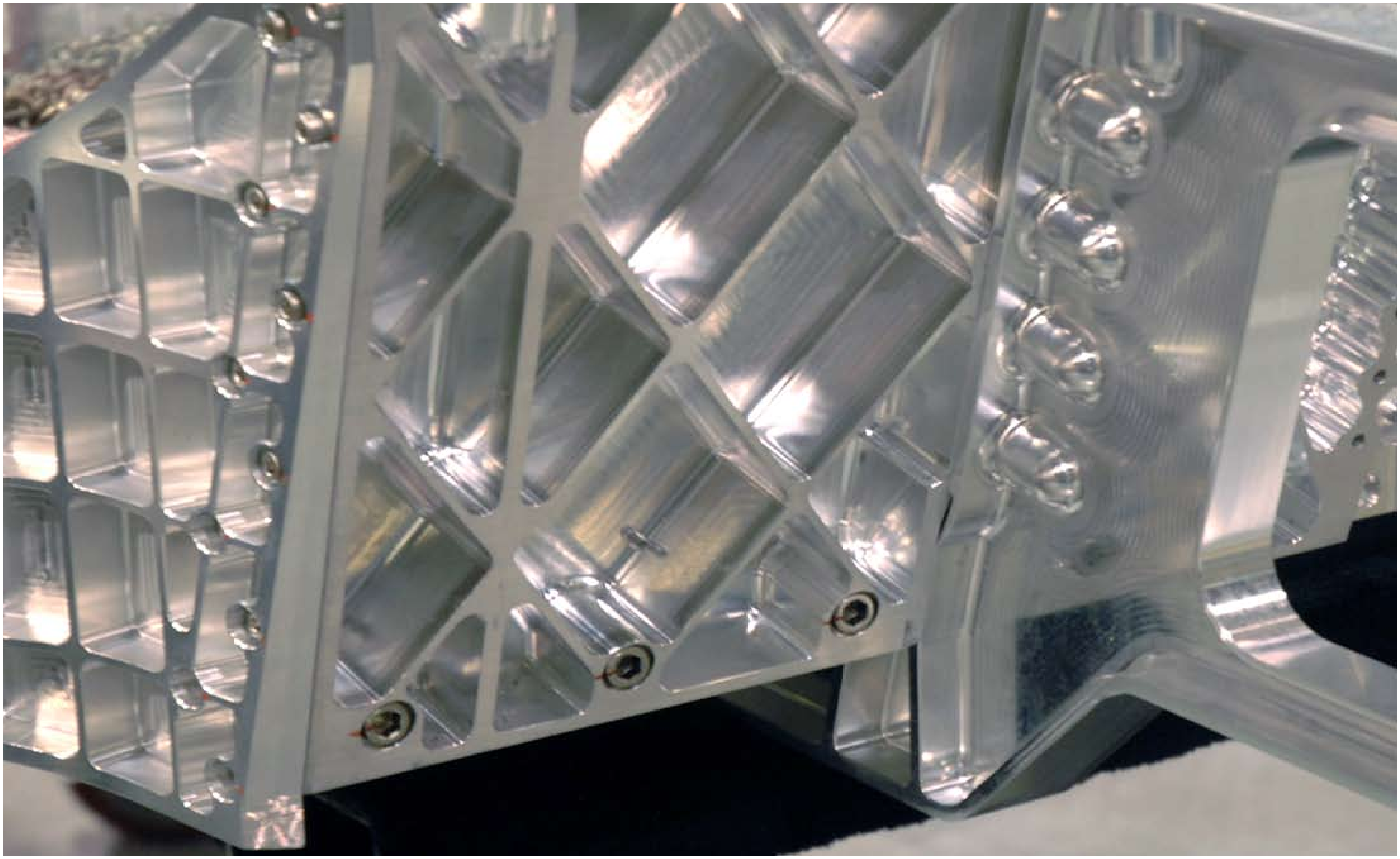
BILLET CHASSIS

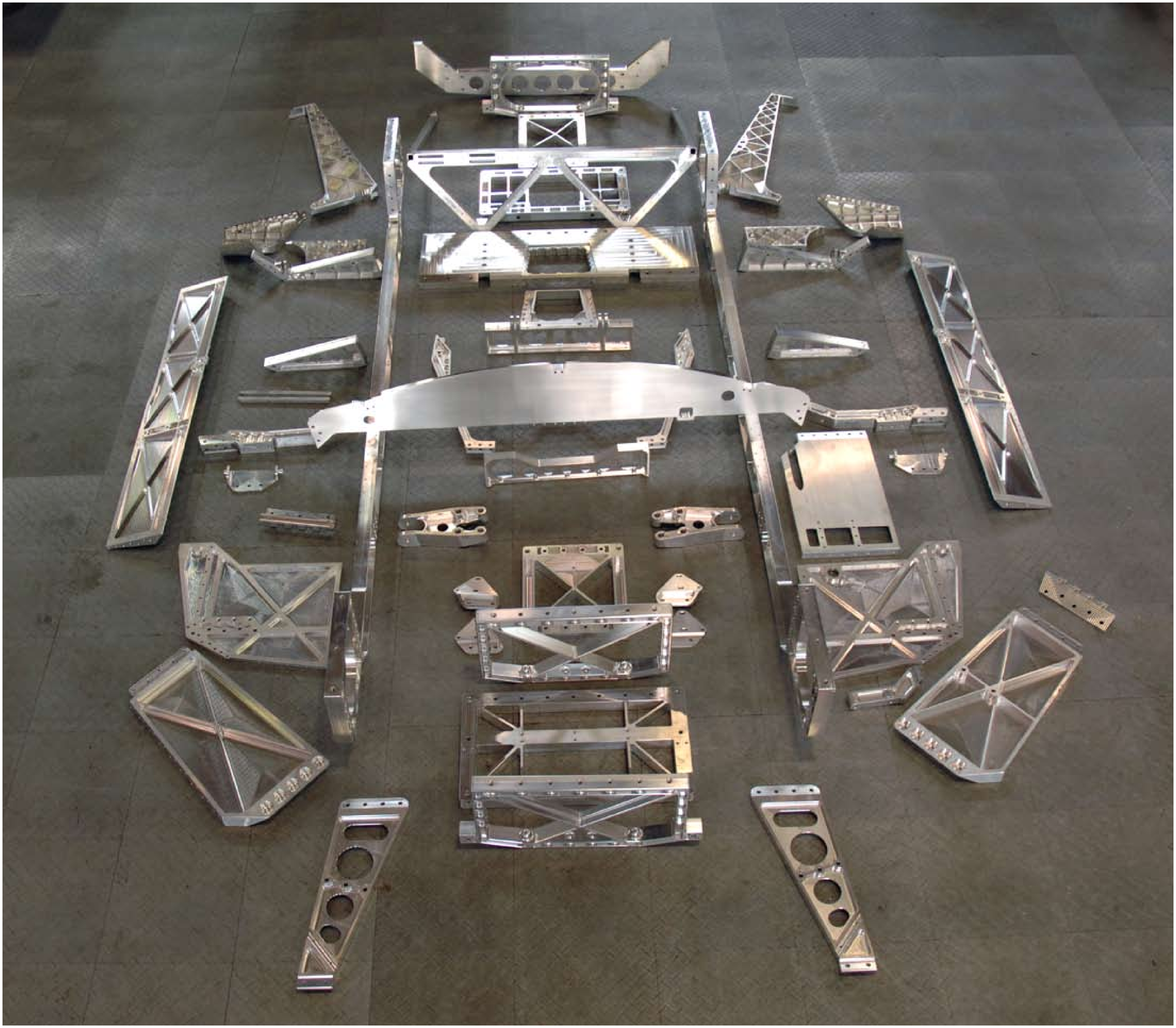
No problem can stand the assault of sustained thinking.

Voltaire



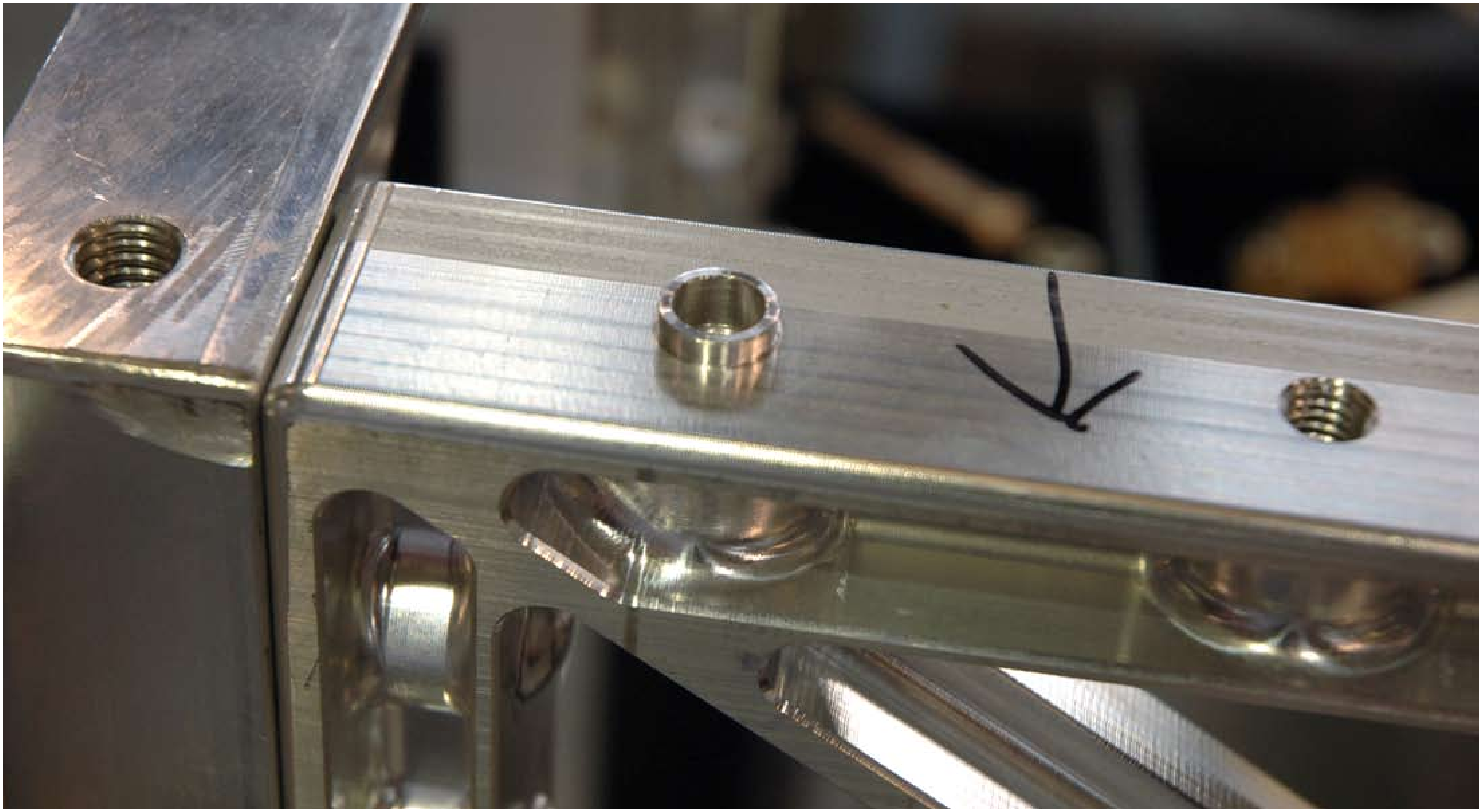
It's astonishing. What a magnificent metal sculpture.
—Larry Ellison

We could have used any number of materials to make the chassis—carbon fiber, steel, even stainless steel. Why did we choose billet aluminum? Steel construction has been around for over 100 years, and we wanted to do something no one had ever done before. Aluminum is light, strong, and machinable into exceptional shapes—limited only by the machinist's creative mind and will to succeed. Engineers dream of making products that will solve whatever problem confronts them. A solid block of aluminum demands to be carved into something useful, something beautiful. Though a simple block of aluminum will suffice to make a seemingly insignificant bracket, what would happen if that bracket were given to an engineer to make it lighter, stronger? What would happen if that engineer then exercised strict weight discipline to make it even lighter still—say, to the extreme? What would happen if we then gave the engineered bracket to an artist who could transform harsh engineering edges into a graceful genesis of beauty?



All of the parts that make up the billet chassis. There are thousands of holes and myriad angles that all have to line up—and work.

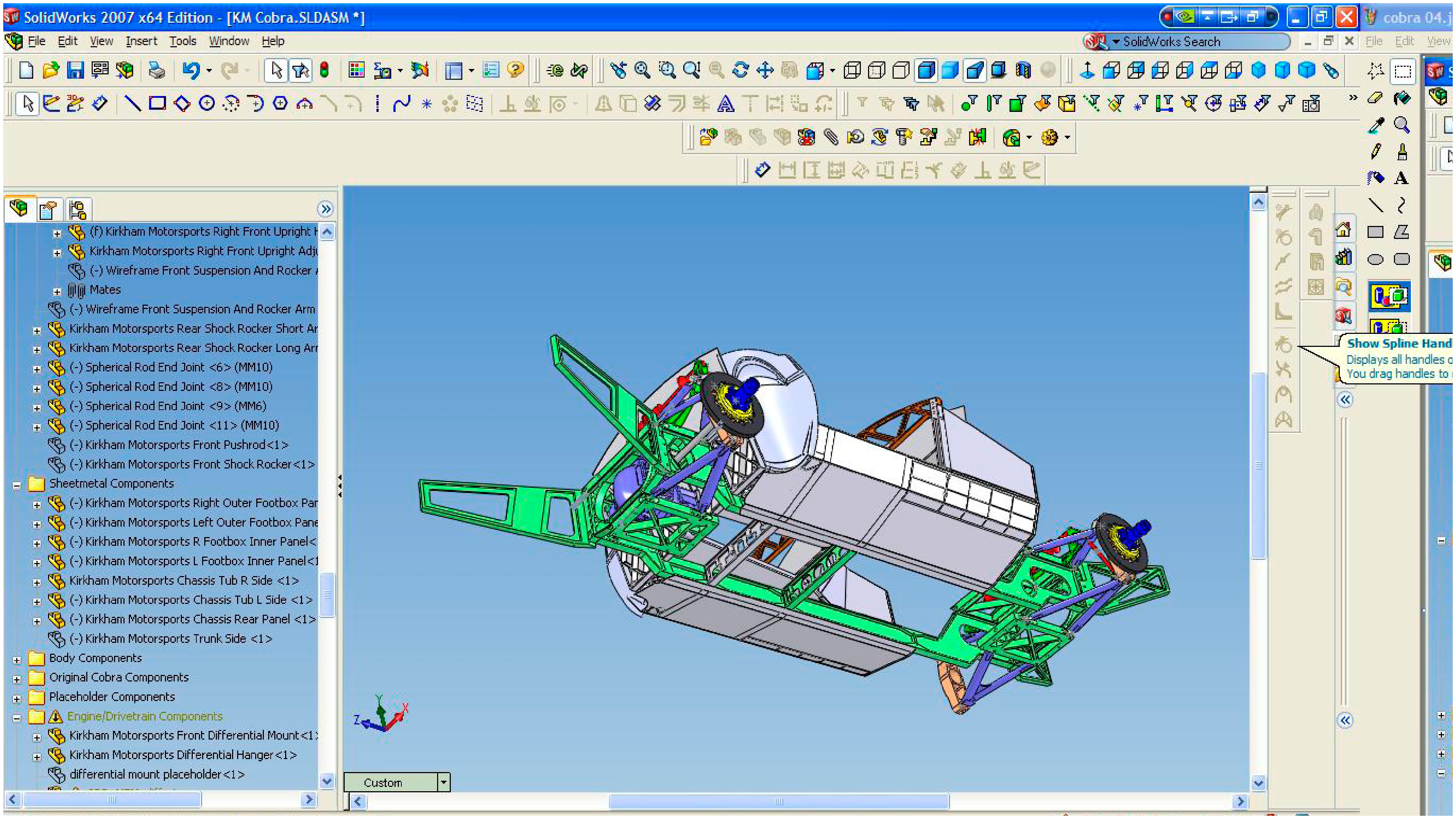
The world has never seen a billet chassis, although when I proposed it to Larry, I couldn't see a reason why one could not be made. But, when I called our friends and customers in the racing world and asked them about an aluminum chassis, they all told me I was crazy. They told me about the 1971–1972 Porsche 917 chassis that were made out of aluminum and prone to cracking failures. To predict the failures, Porsche welded Schrader valves into their chassis tubes and mounted a gauge onto another bung in the chassis. Before a race the team pressurized the chassis with air; every time the car came into a pit stop, they checked the pressure gauge. If the chassis lost pressure, they knew they had a fatigue crack somewhere in the chassis. Porsche engineers are very bright; if they thought aluminum could save them weight, then I reasoned I should be able to use it as well. I just had to figure out how. Welding was not an option, as welding takes the heat treat out of aluminum, cutting its strength in half (as evidenced by the Porsche 917s). There had to be another way.



Chassis components are doweled together—like an engine's connecting rod. The bolt then passes through the dowel.

I began to notice highly stressed parts were bolted together—heads were bolted onto engine blocks and brake caliper halves were bolted together. Maybe I could bolt a chassis together as well. The last key to solving the puzzle came when I looked at a connecting rod and noticed the two halves were bolted together. The rod and cap halves were aligned by a hollow dowel. We could bolt the chassis together the same way—problem solved!

Countless hours were spent thinking, engineering, designing, programming, revising, and creating this car. One of the problems with the original Cobra is the suspension pick-up points are not in the optimal place. This is not the fault of the original designers because back in the 60's, they didn't have the benefit of CAD and CNC machinery to make their parts. Utilizing the latest technology, we knew we could make a better car. When a tubular steel chassis is welded together, it always warps from the welding process. When the steel tubes warp, suspension pick-up points move all over the place, messing up the kinematics of the suspension. Exact CNC milling, then doweling and bolting the chassis together, allowed us to hold the suspension points exactly where we designed them to be.



To get a base-line for our design, we digitized an original chassis and ran it through FEA (Finite Element Analysis). In FEA we can take a part and stress it so we can see what is happening to the part as it goes down the road. If an area of a part flexes too much, we add material to stiffen the part. If an area of a part is too massive and doesn't flex at all, we remove material to even out stresses and save weight.

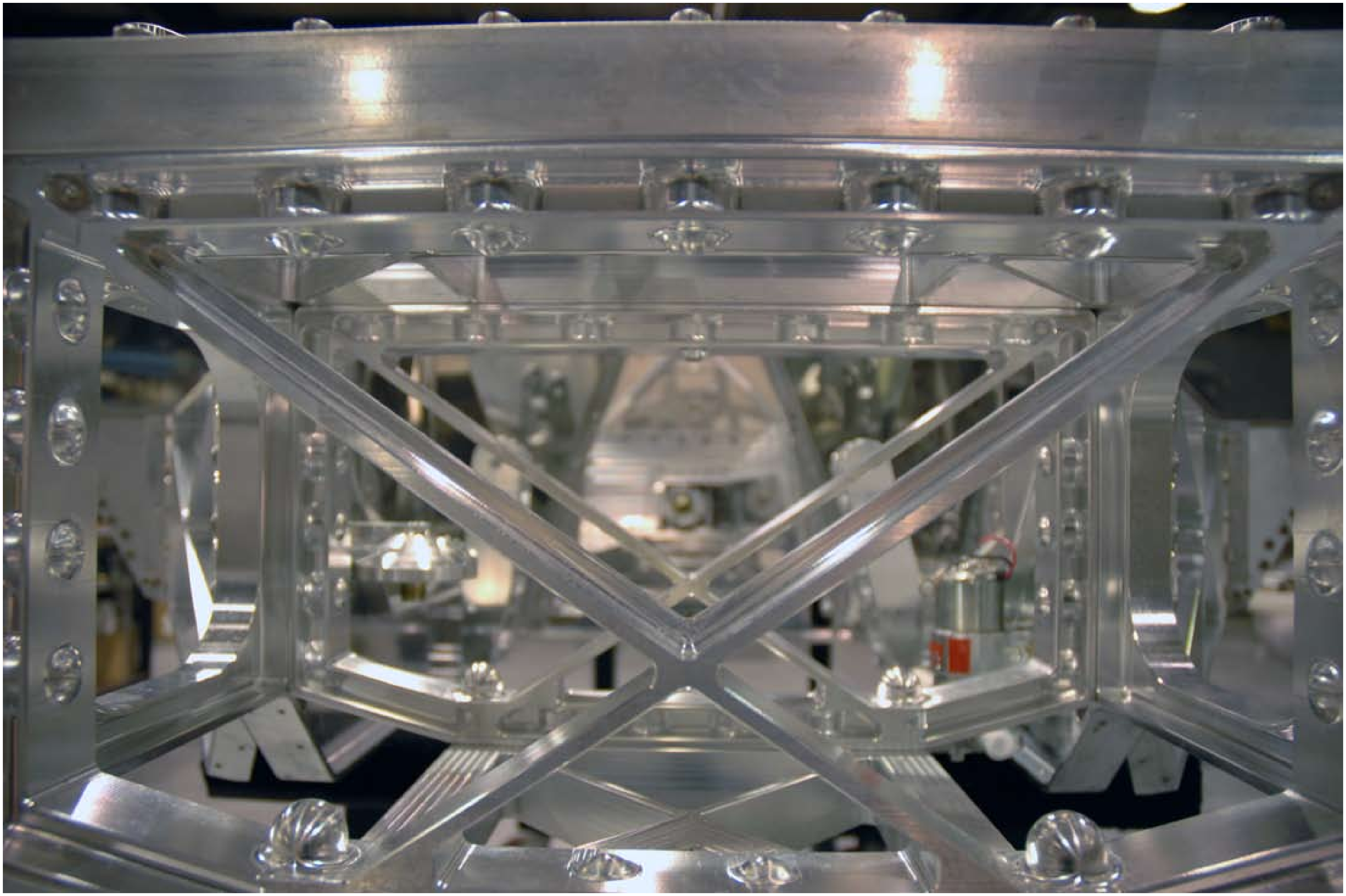
As we flex a part in the computer, the program colors the part with different colors. The different colors represent varying levels of stress that are induced into the part by loading it. By analyzing an original chassis, we discovered the original 427 Cobra chassis had a stiffness of 1450 foot pounds/degree of deflection. Analysis of the billet aluminum chassis showed a stiffness of close to 4500 foot pounds/degree of deflection, or a 300% improvement over an original chassis (actual stiffness is a little lower because we did not perfectly model the bolted-together joints).

In the main frame tubes of the cars we currently make, we use a 0.035 inch thicker tube than what is used in an original car. The thicker tube increases our chassis stiffness (over an original chassis) by 14% to 1650 foot pounds/degree of deflection.

Even a seemingly small 14% increase in stiffness in a chassis is quite noticeable to a driver. For comparison, a "super-car" (like a McLaren F1) typically has a stiffness of 10,000 foot pounds/degree of deflection—though a super car has a roof, which is an enormous help in torsional rigidity.

How did we get the stiffness so high, especially considering aluminum is only one third as stiff as steel? The stiffness of an object depends on the material used to make it (think glass is stiffer than paper) and the geometry of the object itself (think of a flat sheet of paper vs. a box made out of that same paper). We were able to increase the stiffness of the billet chassis by using tall door sills and spreading them far apart. We also made an innovative billet aluminum bulkhead in the rear to carry the suspension loads forward. The structure of the chassis is very similar to how an airplane is built with a stressed outer skin on longerons.

We bolted the sheet metal down to long frame rails to transfer as much of the load as possible to the outer surfaces of the sheet metal. We separated the floor pan from the belly pan by 4 inches (the height of the frame rails). We moved the sheet metal as far apart as possible because the further you can move mass from the neutral axis, the stiffer a part will be (think about an "I" beam). Finally, we stressed the tunnel to help transfer the loads front to rear. In fact, we made every part possible perform multiple duty—achieve its original function and, if possible, contribute to the overall stiffness of the entire chassis.



Looking through the front suspension box and down the transmission tunnel of the finished chassis.

Opposite: The wall thicknesses of the bolt bosses and the stiffening ribs is identical in the firewall to create as smooth a flow as possible for all the stresses. All possible material was removed to save weight. Every blind bolt (a bolt without a nut on the other side) was painted after it was properly torqued. The plate that makes the top of the footbox is 1 inch thick to minimize pedal flex under extreme braking.