. Climbing mountains for sport.

Nose. The front tip of a snowboard.

Probe. A standard piece of avalanche safety equipment that is used to penetrate through avalanche debris and feel for a burial victim.

Rail. See Edge.

Randonee. See Alpine Touring.

Ratchet Buckles. Clasping mechanism on strap snowboard bindings that bites on teeth of a plastic strap to tighten the fit.

Regular. The snowboard stance in which the left foot is the front foot.

Running Length. The range of the bottom of a snowboard that comes into contact with the snow.

Sidecut Radius. The radius of the circle that determines the depth of the curve between the two widest points along the side of a snowboard.

Soft Boot. A snowboard boot without a hard plastic exterior shell.

Split Hooks. Voile's pivoting hardware devices that hold a splitboard together between the nose and bindings and between the tail and bindings.

Stance. The position of on a snowboard.

Switch. See Fakie.

Tail. The rear tip of a snowboard.

Telemark Skiing. A snow sport in which the skier's toes are bound to the ski, but the heels are free. Turns are executed with deep knee lunges.

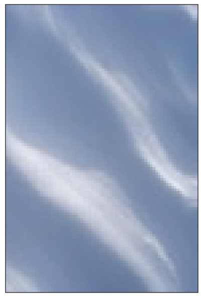
Toe Edge. The metal that runs down the side of a snowboard nearest the snowboarder's toes.

Torsional Rigidity. The strength of a snowboard to resist twisting across its center.

Transceiver. See Avalanche Beacon.

Traverse. To travel across a slope perpendicular to the fall line.

Tree Well. A deep pocket of loose snow usually formed on the downhill side of conifer trees with many low branches.



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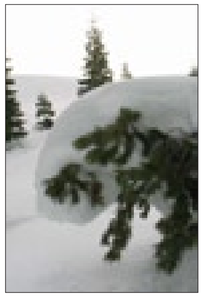


Appendix A

Splitboarder Interviews

Weight:	120
Date:	02/18 - 02/24, 2006
Age:	32
Number of years on a snowboard:	9
Number of Days Splitboarding:	30

CATEGORY	VOILE 153	FLOAT 153
RIDE MODE. Torsional Rigidity: The strength of a snowboard to resist twisting across its center. 0=fluid, 10=rigid	10	9
RIDE MODE. Flex: The stiffness of the board. How does the stiffness fit with backcountry riding? 0=not a good fit, 10=perfect	10	7
RIDE MODE. Carve: How well does the board ride its edges on turns? 0=can't carve at all, 10=perfect carving	9	10
RIDE MODE. Float: How well does the nose of the board float above the snow? 0=Sinks and stops the board, 10=floats above snow	4	10
RIDE MODE. Chatter Resistance: Vibration of the snowboard as a result of high speed, tight turns, and/or icy conditions. 0=maximum chatter, 10=smooth ride, no chatter	10	8
RIDE MODE. Manueverability (onto toe): Does the board turn onto the toe edge without resistance? 0=Unable to turn onto toe edge, 10=no resistance to turning onto toe edge	10	7
RIDE MODE. Manueverability (onto heel): Does the board turn onto the heel edge without resistance? 0=Unable to turn onto heel edge, 10=no resistance to turning onto heel edge	10	10
RIDE MODE. Stability at high speed: Does the board remain stable at high speeds without catching edges or becoming squirrely? 0=Uncontrollable, 10=Smooth ride at high speeds	10	8
TOUR MODE. Edge Control: Ability to hold edges on traverses. 0=slides out on traverses, 10=holds edges without fail	8	9
TOUR MODE. Nose Float: How well does the nose of the board float above the snow? 0=Sinks and gets caught up in snow, 10=floats above snow	3	9
TOUR MODE. Stamina: Rate your energy level after an uphill of 1000ft? 0=Unsafe fatigue level, 10=No fatige in legs	5	10

Appendix A
(continued)

Splitboarder Interviews

TOUR MODE. Kick Turns: Are kick turns smooth with this board? 0=Not possible, 10=Successfu	8	10

COMMENTS?

The Float board is too flexible for backcountry riding because in steep terrain it doesn't spring out of turns as easily as the Voile does. It carves well and turns easily on lower slope angles. The Voile's nose sinks in the snow in both modes in deep snow. The snow is usually deep in hte backcountry. But the stiffness is the biggest thing.

Weight:	130
Date:	02/18 - 02/24, 2006
Age:	37
Number of years on a snowboard:	14
Number of Days Splitboarding:	6

CATEGORY	VOILE 153	FLOAT 153
RIDE MODE. Torsional Rigidity: The strength of a snowboard to resist twisting across its center. 0=fluid, 10=rigid	10	10
RIDE MODE. Flex: The stiffness of the board. How does the stiffness fit with backcountry riding? 0=not a good fit, 10=perfect	9	8
RIDE MODE. Carve: How well does the board ride its edges on turns? 0=can't carve at all, 10=perfect carving	8	9
RIDE MODE. Float: How well does the nose of the board float above the snow? 0=Sinks and stops the board, 10=floats above snow	6	10
RIDE MODE. Chatter Resistance: Vibration of the snowboard as a result of high speed, tight turns, and/or icy conditions. 0=maximum chatter, 10=smooth ride, no chatter	9	8
RIDE MODE. Manueverability (onto toe): Does the board turn onto the toe edge without resistance? 0=Unable to turn onto toe edge, 10=no resistance to turning onto toe edge	10	10
RIDE MODE. Manueverability (onto heel): Does the board turn onto the heel edge without resistance? 0=Unable to turn onto heel edge, 10=no resistance to turning onto heel edge	9	8

Appendix A
(continued)

Splitboarder Interviews

RIDE MODE. Stability at high speed: Does the board remain stable at high speeds without catching edges or becoming squirrely? 0=Uncontrollable, 10=Smooth ride at high speeds	9	8
TOUR MODE. Edge Control: Ability to hold edges on traverses. 0=slides out on traverses, 10=holds edges without fail	9	9
TOUR MODE. Nose Float: How well does the nose of the board float above the snow? 0=Sinks and gets caught up in snow, 10=floats above snow	6	10
TOUR MODE. Stamina: Rate your energy level after an uphill of 1000ft? 0=Unsafe fatigue level, 10=No fatige in legs	5	7
TOUR MODE. Kick Turns: Are kick turns smooth with this board? 0=Not possible, 10=Successfu	7	7

COMMENTS?

The Float bard provided a nice, light ride in tour and turn modes. I wished it was a bit stiffer at times.

The Voile was stiff enough but its small nose wouldn't stay afloat in the deep pow like the float did.

Appendix B

Survey Data

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
13	c	2005 Burton S series 170 w/ Voile touring stuff	5	y	stiffness, brand, wieght, materials, camber, graphics	y	n	n	4
6	b	K2 170 no model it from the late 1980's	4	y	Stiffness, camber, weight, core material, tip shapes, reinforcement materials, brand, graphics	n	s	y	1
6	b	04/05 Voile Freeride 173	2	y	tip shapes, brand, weight, core materials, reinforcement materials, stiffness, graphics	n	n	n	2
12	c	Prior Backcountry 172	4	y	Weight, stiffness, shape, camber, reinforcement, core, brand, graphics	y	n	n	3
26	a	Prior Khyber 160	2	y	1stiffness 2weight 3core material 4camber, 5tip shapes, 6reinforcement materials (glass/carbon), graphics	n	n	y	2
10	c	Voile Mtn Gun 05/06 171 cm	5	y	stiffness, weight, tip shapes, reinforcement, materials, camber, core materials, brand, graphics	y	n	y	5
8	c	2002 Burton Custom 165 factory split	3	y	Everything except brand and graphics.	both	n	n	0
14	b	05-06 Prior Swallowtail Split 172cm	n/a	y	Stiffness, tip shape, weight, reinforcement, core materials, brand, camber, graphics	n/a	n	y	3
4	b	voile, split decision freeride, 2006, 173cm	4	y	tip shapes, materials, core materials, stiffness, weight, camber, brand, graphics	n	s	n	5
19	c	Voilé Mtn Gun 171, 2006, Length 171	4	y	stiffnes, tip shape, weight, core materials, camber, reinforcement materials, brand, graphis	y	s	y	5
16	c	Never Summer T5 165 (2005)	4	y	Stiffness, Shape, Materials, Camber, Brand, Graphics....	y	n	y	5
7	c	prior khyber 160, voile 178st	4	y	Stiffness,tip shape, weight, core, materials, camber,brand,graphic	n/a	s	y	
10	c	Voile Freeride 166 - 2003 Voile Freeride 173 - 2002 Voile Mountain Gun 171 - 2006	5	y	Stiffness, camber, core material, tip shape, reinforcement materials, weight, graphics, brand	n	n	y	1
15	b	Priot Khyber split, 170 cm, 2005 model year	4	y	stiff>weight>core>reinforcers>tip shape>camber>brand>graphics	y	n	n	10
18	c	Voile Freeride splitdecision 166	3	y	Weight, stiffness, core material, camber, reinforcement materials, brand, graphics	n	n	y	7
8	a	05-06 NS legacy 166	4	y	Stiffness, core materials, reinforcement materials, camber, brand, weight, tip shapes, graphics	y	s	y	5
		voile mtn gun 161			weight, tip shapes, stiffness, brand, reinforcement				

Appendix B
(continued)

Survey Data

13	c	2001 voile split descision 163 cm	3	y	Weight, stiffness, tip shape, camber, brand, core, reinforcement	n	n	n	1
10	a	2004 or 2005 Prior Swallowtail 172cm Splitboard	3	y	Tip Shape, Weight, Stiffness, Core Material, Reinforcement Material, Camber, Brand	n	n	n	n/a
3	c	Doutone tour, 2002, 165	4	y	weight - core material - reinforcement materials - stiffness - tip shapes	n	n	n	7
5	b	burton 170 s series 2004	4	y	stiffness weight tip shape materials, camber, core materials, graphics	y	o	y	3
13	c	2006 voile 171 Mtn Gun	4	y	reinforcement materials, stiffness, tip shapes, weight, brand, core material, camber, graphics	y	s	y	1
17	c	2006 Voile Mountain Gun 171	4	y	n/a	y	n	y	9
16	b	Voille 166 (2002) Voille 173 (2004)	2	y	TipShape, Weight, stiffness, camber, core, reinforcement, brand, graphics	n	n	n	0
8	a	steepwater 171 plow 04,05	2	y	stiffness, reinforcement materials (glass/carbon), core material, weight, tip shapes, camber, brand, graphics	y	n	n	0
11	c	self made kit set up. Voile Interface on 2001 LibTechnologies Joey McGuire 158cm	4	y	Camber, Stiffness, Core material, Reinforcement, Weight, Tip shapes, Brand, Graphics	n	n	n	2
20	c	voile, freeride, 2004, 173 voile, mnt gun 2006, 171	4	y	stiffness, weight, tip shapes, all the rest	y	s	y	1
12	c	5150 164 2001	3	y	shape, weight, price	n	n	n	4
8	a	Homesplit burton canyon, 02/03, 168	4	n	Core Material, Reinforcement Materials, Stiffness, Weight, Brand, Tip Shape, Camber, Graphics	y	s	y	n/a
17	a	NeverSummer custom split, made in Feb. 2006	4	y	reinforcement materials, stiffness, tip shapes, camber, core material, weight, brand, graphics	n	n	y	5
10	b	2001 burton Splt66 2005 165 Prior Khyber	4	y	camber, core, stiffness, weight, materials, shapes graphics, brand	y	s	y	3
12	a	*Prior, Swallowtail, 2003, 172cm*	4	y	Stiffness, shape, camber, weight, reinforcements, core, graphics, brand	n	n	n	2
17	c	Viole, Freeride 166, 2003	3	y	Stiffness, camber, weight, brand, core material, reinforcement materials (glass/carbon), tip shapes, graphics	y	n	n	1
					stiffness, core material, reinforcement materials, tip				

Appendix B
(continued)

Survey Data

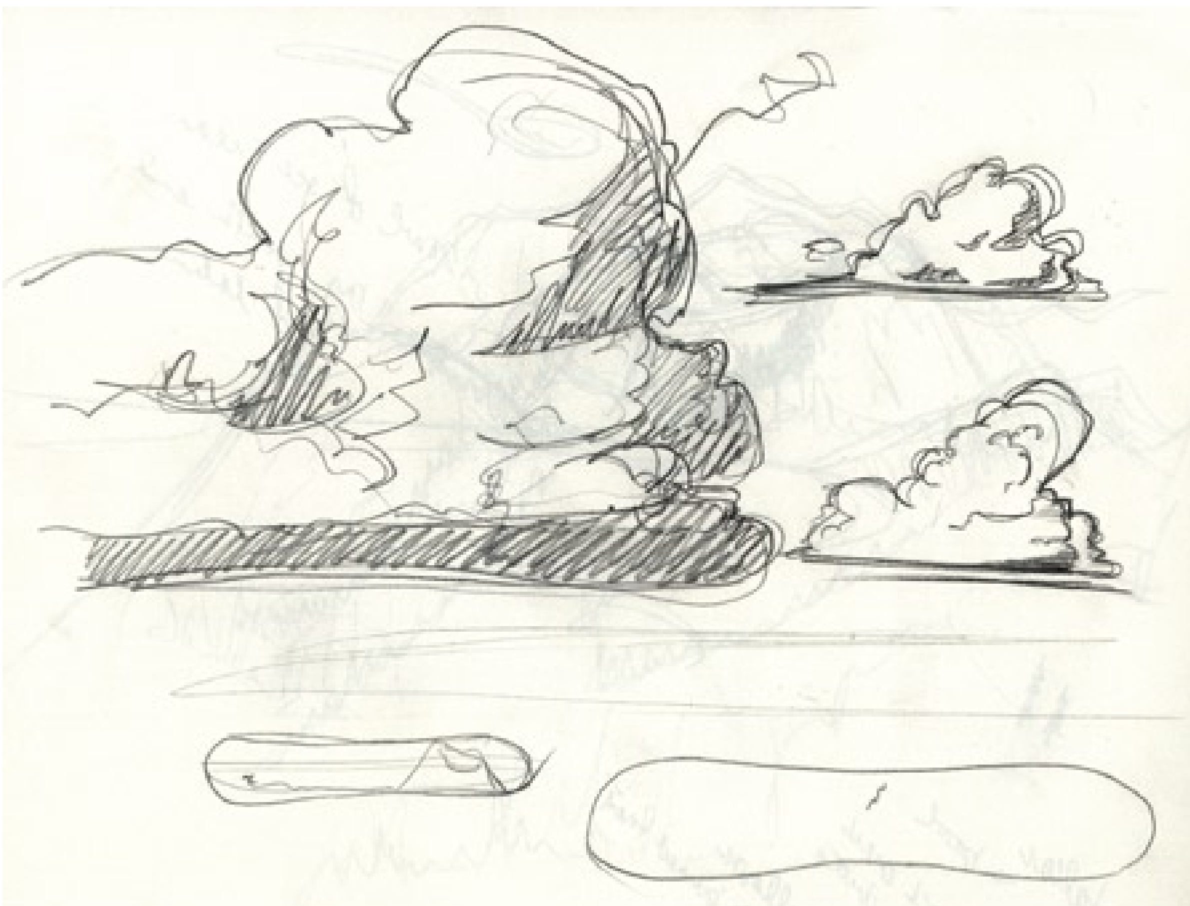
3	b	2005 Prior Kybor 160 2005 Voile Freeride 166	4	y	(unless camber means sidecut, in which case I'd move it to the third position.), tip shapes, graphics	n	n	n	5
21	c	Viole 173(04-05) MLY maverick 169(01-02) Salomon faction 161(04-05)	4	y	core, shape,stiff, material, weight, camber brand, graphics	y	n	n	3
14	c	2004 159 Voile Split Decision	5	y	Stiffness first for sure, tip shapes, weight, reinforcement materials, core material, brand, graphics	y	o	y	5
20	b	Voile 171 Mt. Gun 05/06	4	y	Weight/stiffness/reinforcement/core/tip/camber/brand/graphics	n	s	y	10
10	c	dynastar SUP FR 161 2005 voile hardware	3	y	Stiffness, tip shape, weight,camber, sore material, reinforcement material, brand, graphic	n	n	y	2
13	c	Duotone, Split, 1998?, 163, Voile 166	3	y	Weight, camber, stiffness, tip shapes, core material, reinforcement materials (glass/carbon), graphics, brand,	n	n	n	2
1	a	Prior Khyber 160	3	n	stiffness, core, tip shapes, camber, weight, reinforcement, brand, graphic	n	n	y	2
12	c	Never summer, legecy, 05, 170	5	y	stiffness, core material, reinforcement mat. camber, tip shape, weight, brand, graphics	n	n	n	10
15	c	Prior 168	4	y	Camber, stiffness, Core material, Brand, weight, reinforcement materials, tip shapes	n	n	y	5
18	b	2002 Voile Split Decision 174	4	y	stiffness, tip shapes, weight, reinforcement materials (glass/carbon), core material, camber, graphics, brand,	n	n	y	5
11	b	Prior Backcountry 2005, 175	4	y	stiffness, core materials, reinforcement materials, brand, weight, camber, tip shapes, graphics	n	s	y	1
15	c	voile 166 voile st 178 prior 165	3	y	maaterials, brand, stiffness, weight, shape then graphics	n	n	n	2
10	b	2003 Burton Custom S 165 2004 Burton Custom S 165 2004 Burton Fish 156HD split using the Voile kit 2005 Burton Malolo 162		y	n/a	y	n	n	5
8	a	burton split 05/06 162cm	4	y	shape, weight, stiffness, reinforcement, camber, core, brand, graphics	n	n	y	2
15	c	2003 Burton split 153	4	y	shape, weight, stiffness, brand, materials, nice graphics	n	n	n	1
16	b	Burton, Splitdecision 168, '04	3	y	Core material, Reinforcement material, stiffness, weight, camber, brand tip shapes, graphics	n	s	n	10

Appendix C

Evolution of Board Graphics

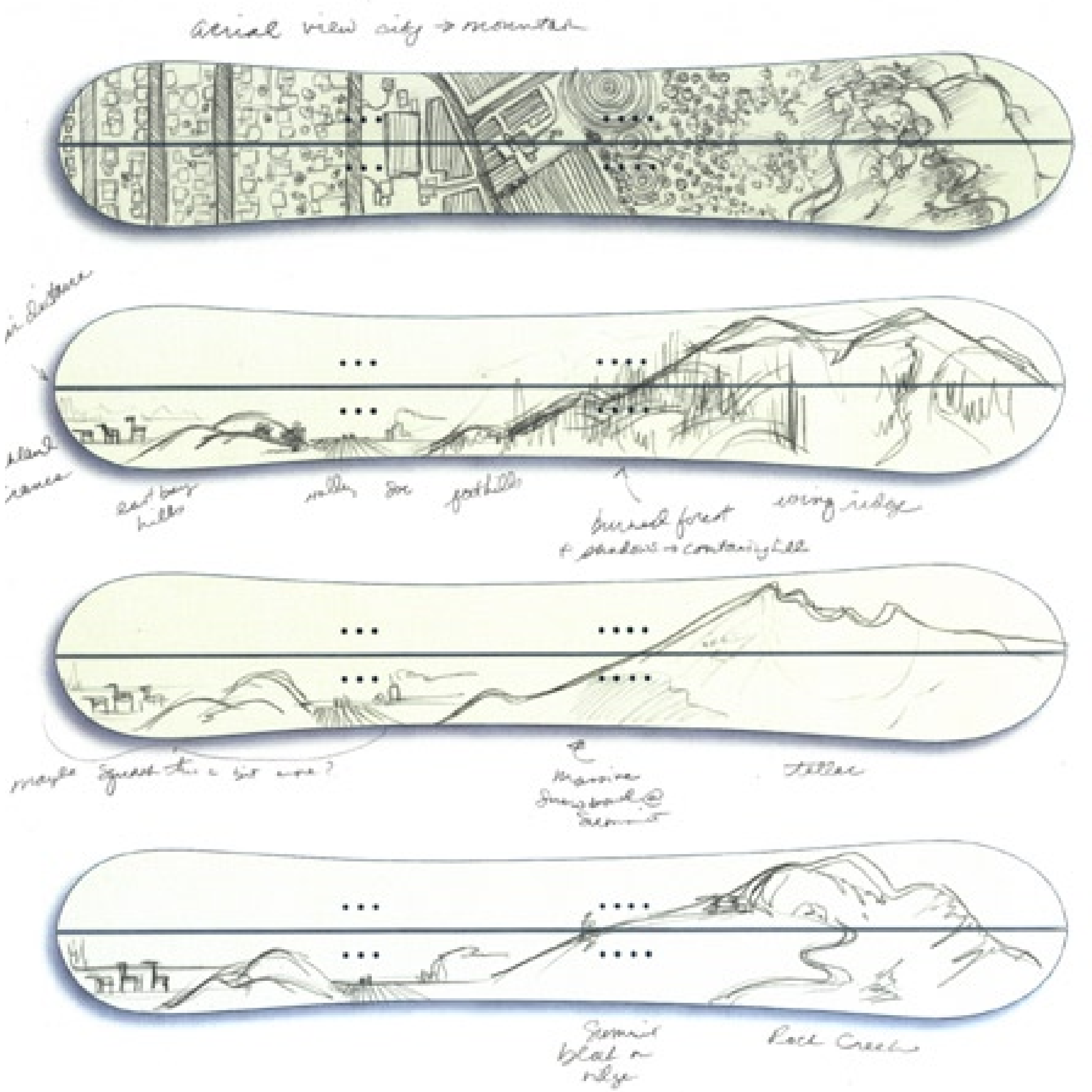
Appendix C
(continued)

Evolution of Board Graphics



Appendix C
(continued)

Evolution of Board Graphics

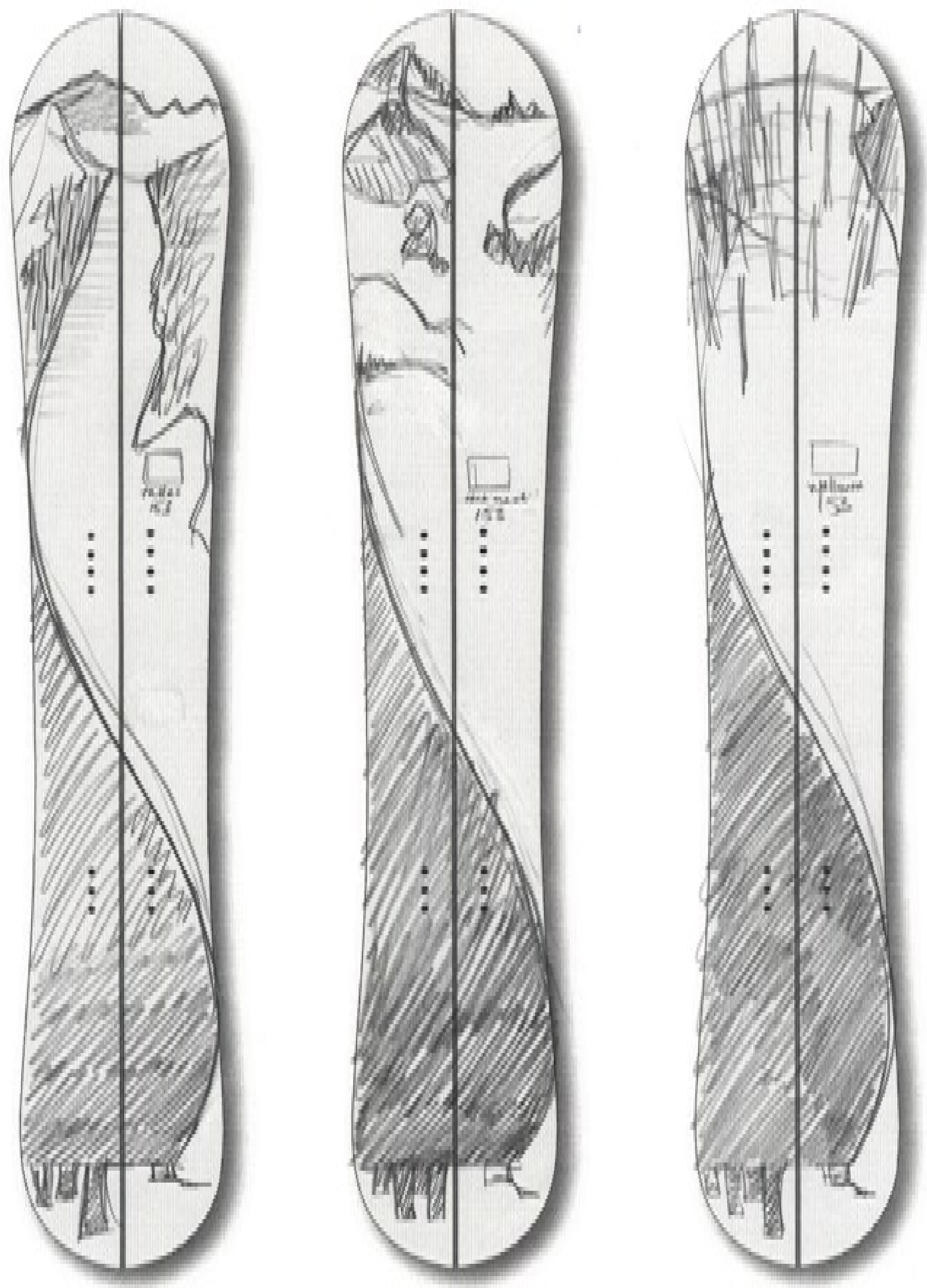


Appendix C
(continued)

Evolution of Board Graphics

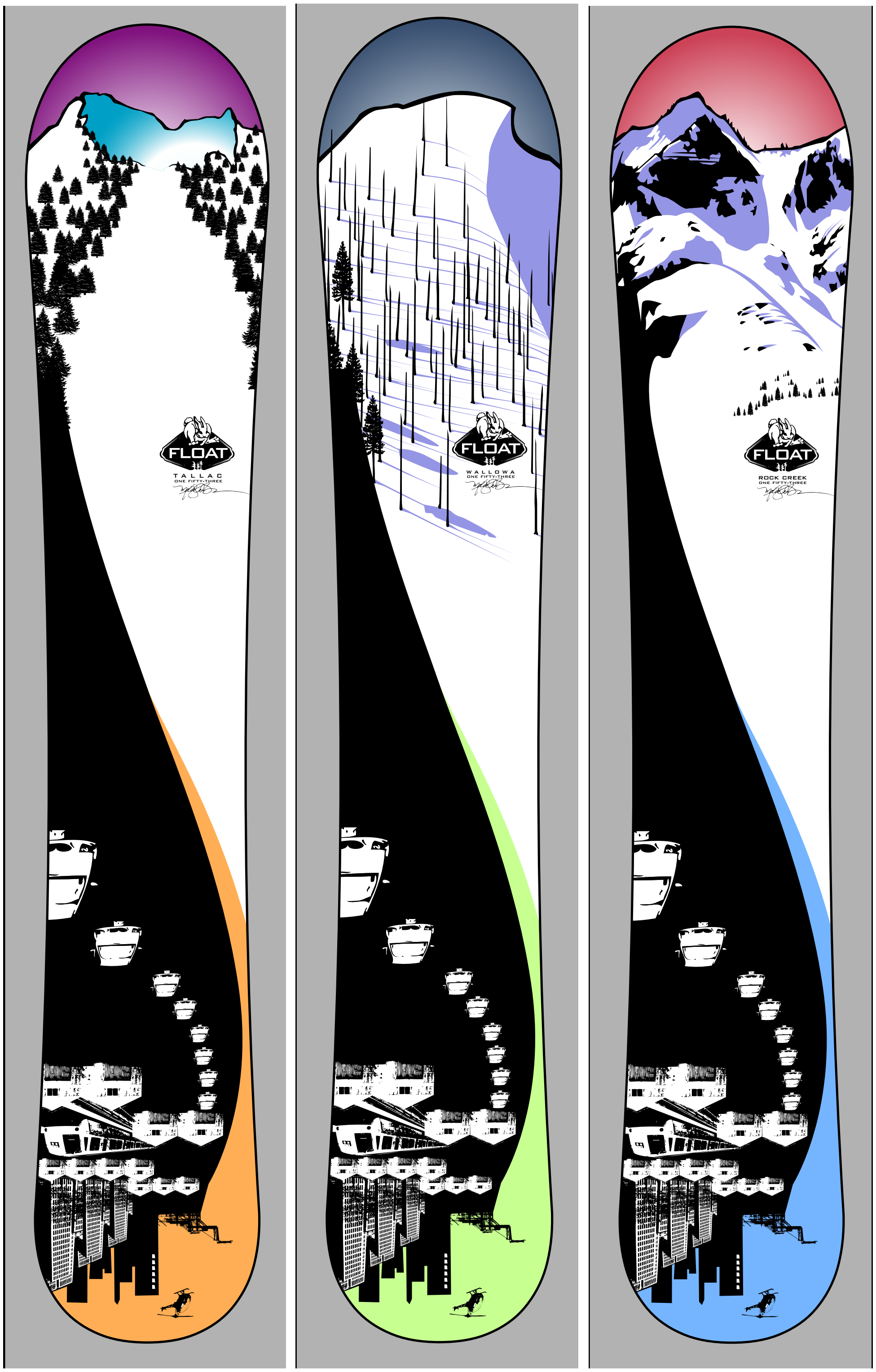
Appendix C
(continued)

Evolution of Board Graphics



Appendix C
(continued)

Evolution of Board Graphics



Appendix D

Lamination Instruction Sheets

TALLAC
Balsa and Basswood
Carbon Tape

1. Lay down sealant tape – leave paper
2. Install valves on vacuum film
3. Prep mold with mold release – leave middle free for spray glue
4. Put the core on the bases
5. Spray glue down bases (nose forward)
6. Mix epoxy
7. Add pigment
8. Wet out bases
9. Put damping foil on rails
10. Wet out damping foil
11. Lay down and wet out fiberglass
12. Cut holes for inserts
13. Wet out the carbon and bottom of core
14. Lay down and wet out core
15. Lay down and wet out tip spacers (fold under edge near core)
16. Lay down and wet out carbon tape
17. Lay down and wet out fiberglass
18. Lay down and wet out carbon fiber
19. Lay down topsheet
20. Lay down PE film
21. Lay down breather fabric
22. Place little piles of breather fabric under valves
23. Adhere vacuum film
24. Tighten valves
25. Turn on pressure!

Appendix D

Lamination Instruction Sheets

ROCK CREEK
Thick Core
No Carbon Fiber Layer
(except on steel inserts and tip spacers)

1. Lay down sealant tape – leave paper
2. Install valves on vacuum film
3. Prep mold with mold release – leave middle free for spray glue
4. Put the core on the bases
5. Spray glue down bases (nose forward)
6. Mix epoxy
7. Add pigment
8. Wet out bases
9. Put damping foil on rails
10. Wet out damping foil
11. Lay down and wet out fiberglass
12. Cut holes for inserts
13. Wet out the carbon and bottom of core
14. Lay down and wet out core
15. Lay down and wet out tip spacers (fold under edge near core)
16. Lay down and wet out fiberglass
17. Lay down topsheet
18. Lay down PE film
19. Lay down breather fabric
20. Place little piles of breather fabric under valves
21. Adhere vacuum film
22. Tighten valves
23. Turn on pressure!

Appendix D

Lamination Instruction Sheets

WALLOWA
Balsa, Spruce, Bass

1. Lay down sealant tape – leave paper
2. Install valves on vacuum film
3. Prep mold with mold release – leave middle free for spray glue
4. Put the core on the bases
5. Spray glue down bases (nose forward)
6. Mix epoxy
7. Add pigment
8. Wet out bases
9. Put damping foil on rails
10. Wet out damping foil
11. Lay down and wet out fiberglass
12. Cut holes for inserts
13. Wet out the carbon and bottom of core
14. Lay down and wet out core
15. Lay down and wet out tip spacers (fold under edge near core)
16. Lay down and wet out fiberglass
17. Lay down and wet out carbon fiber
18. Lay down topsheet
19. Lay down PE film
20. Lay down breather fabric
21. Place little piles of breather fabric under valves
22. Adhere vacuum film
23. Tighten valves
24. Turn on pressure!