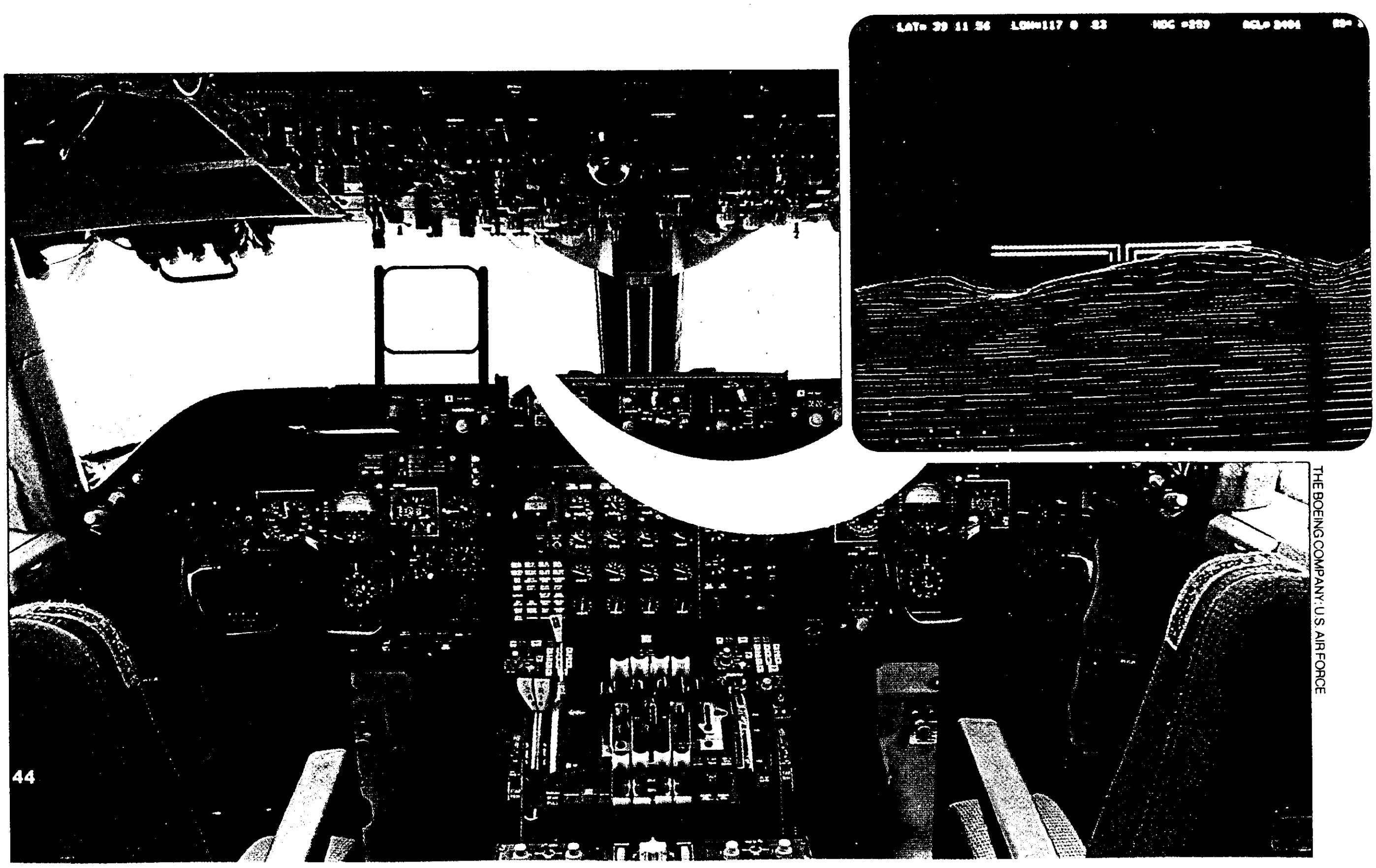
Electronic Vistas in the Cockpit

Despite bad weather or darkness, pilots will be able to "see" the terrain below

by PAMELA WEINTRAUB

It was twilight as the four-passenger Cessna approached Dayton, Ohio, and amateur pilot Louis Tamburino was nervous. He had been navigating by sight, using only a standard aerial map. But it would be dark before he reached his destination, a private air-field on the outskirts of the city. Soon all he could see below were small islands of flickering light in a sea of darkness. He descended, straining to pick out the airstrip's landing lights while fumbling with the map, and growing increasingly anxious about unseen obstructions ahead. The terrain around Dayton is more or less flat, but if any unlighted towers or buildings stood in his path, he was in danger. Tamburino finally touched down safely, but his unsettling experience proved to be the inspiration for a revolutionary new navigational system.

Tamburino, an expert in aviation electronics, was working as a physicist in the avionics laboratory at the Wright-Patterson Air Force Base in Dayton. He knew that the problems he had encountered over his home town that evening could be likened to those of a fighter pilot on a mission over hostile territory at night or in bad weather, flying at treetop heights to avoid enemy radar. At a speed of 600 miles an hour, what could prevent disaster if an unseen hill or tall structure lay ahead?



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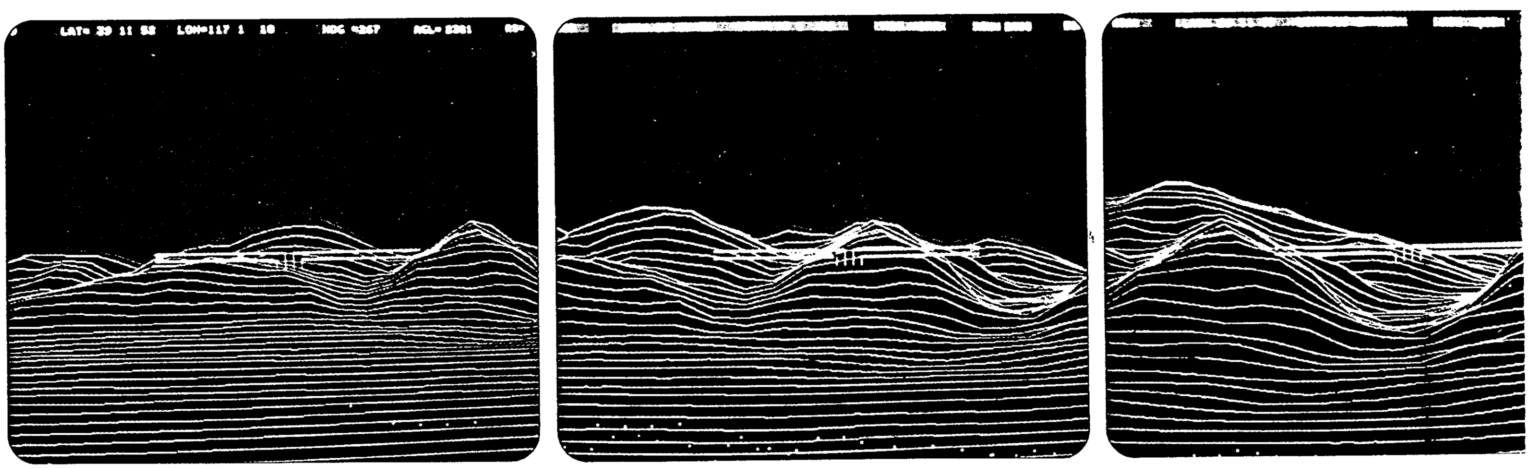
Tamburino had worked with computers that could draw pictures of landscapes when fed data from maps and photographs. The scenes could be sketched from any perspective—straight down, side view, or any angle in between. Allowing his imagination to roam, he thought about storing details like this from all over the world in the memory of a powerful computer. Given the proper longitude and latitude, the computer screen could, in theory, display a simulated landscape of any region anywhere. If the latitude and longitude were continuously changed, the simulation would amount to a moving picture of the landscape as it would be seen by an eye in the sky. And if the needed information could be supplied to a plane in flight and projected onto a display panel in the cockpit, a pilot could "see" unfamiliar territory despite bad weather or darkness.

Not long afterward, Tamburino learned that the Defense Mapping Agency in St. Louis, Missouri, was converting ordinary maps and aerial photographs of the Northern Hemisphere into digital language that a computer could understand. As an aid to strategic planning, the agency was coding the exact location, elevation, and identity of such man-made and natural features as telephone wires in Arizona, forests in Britain, and railroad stations in Siberia. Much of the topography of the United States and Europe had already been digitized, and the agency's goal was to do the same for the rest of the world. Tamburino realized that his fantasy could become fact. He dashed off a proposal to the Air Force, and five years ago won acceptance. He has been working on a model ever since, and last year contracted with the Hughes Aircraft Company in El Segundo, California, to build what the Air Force calls the Airborne Electronic Terrain Map System.

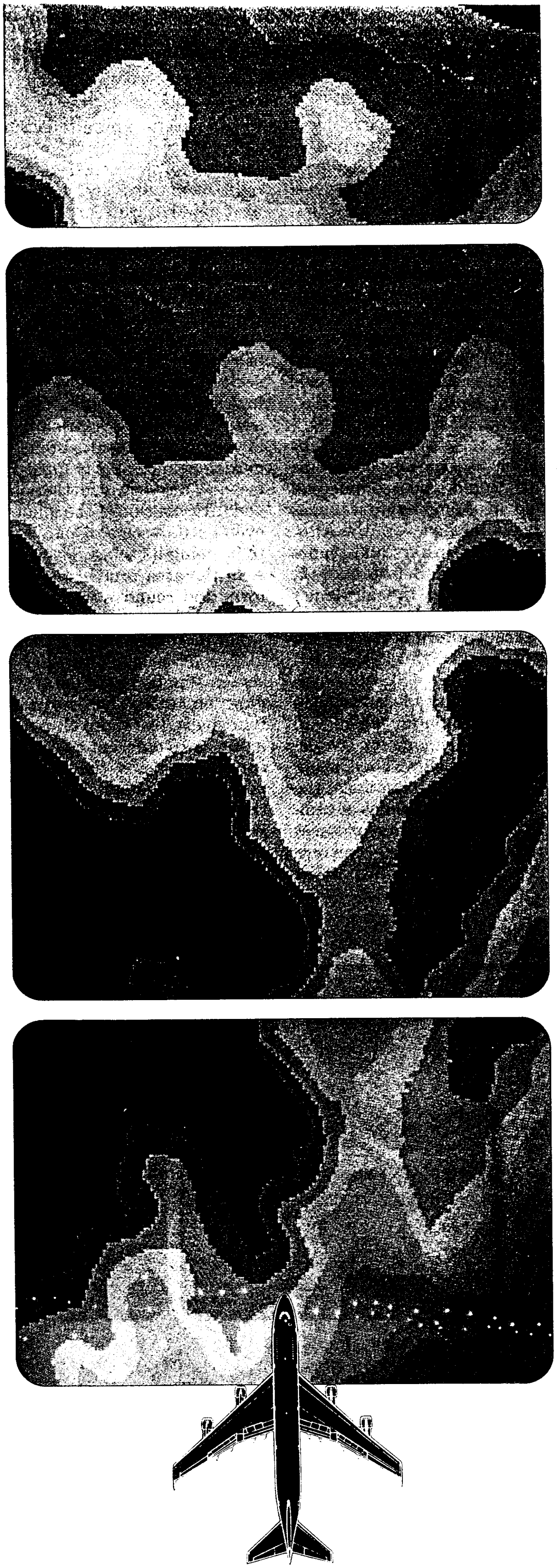
Although they were devised for military use, the new electronic maps could aid commercial flights taking off or landing, tour planes swooping down for a view of the Alps, perhaps even crop dusters and planes that fight forest fires. Before take-off, pilots will insert into the airplane's mapping computer an electronic memory with terrain information for the area of the proposed flight. In the air, a navigational computer will supply the latitude, longitude, altitude, and course to the mapping computer, which will rapidly search its memory for the description of the land below. Then, using a series of geometrical equations, the computer will perform millions of computations to create thirty new pictures every second of the shifting scene outside—which will make it as fast as the moving picture on a television screen.

The electronic display will eventually be able to project aerial views of not only mountains and monuments but also new hazards—or targets—radioed from other aircraft into the plane's computer during flight. If a pilot needs to know about the location of oil refineries, skyscrapers, or local landing strips, the display could be instructed to make those features stand out as bright spots of red. For hills and valleys, he might see something similar to the view below: simulated slopes and horizon, and a stick figure representing his plane, allowing him to steer a path clear of danger. He will be able to flip a switch and preview the terrain farther ahead. And, adds Tamburino, "the pilot wouldn't even need to see a display for the map to be doing its thing. The system could scan the area around the plane on its own, and sound a warning whenever danger loomed."

For more information, the pilot could glance at a supplementary television screen supplied with data by the mapping computer. There he could see contour maps, like those on page 46, in as many as 16 different colors. Unlike the aerial-view maps, these would tell the pilot about the lay of the land beyond the horizon. "The aircraft position is represented by the bottom center of the screen," Tamburino explains. "The red areas indicate land that is higher



A pilot flying at night could guide a plane by looking at electronic pictures similar to those above, projected onto the display panel against the windshield of the cockpit (left). In this simulation of a flight through the Toiyabe National Forest in Nevada, the pictures, left to right, show an airplane, symbolized by stylized wings, turning to the right to find a mountain pass



The red area at the left in the bottom map is Austin Summit in Toiyabe National Forest, and the red area at the right is Mount Prometheus. As the plane proceeds over the terrain in this simulation, it flies between the mountains, approaches a solid barrier, and climbs to fly over it

than the altitude of the plane. As the pilot flies higher, the red regions shrink, and more of the picture turns to yellow, green, and finally blue. If things get too red, the pilot will have to gain altitude—or risk coming to an abrupt halt against the side of the mountain."

The likelihood of such an abrupt halt will diminish as scientists learn more about presenting electronic maps—both the 16-color variety and the aerial views—to pilots. The Air Force is experimenting with graphics that will portray specific natural features, such as forests and lakes. After that, the scientists will perfect images of man-made objects ranging from bridges to buildings to smokestacks. The trick, Tamburino says, is to keep the image as simple as possible without simplifying it so much that the pilot no longer recognizes it. For example, the system could use a bright red triangle to depict a building, or create a detailed drawing that showed everything down to the individual bricks. "We want to be impressionistic," he says, "because the life of the pilot depends upon simplicity. But we still don't know how much abstraction the human mind can take."

The mysteries of human perception will present other problems as well. A building 50 feet tall and a mile away, for example, may appear to be the same size as a skyscraper many miles away. Scientists will have to learn to program the computer to sketch the two structures so that the difference between them is clear to the pilot. Another source of confusion is that land near by seems to rush past faster than land in the distance. To compensate for this, the designers plan to compress the image at the bottom of the map and expand the image at the top.

While the Air Force is designing simple maps to test on pilots in the lab, scientists at Hughes are building a prototype system that could be used in an airplane. Once that is complete, sometime in 1982, pilots will be able to test the maps in flight, which will allow Air Force mapmakers to refine the system still further. By the late 1980s the Air Force will have a system that should substantially increase safety in the sky. ■