LEAN MACHINE

Logic and substance from the Dreamer's Workshop

BY PETER EGAN

Project manager Jerry Williams lowers canopy for test drive.

NINE YEARS AGO, when the Arab Embargo fuel crisis was at its worst and people nervously wondered how they were going to get to work and the nearest Taco Bell, General Motors' Vice President of Engineering Frank Winchell noticed something. He observed that most people on Detroit's freeways were going to work solo, lost in their big almost empty cars. To Mr Winchell, an automobile looked like a lot of equipment to move a person from one spot to another. While the average driver was only 15 or 16 in. wide, the typical car was about 6 ft wide and occupied an entire lane of blacktop. It didn't seem right.

Car pools and motorcycles were obvious and immediate answers, but both had—and still have—a few shortcomings. The car pool is a fine way to deliver a load of people with one vehicle, but it requires planning and patience. Planning to find out when everybody is ready to go somewhere and patience to sit quietly fogging up the windows in a cramped car while your colleagues shave, gulp orange juice, search for mislaid reading glasses, pat the dog and finish whatever else it is they're doing in there. Cooperation is fine, but the great American tradition of going places when we damned well feel like it is lost.

Motorcycles offer far more freedom. They are wonderfully narrow and compact and extremely frugal with fuel. As everyday commuter vehicles, however, they require (a) reasonably good weather and (b) operators who possess at least a modicum of adventure. Research has shown that a very large percentage of the American public will not ride, touch, be seen on or go near a motorcycle under any circumstances, no matter what, so long as they all shall live amen.

The challenge, then, was to come up with a vehicle that seals out the bad weather, gets extraordinary mileage, occupies little more parking and road space than a motorcycle and doesn't intimidate its driver by tipping over on slippery pavement.

Those last two, as seen by Frank Winchell, were difficult, as narrowness and a reluctance to flip and tumble are mutually exclusive traits in a 3- or 4-wheel vehicle. A motorcycle, like a running human, maintains stability by leaning into a turn. Leaning moves the center of mass away from the contact patch (tire or tennis shoe), allowing gravity to balance the centrifugal force pulling outward on the center of mass. The faster the corner is taken, the more lean is needed to counter the centrifugal force.

Cars do not lean into a corner, of course, so the centrifugal force on the center of mass is handled by a weight shift to the outside tires. This is fine, as long as the car has an adequately low center of gravity and a wide enough track. But raise the cg or narrow the track too much and you've got trouble—the road-going counterpart of Wilt Chamberlain standing up in a canoe. And the road-going counterpart of getting wet is, in this case, getting killed, or at least skidding down the pavement on non-rolling parts of the vehicle.

Bad form.

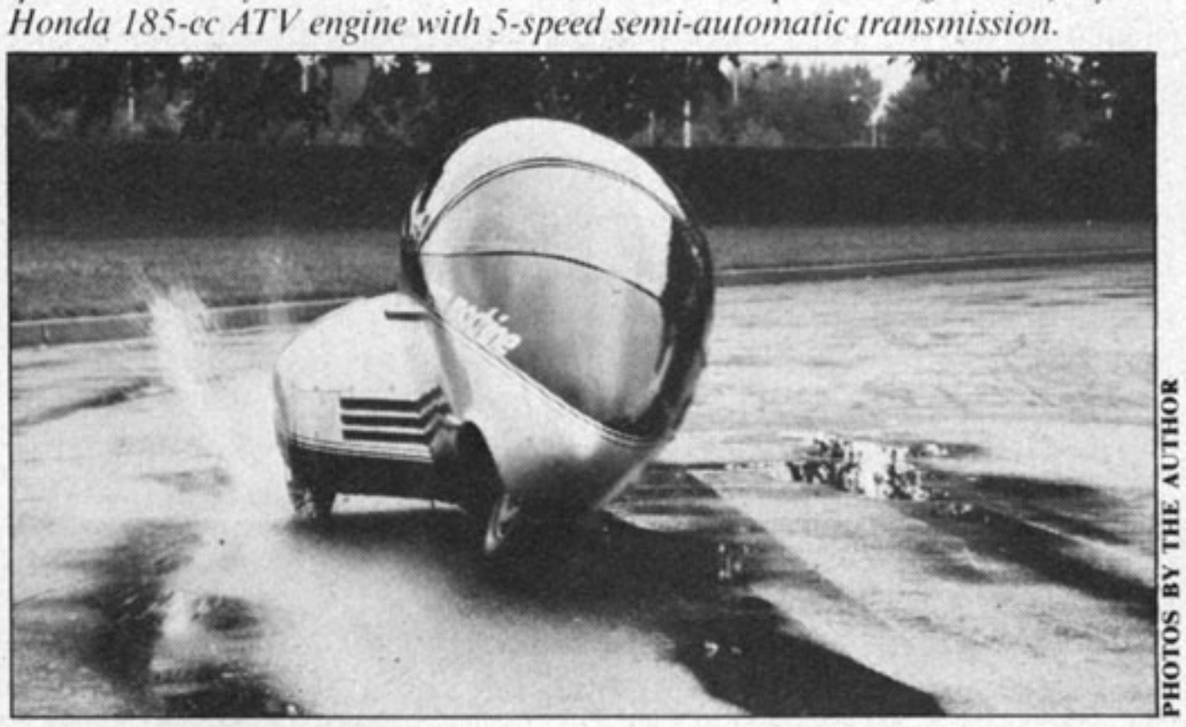
So to get the narrowness and stability he wanted, Winchell decided to build a 3-wheeler that leaned, driver and all, into corners, and to make the degree of lean easily controlled by the driver. Using a 3-wheel design with the single wheel in front would not only allow the machine to lean, but would also permit a very small frontal area for the driver's compartment, or pod, for low drag and high efficiency.

This is all a long-winded way of explaining the shape and existence of the strange-looking vehicle in these photographs. GM gave Winchell and a small band of engineers and techni-

cians free rein to develop the idea, and they spent more than seven years building prototypes of increasingly sophisticated design. The Lean Machine, pictured here, is the 15th and latest version to come out of the GM Advance Product Engineering labs. Many small details remain to be worked out on the machine, mostly ergonometric in nature, but the basic concept is well enough developed that GM was able to offer us a test drive. Being an ex-motorcycle racer of some enthusiasm and no great talent, I was picked as designated scapegoat and packed onto the first plane to Detroit, notepad and camera in hand.

I arrived on a rainy (but clearing any minute) Wednesday, explained my way through three or four security guards, got a plastic laminated security badge while watching myself on a TV monitor, and was led into the bowels of the GM Engineering

GM's experimental Lean Machine allows driver pod and front wheel to lean into corner while rear engine module stays level, permitting high cornering speeds with only a 28.0-in. rear track. Power is provided (for now) by a Honda 185-cc ATV engine with 5-speed semi-automatic transmission.



PHOTOS BY THE AUTHOR

Leaning pod looks strange from rear but feels fine from driver's seat. Clean shape and light weight (350 lb) have enabled Lean Machine to achieve 80 mph and 120 mpg with modest 12-15 bhp engine. Open rear hatch normally covers pull-starter handle.

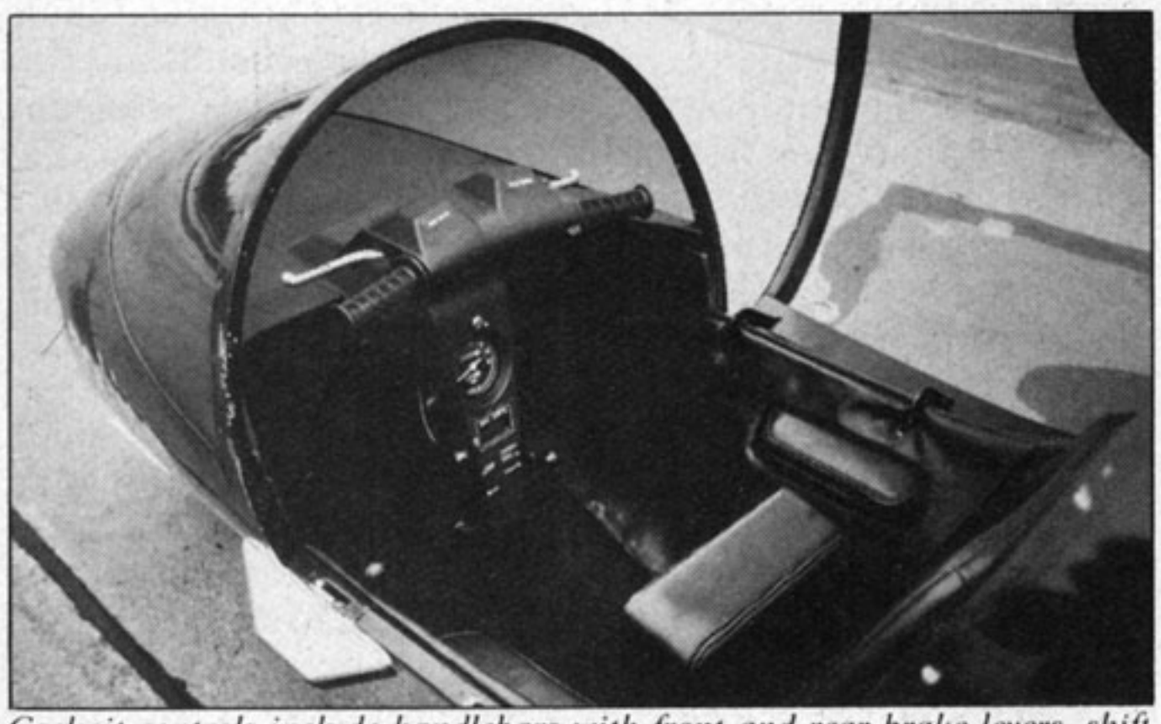
building by Jerry Williams, project manager on the Lean Machine. Jerry introduced me to Clark Irwin, the machine's draftsman and designer, and Darrel Landmesser, who, together with Ken Whitelam, did the fabrication and mechanical work on the vehicle. Frank Winchell, who retired last April, was not present.

First impressions of the Lean Machine are that it's low, very sleek and good looking; compact but not so diminutive that it looks toylike. Dimensionally, it's 103.0 in. long and only 47.0 in. tall, with a wheelbase of 72.0 in. and a rear track of 28.0 in. I was told that the weight was about 350 lb, which is about 100 lb lighter than the average 550-cc street motorcycle. Not bad. A closer inspection showed the finish and craftsmanship to be first rate, despite protests by its builders that much of the fine detail work remains to be done. With one of the upper body panels and the Lexan canopy removed, I was able to peer down into the front of the bodywork to see how the thing was put together.

The Lean Machine has all-aluminum bodywork (0.032 and 0.025 in. 2024T3 aircraft aluminum) riveted into a monocoque from the driver's compartment forward, which probably accounts for its remarkable lightness. The pod rotates around an axis formed by a single, large-diameter tube that extends from the rear drive module forward to the nose. The body is mounted on this central pipe with a roller bearing at the front and a plain bronze bearing at the rear. Body roll around the axis is controlled by a pair of foot pedals connected to a cable-and-pulley system that winds and unwinds almost like the steering on a soapbox racer.

Small-diameter Showa motorcycle forks, intended for use on a 50- to 100-cc bike, are bolted to the front monocoque bulkhead via a tubular steering head bracket that spreads the load to the body. The forks and front wheel lean with the pod, independent of the axis tube. A 3.00-10 Goodyear minibike tire and a chromed steel wheel are used at the front. Extreme forward placement of the front forks makes it impossible to bolt the handlebars to the top triple-clamp, motorcycle style, so the handlebars are moved 18 in. to the rear, steering the forks through a single Heim-jointed drag link.

Hidden inside the rear engine enclosure is a stock Honda 185-cc ATV engine and 5-speed semi-automatic transmission. The engine drives the rear wheels through a Peerless garden tractor differential with axles fabricated by the GM staff. The axles are



Cockpit controls include handlebars with front and rear brake levers, shift lever knob on left side of console and an upright position locking device on right. Foot pedals (not visible) in nose control degree of lean. Seat folds up for easy ingress/egress.

located by trailing arms and sprung by vertical coil-over shocks from the rear of a 200-cc motorcycle. Goodyear 4.80-8 boat trailer tires and 8 x 5 aluminum wheels are used at the rear.

Because the engine has a lawnmower-type recoil starter, there is a small trapdoor in the rear bodywork to cover the handle on the pull rope. The engine has two clutches, one centrifugal and the other mechanical. The centrifugal clutch allows the vehicle to idle at stops and then pull away when the engine is revved, and the mechanical clutch is automatically disengaged by the gearchange mechanism when shifts are made. Shifting is done with a short lever on the center console of the driver's compartment (a downstroke of the lever for each upshift).

Front and rear disc brakes are operated with two motorcycle levers on the handlebars. Other instrumentation and controls include an 80-mph speedometer, a digital oil temp gauge and a ratcheting anti-flopover lever to lock the machine upright when it's at rest.

Considerable wind tunnel work was done on body shapes to make the vehicle as slippery as possible. The results were a decent, if not great, drag coefficient of 0.35, good for a top speed of around 80 mph and steady-state 40-mph fuel economy of 120 mpg with the 12–15 bhp the Honda engine is cranking out. The design team, however, has come up with a teardrop-tail aero body that their computer tells them should have the amazingly low drag coefficient of 0.15. That body, with the proposed installation of a 38-bhp engine, should (in the considered opinion of this same reputable computer) produce steady-state fuel con- ➠

sumption of more than 200 mpg, with an EPA combined city/highway rating of about 150 mpg and 0–60 acceleration of 6.8 seconds. In the real world of mirrors, rivets, dirt, etc, those figures may drop a bit, but even if the drag is compromised out to 0.20 or 0.25, the next Lean Machine will be anything but a gas-guzzler. Especially if the current working model is any preview.

So the machine is low, slick, efficient, narrow, reasonably fast and it leans. But can a normal human being, or in this case someone who is only "slightly odd," hop right into the Lean Machine and drive it?

"No," I was told. "The Lean Machine has its own learning curve, like a car or motorcycle. It's a new, different type of vehicle and it requires practice and training to master. No one gets into a car or on a motorcycle the first time and expects to drive or ride in complete confidence. The Lean Machine is the same sort of thing . . ." Williams told me a small, underpowered bare-bones practice vehicle was normally used to get people accustomed to the dynamics and control of the Lean Machine, but as this was down for repairs I would have to do my apprenticeship in the big one.

To give me some harmless practice, then, we took the vehicle out to the GM skidpad where I could accustom myself to the unusual controls without threat of curbs, trees and other frame-bending distractions. The Lexan canopy was removed so I could hear instructions, or at least shout for help occasionally.

I eased myself into the cockpit, sliding into a semi-reclining position with my feet resting in the stirrup-like pedals that control the degree of lean. Padded elbow rests held my arms in a relaxed reach to the handlebars. The seat was comfortable as a lawn chair, though more snug, and it occurred to me the cockpit would be the perfect place for a quick siesta (much like the office chair in front of my typewriter) or a roadside nap.

"Push the foot pedal toward the thing you want to avoid," Jerry Williams told me, "and the machine will lean away from it." He released the upright position lock and Irwin and Landmesser supported the pod while I got a feel for rolling it back and forth with the pedals. It worked, in effect, like a kid's sled or coaster car that you steer with your feet. In a turn you draw back with the inside foot and push with the outside foot; a fairly natural movement, though a reverse control for someone who has just learned to fly and bank airplanes. At a standstill the pod felt a bit tippy and it took an alert, balanced pedal pressure to keep it upright. Williams assured me it was much easier when the vehicle was rolling.

"You can steer almost entirely with the foot pedals," Williams added, "but you take the pressure off your leg muscles by turning the handlebars toward the leg taking all the load. You make it easy to drive by achieving a balance between the foot pedals and the handlebars."

Someone gave a couple tugs on the pull rope and the engine started. "Go out and try it," Williams said, "and when you come back in don't forget to keep balancing with your feet when you stop. Some people relax when they stop and the machine flops over on its side. It doesn't hurt anything," he said, patting the rubber bump stop on the side of the body, "but this thing will lean over 50 degrees and the sudden tilt is a little bit of surprise."

I twisted the throttle and motored around the skidpad using only 1st and 2nd gears, doing circles in both directions and then figure-eights to get the feel of the machine. It worked pretty much as billed; you steer primarily with the feet and balance the turn with the bars, and the amount of lean is just an instinctive feel. When you lean the correct amount for a given speed and severity of turn, there is no sideload on your body. It feels like a motorcycle, meaning you could take a fast ride on a winding road without any of the seasick effect a car sometimes creates.

While the size of the skidpad and a wet surface from the recent rain kept me pretty well locked into 2nd gear and the lower end of 3rd, I was amazed at the quick acceleration for a vehicle with only a 185-cc 4-stroke engine pushing it down the road. There are plans for a larger-engine version, but it would take most people, me included, a long time to get bored with the 185-cc model. Favorable power-to-weight, coupled with good aerodynamics, is a wonderful thing. The low seating position and close proximity to the road add to the enjoyable sensation of speed.

More than that, the Lean Machine is just plain fun to drive. It's one of those vehicles that draw you into staying on the road (& track) for the sheer pleasure of driving, and it was only from sympathy for the machine's creators and their patient waiting that I came back in and parked it.

When Jerry Williams got in the machine to do some photo laps around the GM road course, I found that watching the vehicle corner is almost as much fun as driving. It manages to be handsome and amusing at the same time, looking as it tilts and sweeps through corners like a mad land shark or some specialized and streamlined creature of the depths.

Williams is correct in his assessment of the Lean Machine's learning curve. This is not a vehicle that your grandparents can willingly climb into and drive as a replacement for their low-mileage Packard Clipper, but for those attuned to motorcycles, sports cars, airplanes, etc, a few hours of safe practice followed by a few days of attentive driving on the street should build enough confidence for controlled, spirited driving. I was shown films of the Lean Machine being driven very hard around a road course, and its speed and stability were amazing (I began to fantasize a Lean Machine Production Class in SCCA). Even with lowly minibike and boat trailer rubber on the wheels, it drifted through corners showing just a trace of controllable understeer at the limit. With 50 degrees of lean, it can produce 1.2g of lateral acceleration.

Safety? Obviously the Lean Machine isn't going to do that well in an encounter with a semi, but the same is true of most small cars and, more so, of motorcycles. Williams places the machine roughly between motorcycles and small cars in the great biological food chain of highway collision. He adds that the Lean Machine can slide or skid its front tire when it goes beyond the limit of adhesion–something a motorcycle can seldom do without crashing. Also, all three tires can safely be locked up in a panic stop without much loss of control; again a touchy area for motorcycles. In short, the Lean Machine is no bumper/safety car and was never intended to be one. It is a sporting commuter vehicle that offers tremendous fuel efficiency while taking up very little highway and parking space.

Williams and the other men on the design team stressed that the machine I drove is really just a composite of proprietary components, taken off the shelf and assembled to prove a point. That being the case, the cambering vehicle is a realistic transportation device. They point out that the right tires, engines, transmissions and other components built especially for the Lean Machine (by GM, one presumes) could transform it into a truly formidable commuter/fun vehicle.

GM has no plans, at present, to produce more copies of the Lean Machine. In fact, the day I drove it, the crew was preparing to clean the vehicle and ship it to the EPCOT (Experimental Prototype Community of Tomorrow) center at Disney World in Florida. There the machine will be on display in a section known as the Dreamer's Workshop.

Too bad, really. At the right price, this is a machine I would love to have sitting in my garage. Others who looked at the pictures and read the technical specifications said the same thing. It's not a vehicle for everyone, but then the same could be said of the MG TC and the Bugeye Sprite and a dozen other machines that brought fun-loving drivers out of the woodwork.

Even if GM decides not to build the Lean Machine at present, however, there is some consolation in knowing that if the Middle East and the world fuel supply should go haywire again, there is a vehicle like the Lean Machine waiting in the wings. When fuel gets tight, our driving might just get to be really fun.