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From weapons of mass destruction to bike frames of aspiration – the story of titanium

Today's frame material landscape is a relatively straightforward one. High-end bikes are made from carbon fibre. Almost everything else is made from aluminium. Steel is a niche material, limited to small specialist manufacturers. And then there's titanium, which is even more niche but used in the same sorts of things as steel – limited-run hardtails and full custom frames.

Times have changed. In the early 90s, steel was the dominant frame material, with aluminium an oddball lightweight option and carbon fibre rare to the point of invisibility. And then there was titanium, existing in a stratosphere above it all. Impossibly expensive but impervious to corrosion, durable and possessed of mythical ride qualities, titanium was the undisputed king of frame materials.

Titanium was discovered in ore form in Cornwall in 1791 by amateur geologist and clergyman William Gregor, although it was named – after the Titans of Greek mythology – in 1795 by Martin Heinrich Klaproth who discovered it independently. It wasn't until 1910 that pure metallic titanium was produced, and it took a further 20 years for William Kroll to devise a process for large-scale titanium production. The Kroll process is still used today, with its considerable energy requirements being a large part of the reason for the high cost of titanium.

It was the Cold War that brought titanium to the fore. During the 1950s and 60s, the Soviet Union and US used vast quantities of titanium in submarines, aircraft and missiles. It's strength to weight ratio, and fatigue and corrosion resistance, made it the perfect choice. And as soon as tubing was being manufactured for use in hydraulic systems, titanium's use in bicycles became inevitable.

Titanium bike frames had something of a false start in the early 1970s. Speedwell in Birmingham, UK, launched its Titalite road frame in 1972 and managed to get 1973 Tour de France winner Luis Ocana to use it for selected mountain stages. Across the Atlantic, Teledyne released the Titan in 1973. Neither manufacturer persisted with bike frames, though, and nobody else took up the titanium baton for another 10 years.

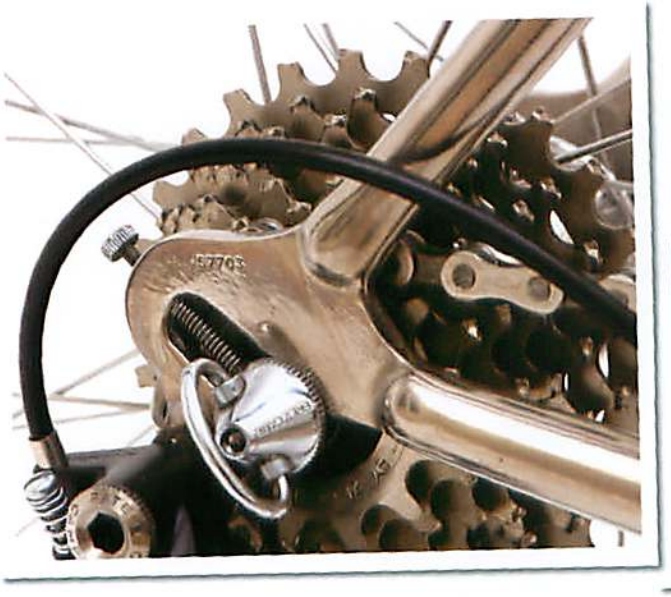
The story of titanium mountain bikes, then, really begins in Boston in 1981. That's where Mike Augspurger, then a motorcycle trials rider and machinist, encountered mountain bikes for the first time.

"Since I was in the city and I didn't have any money, I had to stop riding trials. But I saw this Montesa bicycle. I knew the brand from motorcycles, so I bought one. It was fun, but I wanted to make my own, make it a little better. I looked in the Yellow Pages and found Fat City Cycles. They weren't interested in making my design but they were already making these amazing mountain bikes. So I started working there two days a week – I couldn't afford to work there because they didn't pay well enough, but I got access to

A brief history of Ti

the shop on the other three days, which is when I made the first Fat Chance trials bike. I didn't know anything about bicycles at the time: I didn't know a top tube from a down tube and they had to teach me all that stuff."

"Gary Helfrich was their welder, he and I hit it off right away. He was experimenting with titanium and he had made a frame out of this junk titanium tubing that he'd found, and it was pretty amazing. But [Fat City owner] Chris Chance was not interested. And I don't blame him. I mean, Gary was kind of a loose cannon. You never knew what he was going to do next."



The 1973 Speedwell Titalite and Teledyne Titan were both made of "commercially pure" titanium rather than the alloys used today

Speedwell's skinny frame may have been a bit whippy, but it was very light. And you can't argue with the build quality

Sandy Zweis

"Then there was a magazine article in Bicycling comparing aluminium and steel and other materials. They threw in titanium at the end even though there weren't any titanium bikes. And I read the article and suggested to Gary that we should start a business making titanium bike frames. A few months later he said yeah. I introduced him to a friend from college, Gwyn Jones. He was a member of the DuPont family, so that was the chequebook. It turned out not to be a good partnership, but at least in the beginning he had the sense to give us the money. And that was how we started Merlin."

Titanium is renowned for its comfortable ride. While it's debatable where that reputation originates, it seems likely that the somewhat flexible nature of the early frames plays a part.

"The first Merlins we called the 'rubber bicycles'. They were just 1-1/4in tubes, because that was the only diameter tubing we could buy, and they had a lot of flex in them. The larger frames actually were too flexy, but there was no suspension yet, so in some ways they were especially good because the bike frame would absorb shocks."

Merlin's first frames were mountain bikes, including one for U.S. national champion Joe Murray.

"While Merlin was first out of the gate, it would not have the titanium market to itself for very long."

Merlin Metalworks produced the first titanium mountain bike frame in 1986, with road frames coming a little later

Early Merlins (this one's from 1988) used skinny tubes because that's all that was available at the time

"He was a friend because of our connection with Fat City. Whenever there was a race on the East Coast we would put him up. When he heard that Gary was doing titanium frames he wrote us a letter with his ideal bike, on the off chance that we would build what he wanted. We did, and that was a good way to decide the original top tube length and the angles. We didn't want to argue with anyone over geometry – if we built to the specs of the current national champion, then that was enough to stop people from complaining that they really wanted a 70.5 or something."

While Merlin was first out of the gate, it would not have the titanium market to itself for very long. In Chattanooga, Tennessee, a family-run machine shop was to be the starting point for a second titanium specialist. Mark Lynskey is the eldest of five children, all of whom worked in the family business.

"My father Bill started the shop in 1962. He became an expert in working with exotic metals – chrome-steels, nickel, stainless, aluminum, niobium, hastelloy, titanium. The projects took all sorts of directions, everything from chlorine process equipment, to beverage water treatment systems, to parts in outer space.

"In the early 80s, my brother David, who'd been a runner through high school and college, suffered knee damage and chose to take up cycling. After purchasing several bikes he chose to build his own frame. He decided to use titanium; it's strong, light, and we had some extra in the materials rack. Immediately he started getting requests from friends and local cyclists, and in 1986 we were talked into showing some frames at the Long Beach bike show [precursor to today's Interbike] in California.

"He decided to use titanium; it's strong, light, and we had some extra in the materials rack. Immediately he started getting requests from friends and local cyclists"

"Requests came rolling in and Litespeed was born. At this point it was still almost treated as a hobby but by 1989 sales were such that we decided to do a small addition to our building and begin making titanium bike frames as part of the daily business routine. By 1996, 100 per cent of our business had evolved to bicycles.

"Those first few years were incredibly exciting. There were daily challenges at every turn. The alloys and shapes of titanium needed for bicycles were difficult to find, if they existed at all. So you had to figure out how to work with what you had. Also there was no such thing as bicycle manufacturing equipment designed to work specifically with titanium, so we either had to modify existing equipment or build it from scratch."

By the mid-1990s, nearly every mainstream manufacturer had a titanium bike topping its range and being used by its race team. There were dozens of different brands and

Jones photography - Jim Tidball

YAY AND NAY Seven Cycles's Rob Vandermark on the pros and cons of titanium

GOOD STUFF

VERSATILITY

Titanium allows a framebuilder to create a wide range of ride characteristics – from very smooth and compliant to extremely stiff and efficient. Many people think of titanium as a 'flexible ride'; this reputation exists for a lot of reasons. However, the short answer is that, to the extent that a frame builder is willing to go through the difficult sourcing and material work required, a titanium frame can be among the stiffest frames made – if that's what the rider desires. Titanium's ability to help create a very stiff frame, and its converse ability to facilitate a very comfortable and smooth ride, is unique in the bike material world. Steel comes closest to titanium in this regard.

RIDE CHARACTERISTICS

While titanium is an extremely versatile material, one of the aspects that many riders appreciate most about titanium is its shock absorption and smooth ride feel. A well-designed titanium frame will absorb a lot of road shock and vibration, making it great for longer rides and more frequent rides. Not even steel can provide the smooth ride of titanium.

SERVICE LIFE

A well-designed titanium frame provides excellent service life, meaning it will last for many years. There is all kinds of data that expound the fatigue endurance of every bike material – miraculously every material seems to have the best fatigue characteristics. However, the post-welded fatigue life is what is most important and titanium excels in this category.

DURABILITY

Titanium is the toughest material for bikes. It can handle tremendous rider and racing abuse – crashing, driving into a garage with the bike on a roof rack... This makes it particularly good for mountain bikes. Titanium does not corrode, rust, or get damaged by UV rays. Steel, aluminum, and even carbon, all have environmental limitations. This is a great attribute that enables riders to ride in all conditions.

CUSTOMISATION

Part of titanium's versatility comes in the form of its ability to play a role in customisation. This extends well beyond customisation of frame geometry; titanium is also well suited for customisation of tubeset stiffness and flexibility, and frame options, like the many brake options available for mountain bikes, and rack mounts and tubeset adjustments, to enable a frame to ride appropriately with loaded panniers. These types of customisation are much more difficult with carbon and aluminium.

BAD STUFF

TITANIUM IS NOT STEEL

The single biggest challenge is when builders treat titanium like steel or aluminum. If this happens, the frame will be likely to have issues.

HIGH TEMPERATURE CONTAMINATION

Titanium loves to alloy with elements. Oxygen and hydrogen are a couple of examples. When either of these elements gets introduced into a titanium weld zone – or any high temperature aspect of manufacturing – the fatigue endurance of the titanium pretty much goes to zero. This makes welding particularly challenging and technically more difficult than it looks. Even finger print oil, containing hydrogen, among other nasty elements for titanium, will seriously degrade the strength of a titanium weld.

GRAIN STRUCTURE

Titanium is extremely sensitive to even minor changes to grain structure. Steel and aluminum overcome grain challenges, in part, because they can be heat treated after forming. However, 3-2.5 titanium alloy does not respond to heat treatment, so any change in grain — through forming, bending, flattening, or swaging – means a significant degradation of fatigue endurance.

SOURCING

It is extremely challenging to find US and western European sources of 3-2.5 titanium alloy. For example, in the US there are only two manufactures of this alloy. Working directly with the manufacturer is expensive (large minimum orders) and requires a lot of planning: lead times can easily be six or more months.

designs, but very few actual manufacturers. If you wanted a titanium frame in your range, you had to go to one of the specialists. Litespeed did a lot of this work.

"Bicycle design was a whole new world for us. None of us had a deep cycling background so we had to learn bikes. We really had great fortune in this area. We did a tremendous amount of contract manufacturing of frames for other brands. So we found ourselves at the drawing table with many of the world's best cyclists and designers. I can't describe how much fun it was to be able to be involved with people like Eddy Merckx, Irio Tommasini, Ugo De Rosa, John Tomac, Greg LeMond, Lance Armstrong, Steve Hed, Doug Bradbury, and hundreds of professional and elite amateur cyclists. We learned 10 lifetimes of bike knowledge in a few short years. If I remember correctly, in 1993 we built for 23 different brands of bikes. So you can imagine the lessons we were learning."

Meanwhile all was not well at Merlin. After only a few months the relationship between

the engineering and finance sides of the founding group was deteriorating. Mike Augspurger and Gary Helfrich both ended up leaving the company they'd started.

"It was about a year and a half or two years I was there. Gary left after having several huge fights with Gwyn Jones: screaming temper tantrum things, you know. I hung on just out of sheer greed. I wanted the money and I would put up with almost anything if I thought I was going to get me a lot of money. But finally Gwyn and his lawyers forced me out as well."

Augspurger started One-Off, building custom titanium frames. A lucrative trophy-making contract gave him the opportunity to explore other avenues. Having already done some work with Boston wheelchair athlete Bob Hall while at Merlin, he thought there was a better solution than the traditional wheelchair and devoted a year to developing a three-wheeled, off-road capable handcycle. Today handcycles are the bulk of his work.

"I haven't done a bike frame in a long time. I'll do titanium frame repairs or add brake mounts for discs, if it's someone local. But mainly I stick to the handcycles."

"Miraculously every material seems to have the best fatigue characteristics. However, the post-welded fatigue life is what is most important and titanium excels in this category"

Gary Helfrich, meanwhile, decamped to California and set up Arctos Machine. He continued to make frames in small numbers, although the business evolved to focus on frame building tools. In 2001 he wound up Arctos and went back to university to study environmental planning.

After the departure of Helfrich, Merlin was left with just one welder. Rob Vandermark had joined Merlin early on and served an apprenticeship under Helfrich.

"I worked in a bike store through high school and college; I loved bikes. I started racing road and mountain bikes back then, in the early 80s. And I commuted by bike, too. I was also a bike courier in Boston during part of my college days. At college I was a sculpture major. I loved working three-dimensionally with materials and construction methods – clay, bronze, welding, casting.

"In 1986, I saw an ad in the newspaper by a small frame builders looking for people. This was Merlin Metalworks; they were just starting out. The idea of combining my two passions – bikes and sculpture – was so exciting. So, I applied and, amazingly, they hired me. Still don't know why. I spent my first day crumpling newspapers for frame packing material to ship bikes. So, I guess I started at Merlin as the shipper. However, because the company was just getting going, I very quickly had the opportunity to work in a lot of different areas. After shipping, my first work was machining. I hadn't done any work with titanium at all at this point, and no bike or frame building either, just sculpture and stuff. I started apprenticing and learning to build frames with Gary in early 1987."

Vandermark was to become Merlin's chief designer (you'll find his name on the chainstay of most 90s Merlins) before himself leaving – with three co-workers – to set up Seven Cycles in 1997. Seven builds custom frames in titanium, steel and carbon fibre.

"I love engineering, research, and experimentation. Every material has strengths and weaknesses, even titanium. The way a good carbon bike rides is very different from titanium; it's not necessarily better or worse, but definitely very different. The same is true for steel. I also really like combining materials to leverage their strengths and mitigate their weaknesses."

Just a couple of years later, both Litespeed and Merlin were bought out, both operating under the umbrella of American Bicycle Group. Litespeed's Mark Lynskey: "We weren't actively marketing Litespeed as being for sale, but in 1999 we were made an offer and chose to accept it. I stayed on with the new owners while the rest of the family, including Ruby our mother – dad had passed away a few years before – chose to take on other endeavours outside of the cycling world."

But after a few years, it was Lynskey's turn to move on. "From 1999 to 2005 ABG grew exponentially. It was an exciting time but my role had taken me away from the core of my passion, which is design and manufacture. It had all happened so fast that I didn't realise how out of place I had become, but in the spring of 2005, it became clear to me that I was no longer on my life's path. In July, without any idea of what may lie ahead, I chose to resign. My plan at that point was to take some time off, catch up on lots of things that had gone by the wayside in the past few years and then determine my future.

"Within a few weeks of my 'retirement'. Ruby is starting to inquire about what I'm going to do with my life in ways only moms can. She began to plant seeds of the possibility of the family coming back together and forming a new business. By November, she had us all at her house talking about it and in December we spawned Lynskey Performance Designs. We started with only custom offerings. However, we quickly grew into standard designs as well and today we offer over 20 different models plus customs."

Lynskey is also now the only US manufacturer doing contract manufacturing, building frames for – amongst others, UK brands Ragley and Cotic. Coincidentally, at around the time Merlin and Litespeed were changing hands, the designer of one of the most innovative titanium frames available was just getting started. Jeff Jones had worked for GT and owned bike shops before moving to Oregon to build frames.

Titanium is an expensive material, and the challenge of working with it adds to the cost of frames

Litespeed got started not long after Merlin – both companies exhibited at the Long Beach trade show in 1986

"I didn't think at all about building it. It was very difficult with the amount of welding, the alignment, the cutting...

"I took a titanium welding and frame building class at UBI [Portland's United Bicycle Institute] – kind of like a refresher course since it was about six years since I'd worked at GT. That's when I got fully into titanium and as soon as I did that, I liked it, and nobody asked for anything else.

"Originally I was going to build anything for anybody, exactly however they wanted it, pure custom. But then I built my first truss-fork 26in spaceframe for myself. It just blew my mind. Then I built one for a customer who wanted to go 29in. I hadn't done 29 yet with this frame and fork. I built it for him and on the test ride I was just in love with the bike completely. I kept developing that bike a little further with other people, other builds, for myself and for other people."

The resulting frame is unique, designed as a pure rigid bike with a large-offset truss fork and a riding position that puts the rider's weight further back than most bikes. Unsurprisingly, it's not an easy frame to build.

"When I designed that thing it was all on paper and I hadn't been building frames in a long time. I didn't think at all about building it. It was very, very difficult with the amount of welding, the alignment, the cutting, and getting the torch up into those spaces. And then the fact that the fork is basically another frame..."

After a few years of evolution it was clear to Jones that building all the frames himself was going to be too time-consuming, as well as keeping him from developing new designs. So he went to Merlin, who built batches of frames to his design.

"It was the same thing for them – they didn't think about it, or they thought about it but didn't realise how difficult it was going to be to do. It was hard for them and they told me a few times that it wasn't the easiest or the most profitable job they've ever had."

And then Merlin stopped doing contract manufacturing, leaving Jones without a builder. But then inspiration struck.

"When I was at GT I went to Taiwan because I wanted to show them how to make the RTS3. And I just had my mind blown by the quality of work that was coming out of there, and that was back then, 15 or 16 years ago."

The hunt for a Taiwanese factory to produce the Spaceframe was on.

"I didn't really know exactly who was who – I was aware of work that I'd seen that I liked, but I didn't know who made it. It took a while. The frames are now being made by a small high-end titanium builder. I'm paying a premium to have these things made by this place, but it's worth it. The eccentric bottom bracket machining, which is critical, is perfect; the clearance in the rear end and the forming on the chainstays... It's so exciting for future projects because now I know how much easier it is and how much more possible it is to get things done as I want. They took it over, they're doing it willingly, and doing it right, and actually surpassing things. And helping me along and saying 'we can do this', and I'm like, you can do that? I didn't know you could do that, let's do some of that..."

Opposite: Xzang and Bowl's, Steve Behr, WTB Phoenix, Nik Hill

Outsourcing manufacturing does have its hazards, though, as Jones discovered when a Chinese manufacturer 'paid homage' to his Spaceframe design. "I got this email that said 'we make titanium bikes, please look at our website'. And then it started getting more specific – please go to this page and we think you will find something very interesting... So I click on it and I'm like, oh my God, they did a bad copy of it and they're trying to sell it to me?

"There was a company that was buying stuff from them and selling it. The website had a picture of my cut bar off my website, and he's selling it, and then there's another picture of a loop bar which looks just like my loop bar, only it's kind of cheap looking. The guy's bought them from the Chinese place and he said 'hey, I was tinkering around and came up with a bar'. We sent him a letter and said, what are you talking about, and he took it all down and then he disappeared. It's a weird business out there."

The titanium frame industry has had its ups and downs, but with the expansion of Asian manufacturing making titanium more accessible for brands looking to add a Ti frame to their line and a number of specialist US builders turning out unique custom frames, the future of the magic metal looks secure.

"It's hard to make a cheap titanium bike, so Ti's starting to be seen as *the* choice if you want a premium bike."

Rob Vandermark: "We're seeing a swing back toward titanium for high-end performance bikes. We're seeing a number of reasons for this. Carbon has become ubiquitous – everyone has one so it's not as interesting as it was five years ago. It's in bikes down under $2,000 and it's only going to continue to push downmarket. It's hard to make a cheap titanium bike, so Ti's starting to be seen as the choice if you want a premium bike."

Jeff Jones: "Titanium is always going to be a very expensive material. There's just no way to make it cheaply.

As far as where it's going I think it's just going to be up to what people want to buy. Because carbon fibre can do it one way, titanium can do it another way."

Mark Lynskey: "The perception is that titanium sales dropped as carbon fibre grew, [but] what carbon fibre killed was high-end aluminium. Titanium is growing in popularity as well as sales volume. Carbon fibre is going to be around for a long time but, as with anything that becomes mainstream, it risks becoming boring. It can lack the uniqueness that many cyclists crave. We've made certain our designs are both at the forefront of technical innovation and aesthetics. That's what you really need to do to remain successful. The material you use is almost irrelevant."

Mike Augspurger: "Carbon fibre wins on paper. It wins by a mile if you look at fatigue life and stiffness. But when it comes time to actually build it into a bike frame, carbon fibre isn't any fun at all to work with. It's miserable stuff, you have to use glue, and the finishing is horrible. It doesn't lend itself to a small-scale builder. It's not as much fun. I'm more interested in having a good time."

Mike Davis is done with transcribing phone interviews now ■

VARIETY CLUB 'Versatility' is an oft-touted titanium attribute, seen in these four groundbreakers

GT XIZANG

In the first half of the 1990s, GT was one of the highest-profile manufacturers on the race circuit. The titanium Xizang was the XC racers' weapon of choice, finding race success with Rishi Grewal, Juli Furtado and Britain's David Baker. GT was making high-end aluminium and steel frames in its California factory, but outsourced Xizang production to Sandvik, which also built frames for Marin, Kona, Diamondback and many others. Thanks largely to their race heritage, the highly-polished Xizang frames became something of an icon, and with GT's distinctive Triple Triangle frame design they're instantly recognisable.

IBIS BOWTI

The unique Ibis BowTi used the flexibility and fatigue resistance of titanium to adventurous effect, getting 5in of suspension travel from a frame with no pivots. It was designed by John Castellano and was derived from his Sweet Spot high-pivot unified rear triangle design used on the Ibis Szazbo. The flattened tubes running the length of the bike acted as leaf springs, allowing the shock to run very low air pressure – it was mainly concerned with bottom-out control and damping. John Castellano is still building his unique designs, but the BowTi is yet to reappear.

WTB PHOENIX TITANIUM

Wilderness Trail Bikes was founded by mountain bike pioneers Charlie Cunningham, Steve Potts and Mark Slate. Today it's best known for components, but between 1993 and 1998, Steve Potts built about 600 Phoenix frames. Most were steel, but around 100 were titanium. At the time the mountain bike world was getting excited about full suspension and aluminium, so the Phoenix was definitely a niche choice even then. The steel Phoenix has a reputation as one of the finest handling steel frames made, and the titanium edition is now much sought after. Steve Potts is still building titanium frames under his own name, the only one of the original Marin County riders to be doing so.

COVE HUMMER

If the Ibis BowTi was the ultimate expression of titanium flex, the Hummer was its antithesis. Cove is based on Vancouver's North Shore, and the Hummer was designed for the area's ultra-technical trails. That meant two attributes unique to titanium bikes at the time: first, it was overbuilt – titanium was used for strength and longevity rather than comfort, with oversized tubes and a compact frame making for a super-stiff platform; and second, it thumbed its nose at conventional XC race frame geometry with a super-slack setup that was made for the steeps.