# is to build the world's most advanced bicycles.

Ambitious in the extreme. But attainable if you could bring together the right team and if the focus were precise:

Cut through the folklore, mythology, and the sheer inertia of what had passed for bicycle science. Apply the new technologies. Disciplines as diverse and fundamental as biomechanics, aerodynamics, and above all the new materials science. The singleminded goal would be the most advanced, most ruthlessly efficient performance bicycles.

Form would follow—cleanly and simply. Nostalgia would have no place here. But there would be a certain romance for those riders who share our vision.

**DEFINING PERFORMANCE.**

The first challenge was to get to the core of what determines bicycle performance without falling prey to the accumulated cant of a century of metalworking. Understand the forces that exist between rider and machine when they're being pushed to the limit. From this would follow the design parameters. The interplay of performance attributes that would *be* the ultimate bicycle: lateral stiffness for hillclimbing, stand-up sprints, and more subtly, for overall biomechanical efficiency. Resiliency and vibration damping for enhanced ride "feel" and reduced rider fatigue. Torsional rigidity for fast downhill tracking. Lightweight for all the obvious reasons. Suspension engineering that keeps the power on the ground by isolating the mass of frame and cyclist. True aerodynamics for road racing and triathlon.

One thing was clear early on—the sheer complexity of the design parameters dictated that the medium must be advanced composite materials. Continuous fiber one-piece frames. Because once you have the facts nothing else makes sense.

***"Get a pencil and list the qualities you'd expect in the ultimate bicycle frame. Congratulations. You've just reviewed the Kestrel."***
**—*Bicycling Magazine***

**THE UNIFRAME CONCEPT.**

The Kestrel design team is spearheaded by aerospace engineers. That is significant when you realize the cutting edge of the new materials science is aerospace. An industry that is defined by performance, and one that has disdain—they use the epithet "black aluminum"—for shackling the latest high technology composites to the traditional metalworking ways.

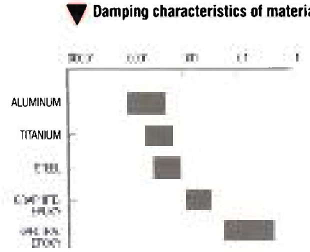
Free from the constraints of metallurgy, and working with a medium that lends itself to fluid shapes and continuous fiber flows, it was all but inevitable that our engineers would build every Kestrel as a one-piece structure. The Kestrel Uniframe™ designs that resulted, without joints or discontinuities, are not prone to the stress concentrations that are the bane of traditional frames and the cause of catastrophic failure in tube-and-lug composite frames. Terminating the fibers at the joints or at the rear stay junctions invalidates the concept, and the beauty, of the medium.

Bicycle enthusiasts are already familiar with many of the advantages of advanced composite materials. Phenomenal strength-to-weight ratios, superior fatigue life, and so on.

***"The more I learned about Kestrel's one-piece frame construction, the more I realized how consistent it was with my own ideas of optimal use of composites in aeronautics . . . The same kind of construction that went into the Voyager."***
***—Burt Rutan, Designer/Builder of the Record-Setting, Globe-Circling Voyager Aircraft***

But what eminently suits composites to engineered frame performance is a unique and arcane principle: anisotropy.

▼ **Damping characteristics of materials**




Data provided by Allied-Signal Inc.

Meaning that unlike metal, the properties of composite structures vary according to their specific fiber orientation. This allows literal "tuning" of the frame by adjusting fiber angles at specific locations on the frame.

The craftsman who hand-builds the Kestrel, layer by layer, changes weave, ply, and fiber alignment to build in the desired responsiveness at that point. Some layers are aligned straight across, others wrap around, and still others cross diagonally at precise angles. The right mix of layers, plies, and direction accomplishes the seemingly impossible. Like chainstays with both lateral and torque stiffness combined with vertical shock damping.

***"The Kestrel avoids the compromises between comfort and rigidity, and strength and lightness, that have plagued bicycle designers for a hundred years."***
**—*Bicycling Magazine***

▼ Ken Glah: Fastest bike split, Hawaii Ironman

The need for a powerful design tool is dictated by the almost infinite variability in the performance of composite structures implied by their anisotropic property. To fully exploit anisotropy, Kestrel engineers turned to Finite Element Analysis, or FEA. A computer modeling technique that isolates the forces on a structure and allows testing of thousands of approaches in the search for the optimal design.

But to realize the full potential of anisotropy there must be a continuous laminate—hence the enormous significance of Kestrel's true one-piece Uniframe design.

▼ Kestrel off-road suspension engineering

***"Once the idea of tubing is eliminated, the designer is free to pursue design properties that were never eligible for consideration before. If you want a frame to act like it is one piece, you shouldn't make it out of 16 separate pieces."***
**—*Cyclist Magazine***

**EXOTIC HYBRIDS.**

Carbon fiber (also called graphite) is the workhorse of advanced composites, but beyond carbon fiber there are the exotics: aramid, ceramic, boron, and most recently, Spectra®. Spectra® has the highest strength-to-weight ratio and impact resistance of any advanced composite fiber available. Yet it also has the highest shock damping characteristics. It is this superior vibration damping property which has allowed Kestrel to actually suspension engineer their frames by means of a shock damping rear structure of Spectra®/graphite formed over a foam core.

***"The bike tracked the road so flawlessly I was convinced it had sprung suspension. The overall effect is a 'tuned' frameset, with qualities unlike anything I've ridden before."***
**—*Bicycle Guide***

▼ Gas shock/swing arm suspension