



## Road Sailing

### **The T-Zero sporty electric car challenges drivers to learn how to make clean living fun**

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Alan Cocconi looks like one of those guys with burning eyes that Hollywood always casts as a mad scientist whose crazy idea turns out to actually work. Ka-Zowie! See the world saved in the last reel!

The real world hasn't quite come to the closing credits, or so we can hope, and neither is this particular scientist really a nutter. But he is an ardent mountain biker. That means he loves clean air and it follows that his work to preserve it is fueled by passion. And by fuel - part-time.

Hybrid gasoline/electric automobiles are no longer novelties, but his particular approach is unusual. Alan Cocconi's eponymic AC Propulsion Corp. of San Dimas, Calif., is working with the state's South Coast Air Quality Management District to develop a relatively lightweight, battery powered, high-performance sports car, plus an optional small trailer containing a gasoline-burning, computer-governed generator for use on extended trips.

The AQMD's main interest is the "range extender" trailer, which is called - what else? - The Long Ranger. The present prototype houses a 500-cc Kawasaki motorcycle's water-cooled parallel-twin driving a hot-rodded generator from a jet aircraft engine. Cocconi calls it a "genset" and claims its 20-kilowatt output can keep the hybrid cruising at 75 to 80 mph for as long as the 9.5 gallons of gas hold out, upward of 300 miles. Around town, Cocconi says, intelligent, sensitive use of EV driving and recharging techniques can raise the effective miles per gallon to as much as 200.

The stubby Long Ranger also features BackTracker, AC Propulsion's own electronic self-steering system for automatic highway stability and no-brainer backing up.

What's the point of an EV that hauls around 350 pounds of petroleum power plant? Simply

to optimize its EV-ness: to let its driver shut off-and even drop off-the genset when circumstances permit.

Cocconi explains: "Our experience with hybrids shows that, typically, only 20 percent of your miles are fuel-powered. The rest of the time you're running on battery."

And running fast, in this case. This little red flier is a simple, doorless two-seater said to weigh 2400 pounds and to pack 220 horsepower, an equation promising the acceleration of a Corvette with the handling of a racer. Indeed, the space-frame chassis, all-independent suspension and non-assisted rack-and-pinion steering derive from Formula Ford practice.

The name tzero comes from a scientific symbol that signifies the "beginning point in time." Unveiled last winter (AW, Jan. 13), this first tzero is still very much a prototype, although eventual limited production is planned.

Cocconi, 39, earned his engineering degree at Cal Tech. A specialist in high-power electrical circuitry, he spent several years consulting for GM on the SunRaycer, winner of the 1987 Solar Challenge in Australia, and also on the 1990 Impact, prototype of the present EV1.

AC Propulsion was founded in 1992. Today, much of the firm's work involves high-performance powerpacks for the quietly growing electric vehicle racing world. The same proven hardware was the basis for Cocconi's first hybrid street system, which he installed in a Honda CRX. Using an earlier prototype of his genset, Cocconi and his girlfriend Janet (whom he met on a Sierra club hike) demonstrated the hybrid's range potential in 1995 by driving cross-country from Los Angeles to Washington D.C. and back. Later that year, in a newer hybrid based on a four-seater Civic CX, they repeated the trip. This car is still Cocconi's daily commuter. (The personal relationship also endures.)

AC Propulsion was now ready to attract attention, and the tzero project was conceived as the means. Emphasis on high performance called for a purpose-built lightweight car. To save time, the California company came to an arrangement with Michigan engineer David Piontek, who was making a stark little motorcycle-engined roadster he called the Sportech.

However, the tzero differs considerably from the Sportech. The steel tube chassis and glass fiber bodywork have been re-engineered, and due mainly to the 28 Optima lead-acid automotive batteries inside the body sills, curb weight is about double.

Mounted amidships, as was the transverse four Suzuki in the Sportech, the air-cooled, AC induction motor weighs 110 pounds and puts out the electrical equivalent of 220 hp (165 kilowatts). An electronic control unit adds another 70 pounds. Using a control technique called field weakening, Cocconi has tuned the motor's power curve to crest at 6000 rpm, and to stay crested all the way to the 12,000-rpm redline. The 180 lb. ft of torque, by contrast, comes on full-strength at zero rpm when the accelerator is floored. Traction control is an essential part of the package to prevent wild wheelspin.

There is no clutch or torque converter, however, and the modified Honda transaxle contains only a single forward gear ratio, plus reverse. The ratio presently installed limits top speed to 90 mph, but 0-to-60-mph acceleration has been timed at 4.9 seconds, sans trailer. Even with the Long Ranger hooked up, we recently discovered, driving the tzero is (pardon the

expression) a gas.

Drop any preconceptions involving golf carts. Hoisting legs over the rather tall side-sill - there are plans to lower it in the next iteration - and slithering them down into the footwell is a race car maneuver. So is buckling into the four-point safety harness.

Flicking switches brings the dashboard alive like the command console of a starship. The array of 28 tiny lights above the steering wheel hub has to do with battery condition. Rather than try to explain it all to an EV novice, Cocconi says to ignore it for now. More familiar looking is a gauge resembling a tach, but this turns out to be an ammeter indicating charge to the left of the 12 o'clock zero point, and discharge to the right. Inset in this dial is another one showing battery voltage.

At least the 120-mph speedometer is what it seems to be. So is the odometer, which indicates that the prototype tzero has covered more than 8500 miles to date.

To the left of the instrument cluster is a rocker switch. This toggles between forward and reverse gears, while a yellow button selects neutral. To the right of the speedometer is a lever to select the degree of regenerative braking - up for less, down for more. Farther right sits a temperature gauge to monitor the motor, and next comes a multifunction LCD computer readout.

Below the radio (nonfunctional at present), the pedestal between the seats houses controls for the trailer generator. Cocconi leaves that off for now, and tells us to turn the "ignition" key, toggle into the forward gear, and step on the right-side pedal.

A moment later he wants to know what we're waiting for.

Well, for something to happen. Like an engine to start up. Like a clutch that needs to be operated, or something. How about just noise?

tzero rookies have a lot to learn. Indeed, getting the best performance out of this electric extrovert would take the same sort of study, experience and environmental awareness demanded by such arts as sailing. There's a *lot* going on.

Item: Cocconi wears a watch incorporating an altimeter, and refers to it constantly. But he says that just from the behavior of the charging system, he builds up a good mental image of the terrain he's traversing.

Item: Terrain awareness is important. It's a big mistake to start a long, steep descent with the Optima batteries charged up full. Regenerative braking - using the motor as a generator - requires someplace for the electrical energy to go, and for this the tzero offers only its batteries. But relying solely on the aluminum-rotor wheel brakes is considered unwise. Alan, who spends all the time he can in the mountains, once forgot to shut off the genset early enough and had to drive around the summit for a while to draw down the batteries before heading downhill.

Item: Perhaps surprisingly, it's not necessarily a mistake to let the batteries die atop that mountain. One evening after a TV shoot with his Civic, pre-trailer, Alan found himself atop L.A.'s 5600-foot Mount Wilson with no juice left. No problem. Regenerative braking on

the descent built up enough charge to get on home across the flat lands.

Energy management is not the only way that tzero travel resembles sailing. This environmentally conscious conveyance keeps us continually aware of the environment. Though not harsh, the racerish suspension lets every quality of the road surface come through. The lack of side windows bring every nuance of ambience inside, and at freeway speeds wind noise makes conversation hard work. Despite the hinge up roof, weather protection is minimal, and during our trip the sight of rain ahead prompted a route rethink.

On a sinuous mountain road, the tzero is a joy to drive hard. Chassis tuning is partly the work of the FF racer Tom Gage, who is AC Propulsion's business manger, and his contribution can be felt in the taut ride, light and talkative steering, and nimble but stable handling. The specially made Toyo tires behave well.

What about the Long Ranger back there? We don't try leaving it behind, partly because we seldom think of doing so - it is that unobtrusive. Apparently, the self-steering system makes the trailer do its own work and prevents any detectable influence on the tzero's handling. More importantly, as Cocconi points out, the BackTracker damps out the oscillations to which the short-coupled trailers are prone when running straight.

He does add that BackTracker is suitable only for short trailers, because of its behavior in tight corners. A yaw-sensor in the hitch ball feeds a computer, which controls an electric steering system for the trailer wheels. This all but cancels any angle at the hitch, so the trailer stays virtually in line with the car. This means its rear end runs wide in sharp turns, including when reversing.

For the driver, laboriously learned trailer-backing techniques have to be unlearned. The trailer is treated simply as a rigid extension of the car, like a pickup bed, with one exception: speed. Going too fast in reverse can confuse the computer and allow sudden jack-knifing.

Shedding the Long Ranger's mass might improve performance a bit, but it's ample as is. Altitude has no effect on the power level, of course, though battery state does. At optimum charge there's no lack of lunge, and the tzero/Long Ranger hybrid storms between corners like any satisfying performance car. This endearing little road racer even sounds the part, as multiple whines from the transmission make up for the silent motor.

A fortunately brief encounter with wet pavement demonstrates the value of the traction control, when an injudicious stab at the accelerator gets the tail - and the trailer - half-sideways before the electronic control steps in.

But after several miles of our heavy-footed assault on the mountain, Alan points to the electric motor's temperature gauge and calls for a breather. He plans more work on the air-cooled casing.

For our part, we start listening more carefully to the tzero's creator and try driving his way, with energy conservation more in mind. Mainly, that means cranking up the level of regenerative braking (it feels like compression-braking from lifting the accelerator of a conventional car), staying off the wheel brakes, and carrying speed through turns as in a race car-wheel! Of course, our venture into the wilderness is only possible with the genset

trailing along. It does not have to operate all the time, which is good, because the little twin usually has to go all-out to move enough electrons. The resulting heavy, steady drone is not too obtrusive on the truck-infested freeway, but it can be annoying in quiet neighborhoods.

To Alan Cocconi, figuring out optimal deployment of the generator is all part of the fun. Watching the LCD computer display, and evaluation terrain and traffic (and our driving, no doubt), he decides to silence the genset about 30 miles from home base. On arrival, the tzero still has 33 amp-hours (of 45 max) showing on the display. We suppose that might be enough for another 60 or 80 careful miles.

But after our extended-range day trip of 186.29 miles, the Long Ranger has burned 4.369 gallons of premium. That works out to 42.6 mpg, impressive for the performance we've enjoyed. An even better number would have come up had we relied on the batteries for more than the 9.1 kilowatt-hours recorded by the computer. And if we ever became skilled at this road-sailing game...

That's the sporting challenge here: learning how to make clean living fun. AC Propulsion hopes that will stir enough enthusiasts for both sports cars and the environment to make a production run of from 30 to 50 tzeros possible. But as a hand-built car, it can't be cheap. The company anticipates a selling price of about \$80,000 for the car itself, plus \$20,000 for the Long Ranger.

To the Air Quality Management people, of course, the "range extender" is the important end of the program. Hitched to any EV, it could help reduce market resistance to recharging - dependent vehicles.

And Cocconi could get back on his mountain bike knowing that his trailer has helped to keep the terrestrial movie running.