Popular Mechanics

INSIDE MAX HEADROOM

Behind The Scenes On The Hit TV Show

EXCLUSIVE! BURT RUTAN'S LATEST

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- High-Performance Twin Rotary Engines
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- Computerized Fly-By-Wire Controls

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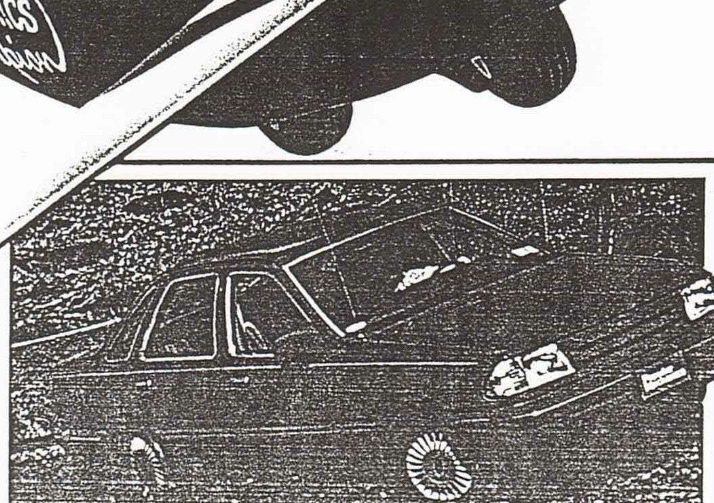

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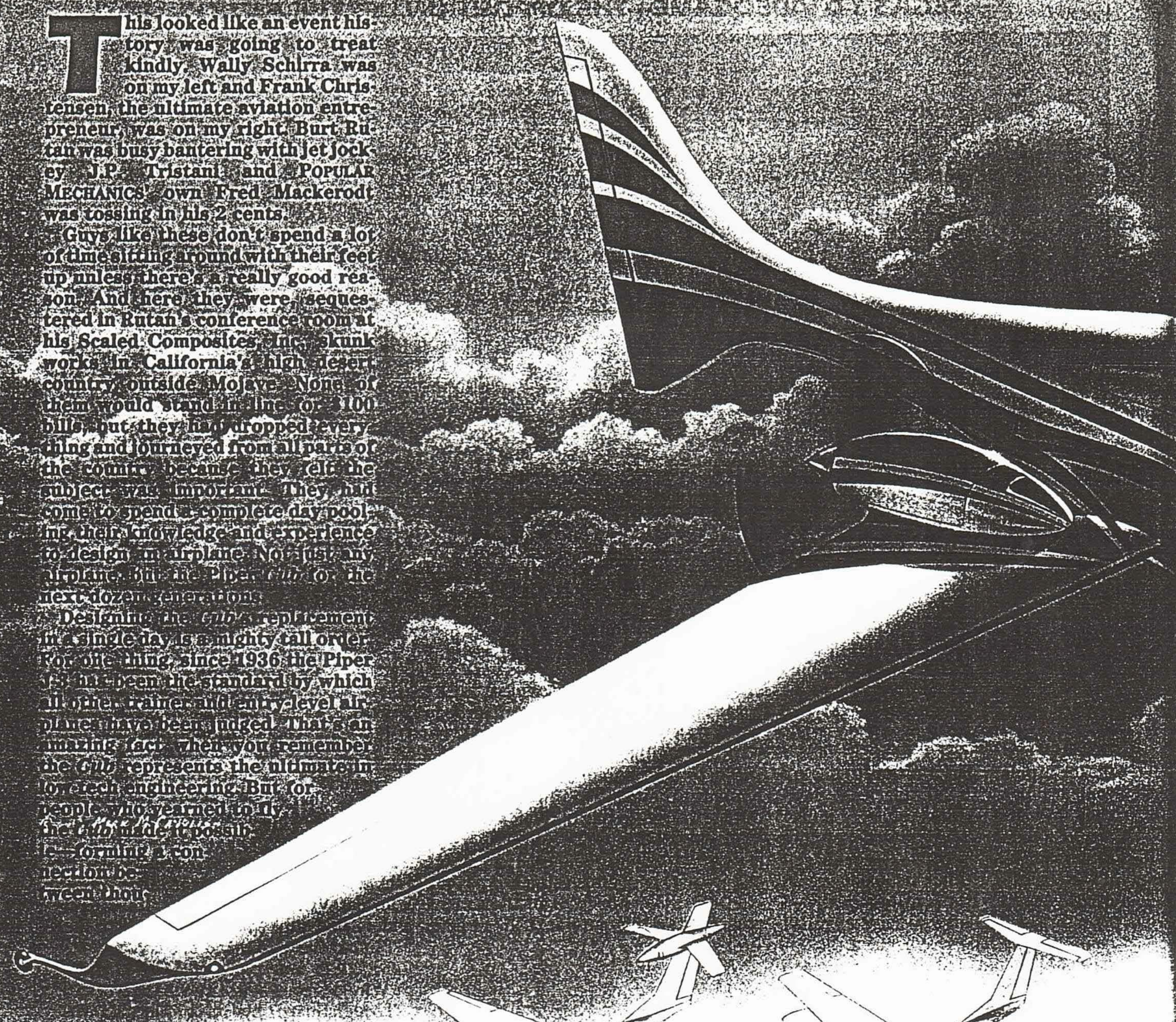


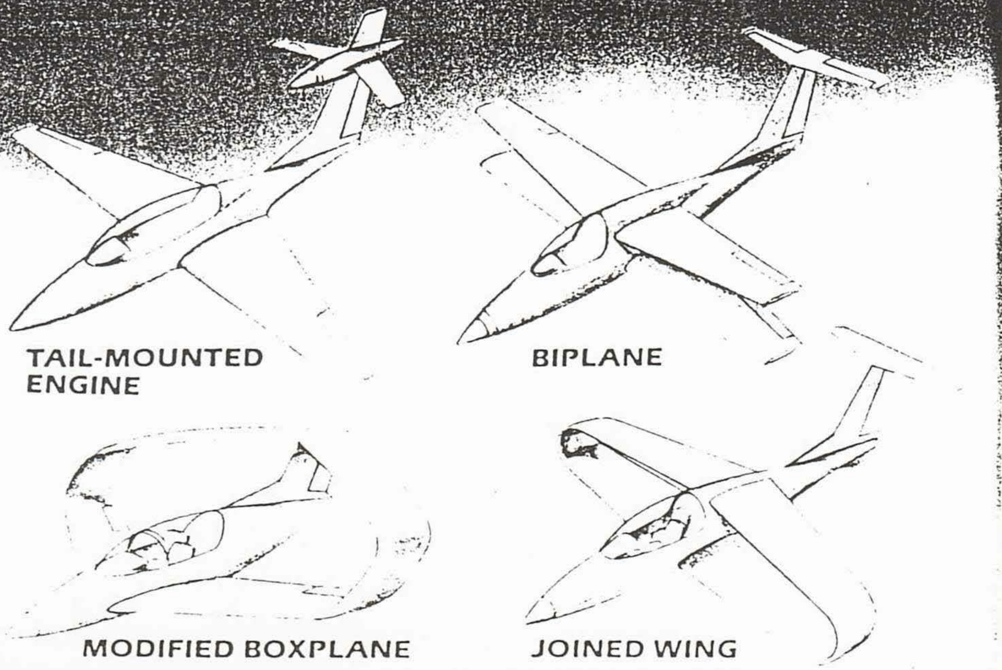
This looked like an event history was going to treat kindly. Wally Schirra was on my left and Frank Christensen, the ultimate aviation entrepreneur, was on my right. Burt Rutan was busy bantering with jet jockey J.P. Tristani and POPULAR MECHANICS' own Fred Mackerodt was tossing in his 2 cents.

Guys like these don't spend a lot of time sitting around with their feet up unless there's a really good reason. And there they were, sequestered in Rutan's conference room at his Scaled Composites, Inc., skunk works in California's high desert country outside Mojave. None of them would stand in line for $100 bills, but they had dropped everything and journeyed from all parts of the country because they felt the subject was important. They had come to spend a complete day pooling their knowledge and experience to design an airplane. Not just any airplane, but the Piper *Cub* for the next dozen generations.

Designing the *Cub*'s replacement in a single day is a mighty tall order. For one thing, since 1936 the Piper J-3 has been the standard by which all other trainer and entry-level airplanes have been judged. That's an amazing fact when you remember the *Cub* represents the ultimate in low-tech engineering. But for people who yearned to fly, the *Cub* made it possible—forming a connection between thousands of pilots and the exhilaration of flight.

The luminaries gathered at Mojave had come to do more than simply design an airplane. They had come because aviation is ailing, and a new-generation *Cub* would be part of the cure. The number of student starts has declined steadily, not to mention the number of new pilots who buy small airplanes. Certainly, one of the contributing factors is the apalling increase in the cost of flight instruction and training aircraft.

The cause for the increase is a complex interplay of inflation, labor, FAA certification costs and, most of all, product liability insurance. Product liability has had such a damaging effect on aviation that the Mojave Pow Wow decided it was best to ignore the regulatory problems of liability and FAA certification and

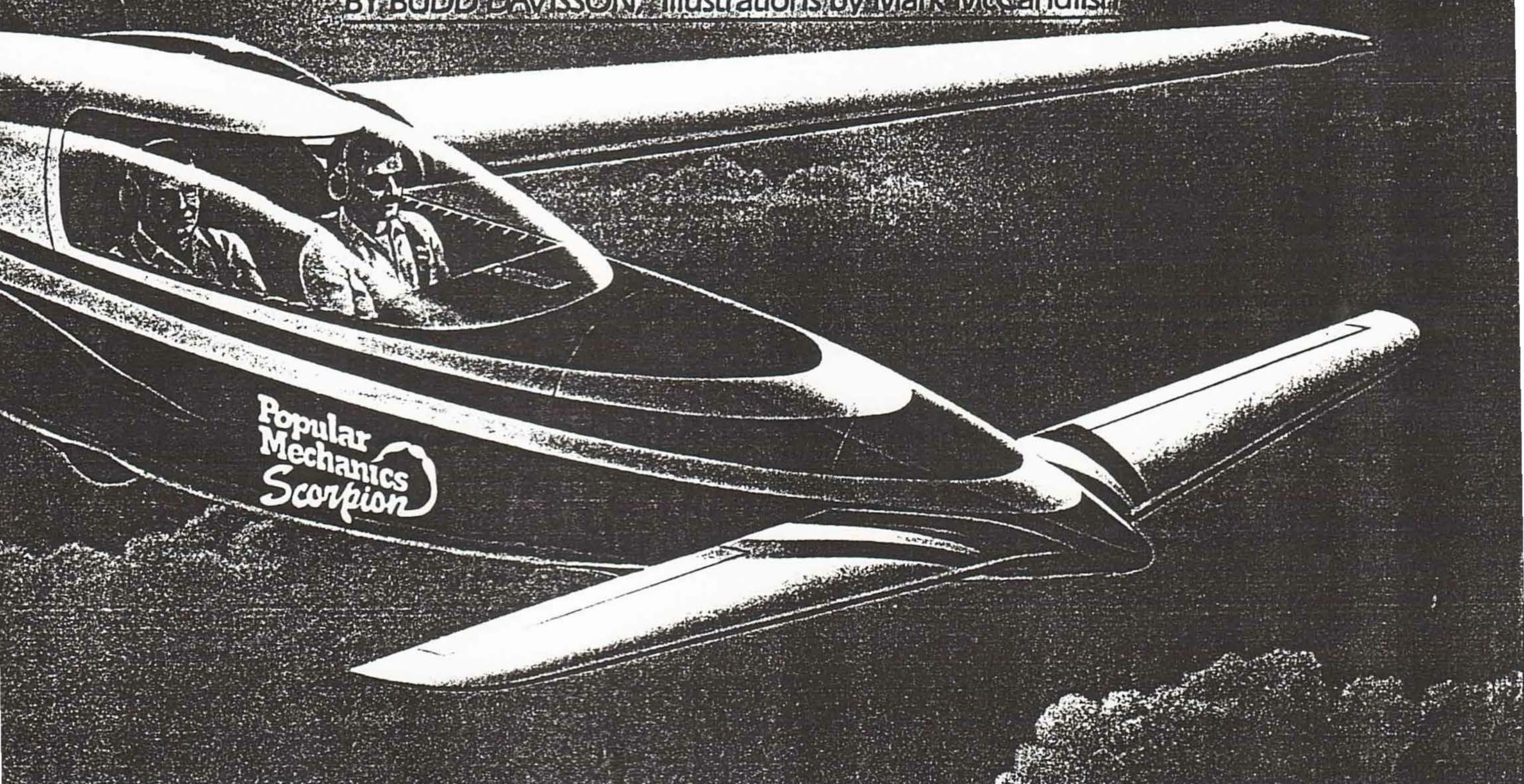


Several revolutionary concepts for the light plane of the future evolved from PM's aviation think tank. Among them (top left) was a plan for mounting the engine in the tail; a contemporary biplane (top right); a NASA inspired boxplane (bottom left); and a radical joined wing (bottom right). The final aircraft (illustration) was a synthesis of ideas drawn from the leading edge of contemporary aviation technology.

WINGS FOR TOMORROW

Burt Rutan and a panel of aviation experts help PM design an affordable entry-level sportplane for the 21st century

BY BUDD DAVISSON; Illustrations by Mark McCandlish



do its design work in a vacuum.

When tackling the project, PM selected the following team and turned it loose: Burt Rutan, world reknown designer of a wide variety of airplanes, including the *Starship* and *Voyager*; Wally Schirra, Navy test pilot and the only astronaut to hitch rides in all three of America's early space vehicles—Mercury, Gemini and Apollo; Frank Christensen, industrialist/entrepreneur who owns the factory that cranks out Christen Eagles, Pitt Specials and soon the Husky bushplane; Fred Mackerodt, aviation journalist and experienced pilot; J.P. Tristani, commercial airline captain and former Navy test pilot; and Mark McCandlish, one of this country's foremost aviation illustrators. Rounding out the list were PM's Editor-in-Chief Joe Oldham and Science/Technology/Aerospace Editor Tim Cole. I was there to serve as referee.

As we finished breakfast around the conference table, we laid down our only two hard and fast guidelines. First, the airplane was supposed to be of revolutionary design. Anything less, we felt, would fail to breathe life into aviation. Revolutionary versus evolutionary—we soon had to chant it to ourselves to keep on the right track.

The second guideline was really a definition of the mission. The airplane was to be an entry-level training platform that removed all hardware barriers between flight and the average man on the street. It was to be the most user-friendly airplane ever designed.

"Revolutionary versus evolutionary" was a bigger challenge than most of us anticipated. We sailed right through the second subject of discussion—the number of seats. Two was the unanimous answer. Then, I posed the question of whether the seats would be tandem or side-by-side. The military types preferred tandem. As an instructor, I pushed for side-by-side.

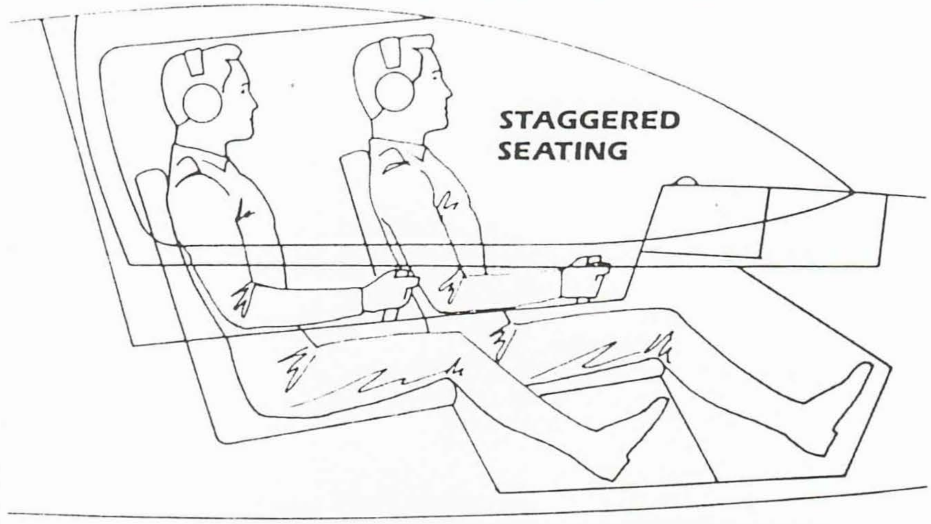
Then Burt spoke.

"Why does it have to be either?"

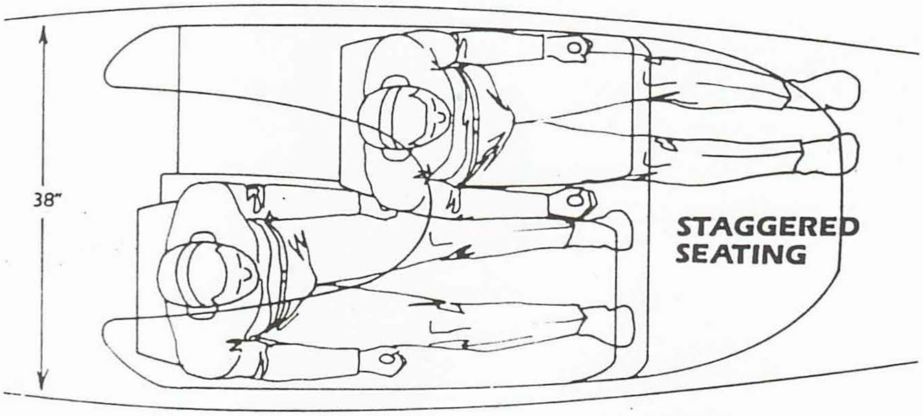
It was like throwing on a light switch. Burt made the case for staggering the seating—setting the right seat back approximately 15 in. and overlapping the left seat by about 6 in. This gave a bundle of benefits: narrower fuselage, the instructor could still read the student's face for signs of panic, the instructor was closer to the student's line of sight so their visual references were almost the same, and the right seat passenger/instructor had unrestricted access to the small payload bay behind the pilot. Most important, staggering the seating gave passenger and pilot plenty of elbow room—a pretty dear commodity on a lot of 2-place airplanes with athwartship seating.

The PM *Scorpion* was taking shape from the inside out. The seating discussion led to flight controls and from there to the instrument panel. Everybody in the room agreed that a side stick on an armrest at the side of the seat was the best way to control the airplane. At the same time, it was argued that the left seat—the command/student seat

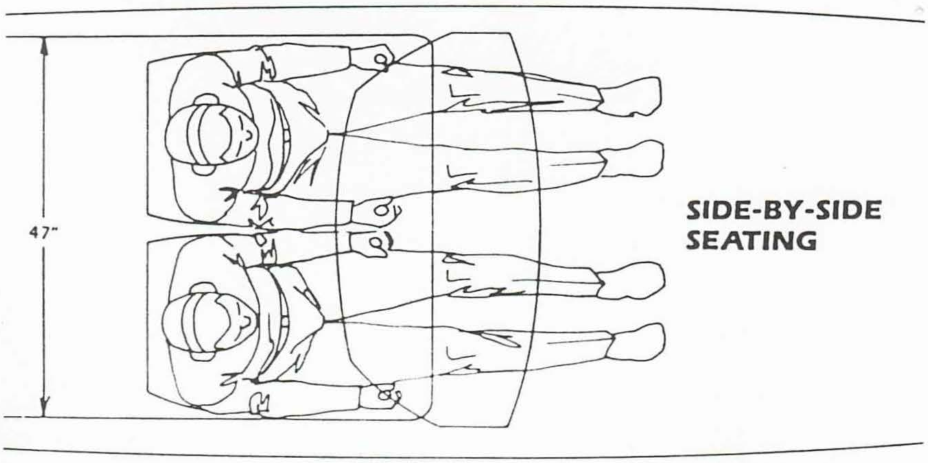
COCKPIT ERGONOMICS



Staggered 2-place seating is one of *Scorpion's* most striking features. In profile view above, passenger and pilot can still interact, and passenger has access to small payload bay behind left seat.



Elbow room, in this top view, is enhanced even though fuselage is narrower. Engines can be placed closer together to counteract asymmetrical thrust with one engine out.



Comfort suffers in a typical 2-place trainer with side-by-side seating, even though the cabin is typically wider. *Scorpion* concept is tighter, but more comfortable.

—should have a conventional Cessna/Beech/Piper type of control yoke. Then Burt once again pointed out the difference between revolutionary and evolutionary. Even though we liked side sticks, we had clung to our evolutionary upbringing and reasoned the yoke was needed to allow pilots to make an easier transition to the older and, as we were learning, terribly traditional designs. If we tied our thoughts to them, our *Cub* of the future would be just another link in the evolutionary chain of today.

So it was side-stick controllers for both pilots.

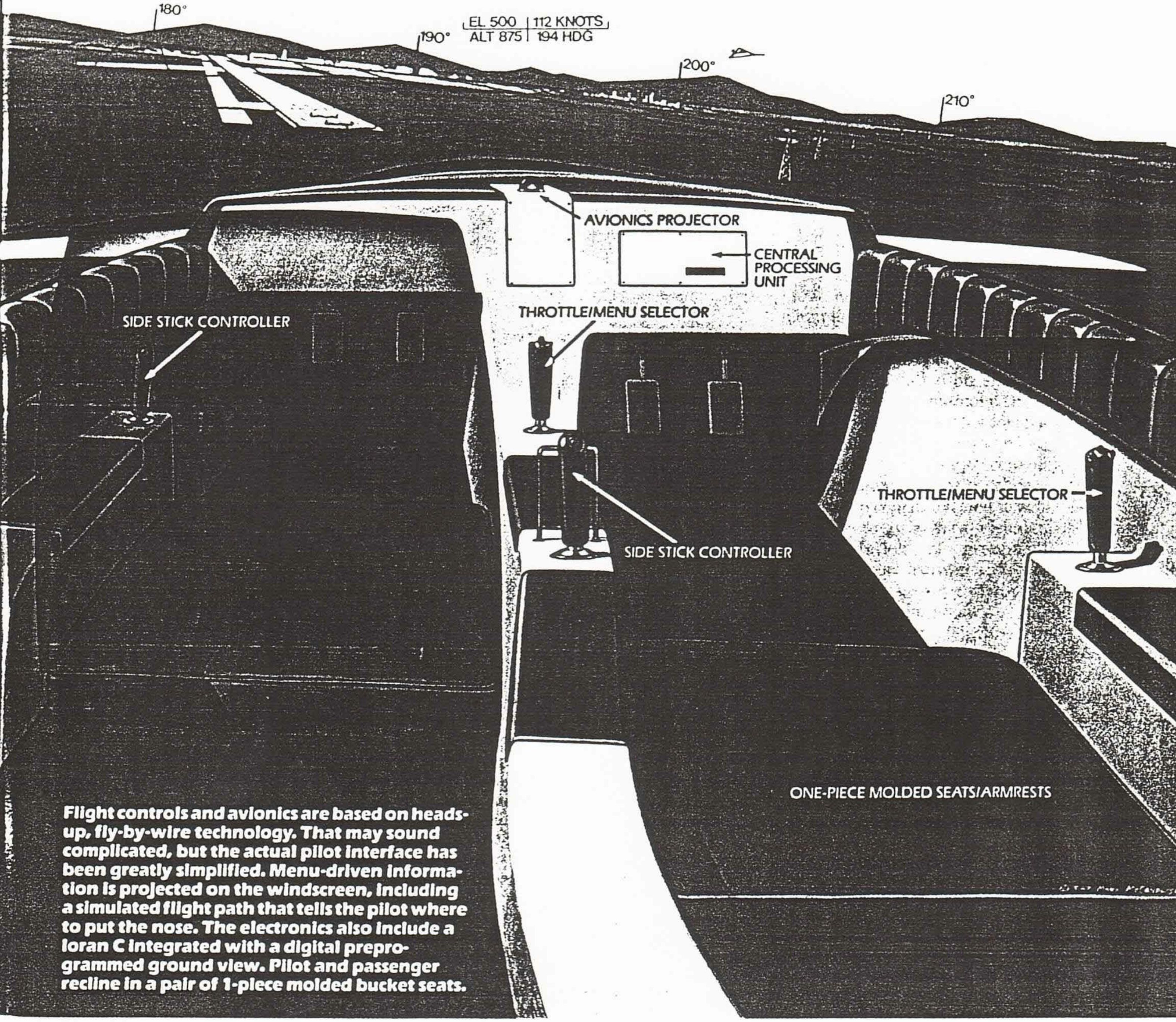
By the time we progressed to the instrument panel, everyone was brimming with revolutionary ideas. We quickly concluded that nothing on an airplane's panel makes any sense in today's world. The instrument panel on a modern light plane looks the way it does because that's the way it looked in 1950. And 1940. And 1930. And the instrument panel looks the way it does because instruments were invented one at a time. Somewhere back in aviation's dark ages someone wanted to know how fast they were going so the airspeed indicator was invented. Then, they wanted to know how high they were flying so along came the altimeter. The process continued until the panel was covered with individual dials giving individual bits of information. As a result, nothing on a typical airplane panel is direct and to the point. Indeed, we argued that one reason so many people don't learn to fly is because the panel itself is so intimidating.

The Mojave approach was to create a system that boiled down every single piece of important information to one visual display that took no talent to decipher. Since we were ignoring how it had been done in the past, the information and control problem was coupled with today's technology. And it was immediately decided that the heart of the *Scorpion*'s avionics would be a redundant pair of inexpensive microprocessors. The processors would collect all flight information, do all the ingesting and extrapolating and feed the results into a menu-driven graphic control display that would be projected on the lower part of the windshield. The windshield itself would be light-sensitive—automatically tinting slightly in bright sunshine for readability, becoming clear in bad weather. Individual menus would cover navigation information (like heading, loran C waypoints, and so on), flight control data (like airspeed and altitude), engine parameters (like rpm, manifold pressures, temperatures), and a miscellaneous menu for such information as airport approach directories. The pilot would flip through the menus with a button or trigger on the throttle and could even choose a split-screen format.

The displays wouldn't be numbers or figures—just simple graphic designs or iconography that immediately conveyed all the information normally found on all those little dials found aboard a more traditional aircraft.

It was also decided that there was no reason for the control presentation to differentiate between VFR (visual flight) and IFR (instrument flight) conditions. The same information would control the display in all weather conditions. It was also agreed that much of the collision avoidance and routing

VIEW FROM THE COCKPIT



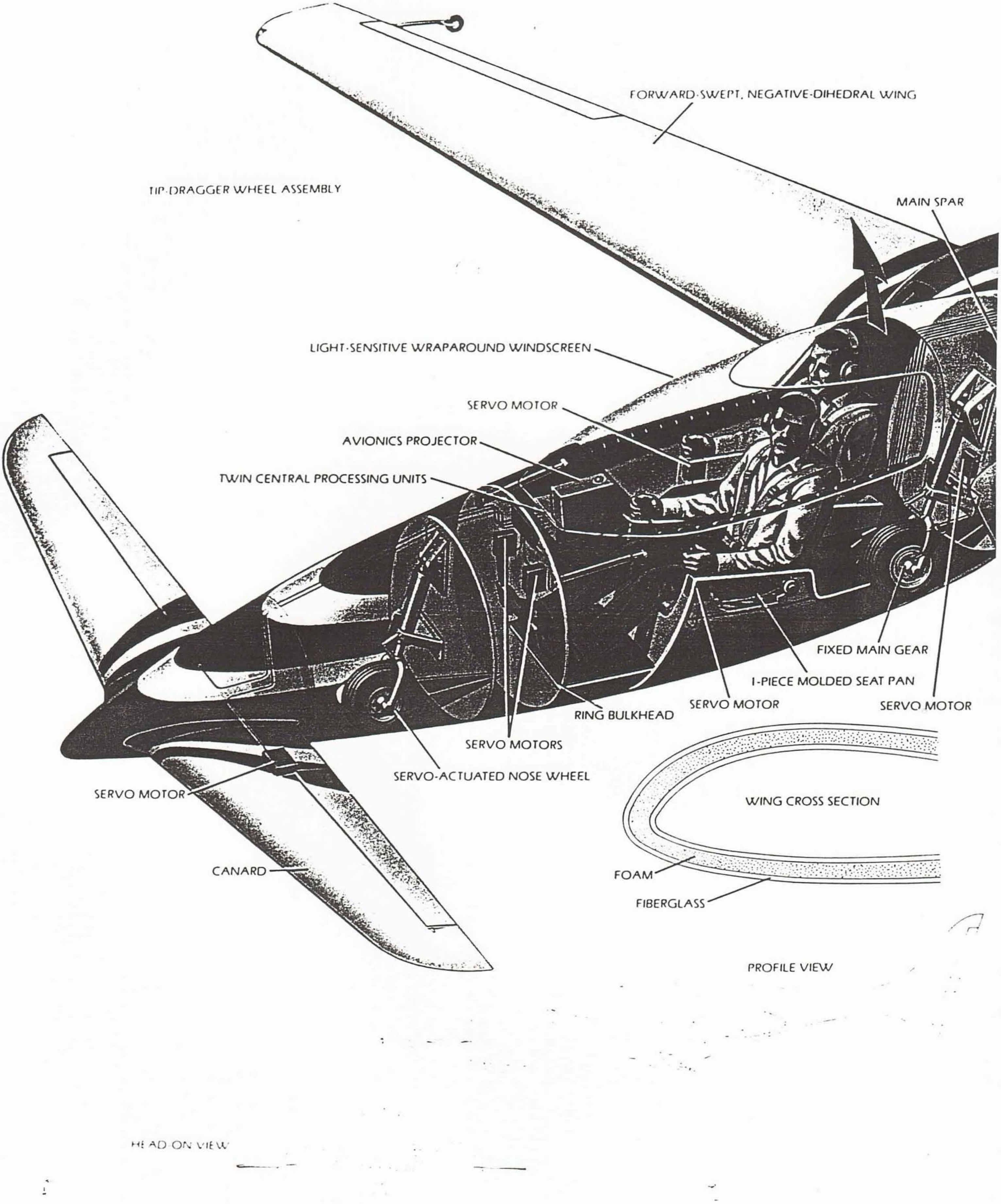
Flight controls and avionics are based on heads-up, fly-by-wire technology. That may sound complicated, but the actual pilot interface has been greatly simplified. Menu-driven information is projected on the windscreen, including a simulated flight path that tells the pilot where to put the nose. The electronics also include a loran C integrated with a digital preprogrammed ground view. Pilot and passenger recline in a pair of 1-piece molded bucket seats.

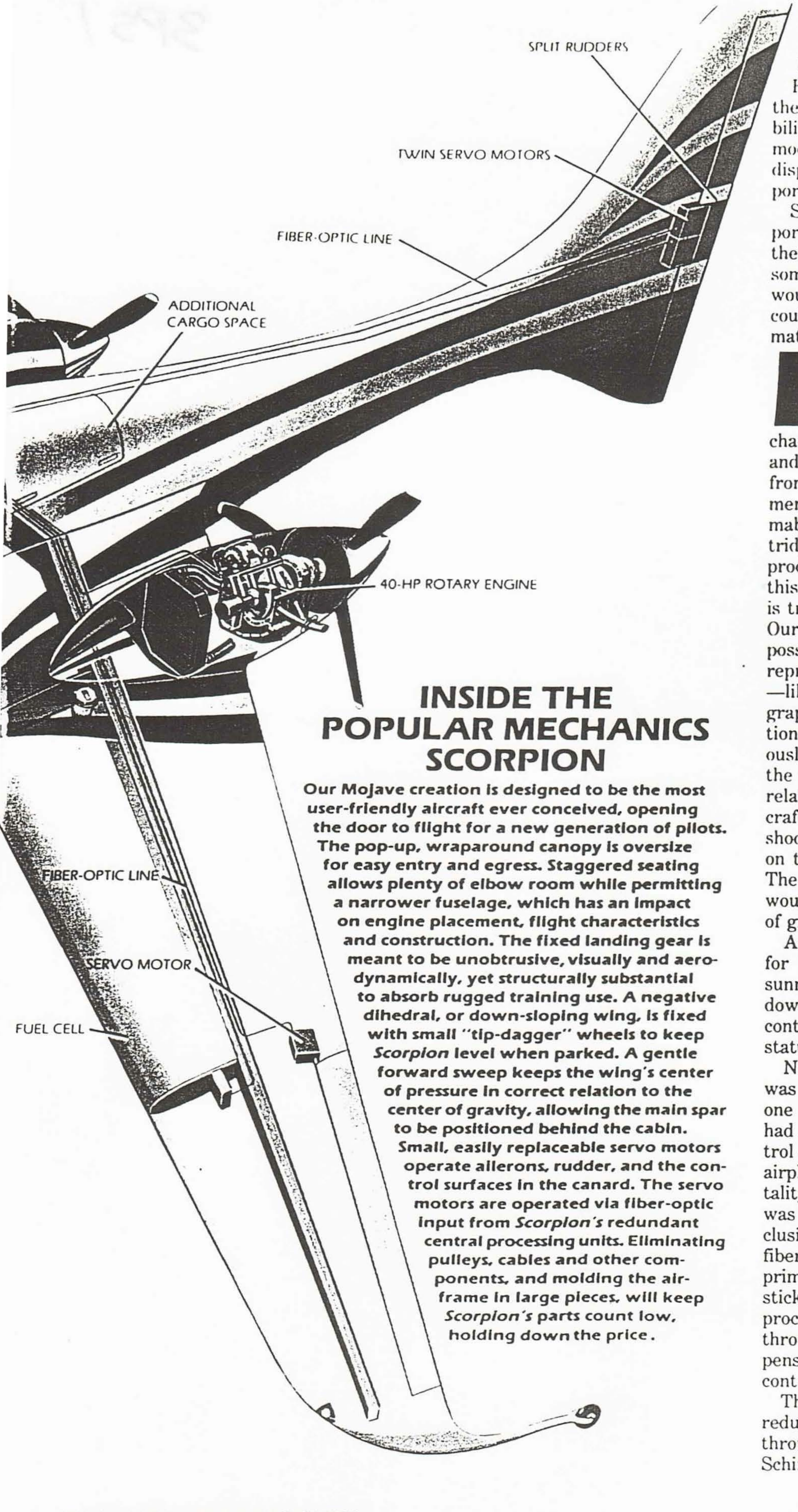
work would be performed by the microprocessors, with relevant information displayed on screen. The discussions concerning our Heads Up Display (HUD) didn't end with simply presenting raw data to our pilot. We wanted to give him or her real "attitude control" that guided the airplane in all conditions. The initial concepts centered around a set of cross hairs or a "flight envelope box" that would be projected onto the windshield with an outline of an airplane, as seen from behind, superimposed over it.

But that too seemed evolutionary. The final HUD was a graphic presentation of the horizon with an aerial highway or railroad track running down the center. The pilot's job would be to keep the plane positioned so that it appeared as if he was flying down the center of the highway and just above it as it receded into the distance. Parallel bars running across the railroad track would give the pilot a quick visual reference of speed and distance.

The processors would be crunching flight numbers and would move the railroad track according to where the plane should be headed, thereby telling the pilot what ought to be done with the airplane's nose. In other words, navigation information would be fed into the HUD, which would guide the pilot left, right, up or down.

An alphanumeric keypad mounted on the forward end of the console between the two pilots would provide a means of plugging navigation and other raw data into the central processing units. We assumed that loran C coverage will expand to eliminate the current mid-continent gap and we determined that most navigation would be by that method. This would allow the pilot to climb in the bird, punch in a 3-character alphanumeric designator the FAA uses


FORWARD-SWEPT, NEGATIVE-DIHEDRAL WING
TIP-DRAGGER WHEEL ASSEMBLY
MAIN SPAR
LIGHT-SENSITIVE WRAPAROUND WINDSCREEN
SERVO MOTOR
AVIONICS PROJECTOR
TWIN CENTRAL PROCESSING UNITS
FIXED MAIN GEAR
1-PIECE MOLDED SEAT PAN
SERVO MOTOR
SERVO MOTOR
RING BULKHEAD
SERVO MOTORS
SERVO-ACTUATED NOSE WHEEL
SERVO MOTOR
WING CROSS SECTION
CANARD
FOAM
FIBERGLASS
PROFILE VIEW
HEAD-ON VIEW



INSIDE THE POPULAR MECHANICS SCORPION

Our Mojave creation is designed to be the most user-friendly aircraft ever conceived, opening the door to flight for a new generation of pilots. The pop-up, wraparound canopy is oversize for easy entry and egress. Staggered seating allows plenty of elbow room while permitting a narrower fuselage, which has an impact on engine placement, flight characteristics and construction. The fixed landing gear is meant to be unobtrusive, visually and aerodynamically, yet structurally substantial to absorb rugged training use. A negative dihedral, or down-sloping wing, is fixed with small "tip-dagger" wheels to keep *Scorpion* level when parked. A gentle forward sweep keeps the wing's center of pressure in correct relation to the center of gravity, allowing the main spar to be positioned behind the cabin. Small, easily replaceable servo motors operate ailerons, rudder, and the control surfaces in the canard. The servo motors are operated via fiber-optic input from *Scorpion's* redundant central processing units. Eliminating pulleys, cables and other components, and molding the airframe in large pieces, will keep *Scorpion's* parts count low, holding down the price.

to identify his destination airport, and let the digital railroad track lead him there. No muss. No fuss.

Existing loran units already allow the pilot this kind of navigational flexibility as well as having various backup modes such as a single button that displays the location of the closest airport.

Some also display runway and airport information. In short, getting there by airplane has already taken some fabulous strides. The Mojave bird would integrate existing systems that could simplify all phases of flight information and control.

In addition, some loran units currently evolving in the marine community merge position with environmental information like channel markings, depth, obstructions, and so on. This information is digitized from charts prepared by the government and installed on small programmable read-only memory (PROM) cartridges that plug into a loran's central processing unit. It won't be long before this kind of technology (technology that is truly inexpensive) reaches aviation. Our group concluded that it will soon be possible to project a visual digitized representation of ground features—like airport runways, towns, topography, TV towers and other obstructions—using simple icons. A continuously updated loran position would shift the unfolding scene on the windscreen relative to the movement of the aircraft, allowing the pilot to visually shoot approaches in any weather based on the image on his own windscreen. The flight envelope railroad track would pass over visual representations of ground features.

And remember, for pilots who yearn for VFR simplicity on those bright sunny days, all displays could be shut down while the central processing units continued to silently monitor engine status and position.

Naturally, since the conversation was homed in on microprocessors, no one around Rutan's conference table had any trouble getting rid of the control cables and pulleys usually found in airplanes. In fact, the fly-by-wire mentality that permeated the discussion was carried through to its logical conclusion when someone suggested using fiber optics cast into the structure for primary control. Input from the side sticks would integrate with the microprocessors, which would send signals through the photonics to small, inexpensive servo motors mounted in the control surfaces.

The concept of incorporating certain redundancies into the design surfaced throughout our discussion. Both Schirra and Tristani outlined the back-

(Please turn to page 100)