TECHNOLOGY: METHODS AND MACHINES TO SHAPE THE FUTURE

Dazzled by the rapid progress of past decades, Americans are inclined to look to technology to solve their transportation problems in one brilliant burst of invention. Some day technology may do just that, perhaps through some of the new devices shown on pages 92-93. But the most promising transportation research today is concerned with finding a more sophisticated way of making the tough decisions that will be with us until the Buck Rogers era comes.

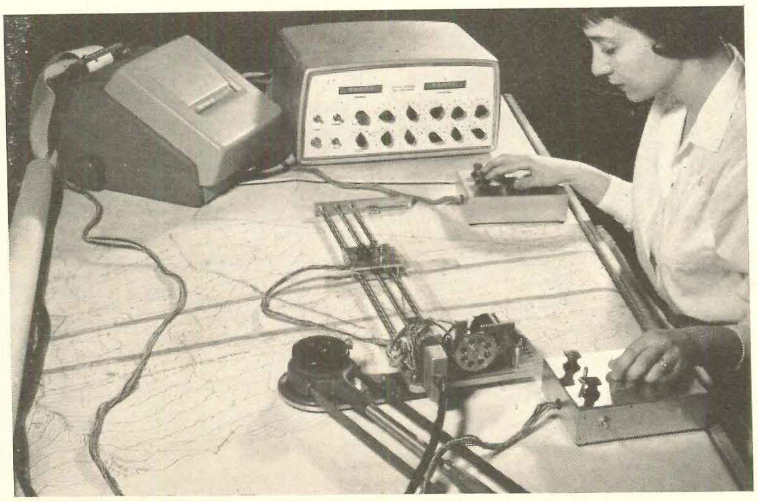
Up to now, the trouble has been that the design process used by transportation planners has been too narrow and cumbersome to take into account all the social, economic, and visual consequences of their deeds. But recently, from M.I.T.'s Department of Civil Engineering, and the Harvard–M.I.T. Joint Center for Urban Studies, there has come an impressive series of reports (many of them sponsored by the U.S. Bureau of Public Roads) which describe promising new techniques. While they vary in scope from the practical method for highway location analysis described on this page to a pioneering graphic approach (overleaf), the new methods have one element in common. All of them rely heavily on the digital computer to reduce vast quantities of information to a form that allows the designer to make decisions in a less arbitrary way than he has had to heretofore.

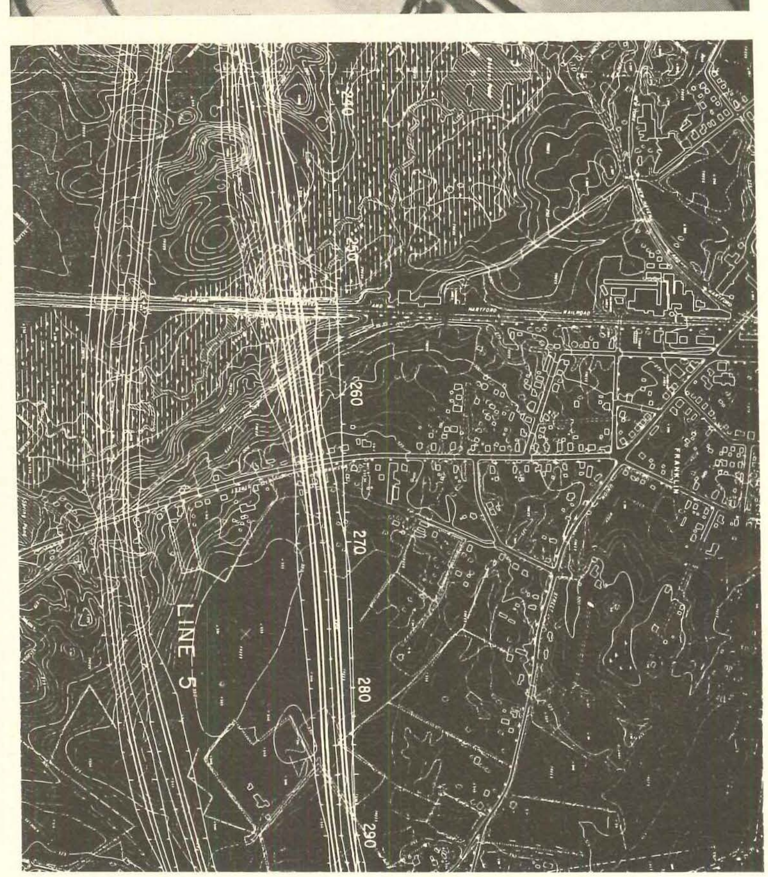
Computers to help map the best highway route

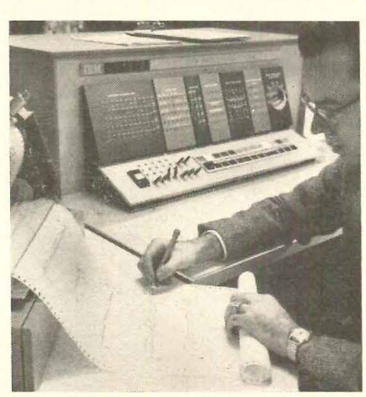
M.I.T.'s Digital Terrain Model System (photos, right) is already being used by four state highway departments and a number of private consultants. The key to the system is the translation of the three-dimensional terrain map of an area into a pattern of digits that can be stored in the memory of a computer. Once this is done it is possible to analyze rapidly and economically not just one or at most two alternate routes through the area, but as many as a dozen.

The design process starts with the engineer sketching the centerlines of as many alternate routes as he wants to consider. The computer compares what each route would do to the original terrain, and finally, comes up with a summary of all construction and user costs—including the amount of gas, oil, and tire rubber that would be consumed. One of the subprograms that has been devised can also calculate the costs for the land to be taken for the right of way, and the number of people displaced by the alternate routes. (This analysis has not yet been used, since no area has assembled enough detailed data to feed into the computer.)

So far the M.I.T. program can only rank a large number of alternate routes in terms of cost. Other M.I.T. researchers are working on a more far-reaching approach that can account for social, esthetic, and other non-monetary values as well. Before an engineer can use the design method shown in the illustrations here, the much more complex and significant decision that a highway is to be built in a given area must somehow have been already made. The greatest challenge has been to work out a rational process for the basic plan







First step in using the Digital Terrain Model system is the translation of a contour map into digits that can be stored by a computer (top photo). Map (above), taken from M.I.T. report by Roberts and Suhrbier, shows computer-generated plans for two alternate highway routes, including the effect of road construction on existing contours (spiked outer line). With a special attachment, the computer also prints out vertical cross sections of proposed routes (left).

of a total transportation system, taking not only engineering and costs into account, but politics and other social factors as well.

Rapid changes in land use (and consequent traffic generation) have confounded some of the most ambitious highway systems, making them obsolete soon after they have been built. The fact is that highway planning and land use planning are two aspects of the same process, and the problem of relating the two goes beyond getting the separate agencies involved to talk to each other. What the planners have to come to grips with is essentially an endless series of interrelationships shown circling around in the diagram at right.

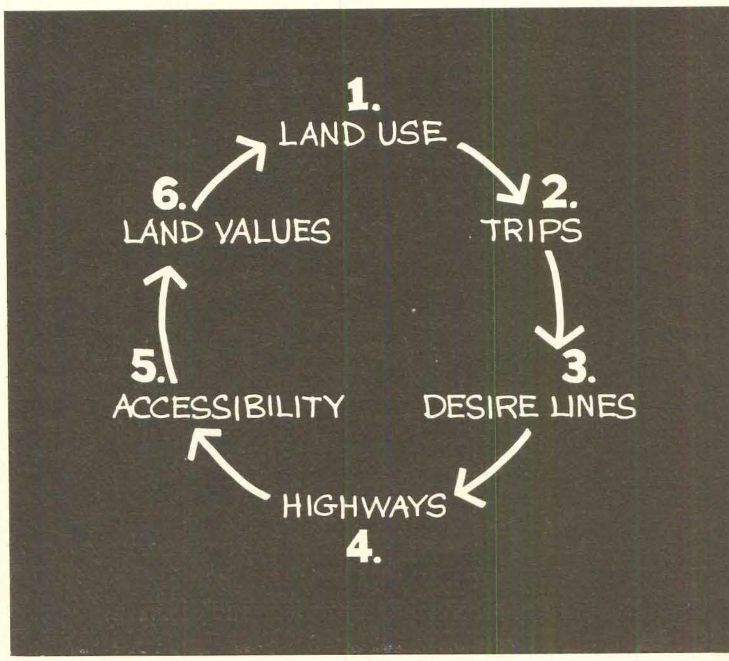
The search now is for ways to express the relationships between steps in this circle. The planner must analyze and fit mathematical formulas to the increasing amount of raw data that is being collected on the way each of the elements behaves in a city today. With a mountain of data on existing conditions, a set of mathematically expressed relationships between these conditions, and a set of formulas to project trends, however, the planner can call on the computer to calculate its way around the entire circle in a few hours. Thus he is able to work his way around many times in a series of successive approximations, to devise a plan that comes closest to fulfilling the goals of the particular community involved.

The basic elements of one such comprehensive design procedure devised at M.I.T. are illustrated in the block diagram at right. For a key step in this process, the making of policy decisions, there are, of course, no formulas that can be constructed. In a free society, this step must be based on the clearest possible expression of what the people want their city to become. But the planner must have this before he can do a competent job.

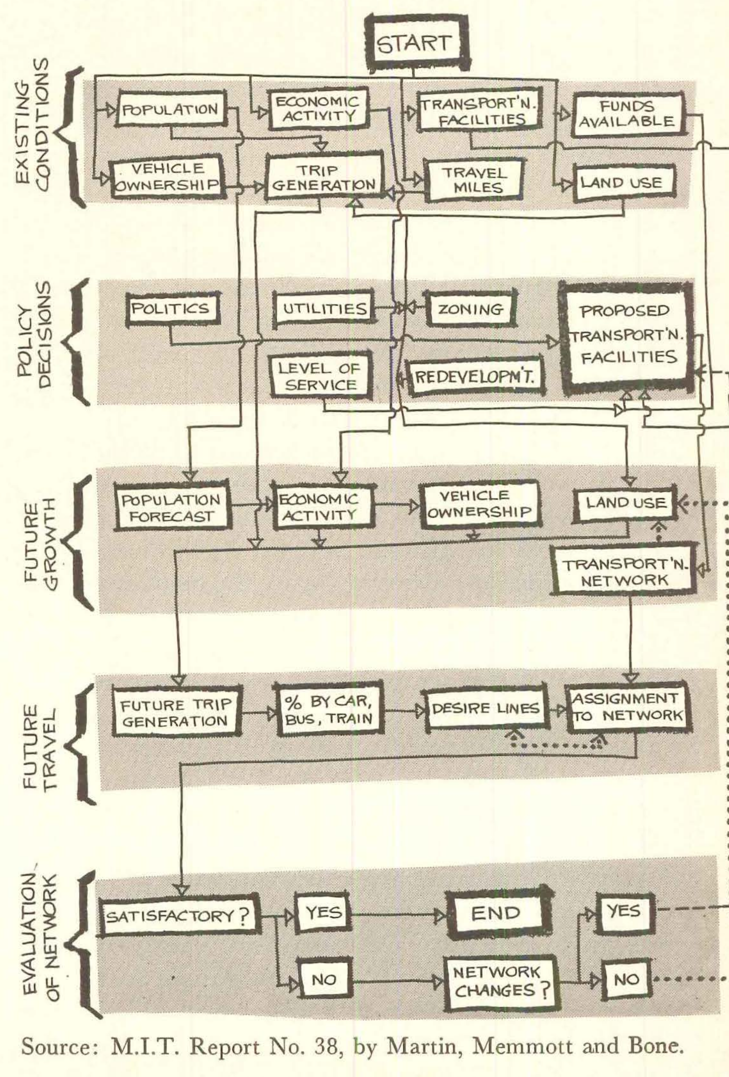
The expression in numbers of the complicated relationships between all the variables that act on a problem is called a mathematical model. The models that have been constructed so far are crude and inexact: the researchers simply do not know enough yet about how variables actually operate to establish many of the essential relationships. But as knowledge improves, this method of analysis could grow enormously in value; it provides the framework for measuring plans against a broad range of community needs and seeing just how well each plan will do.

Twenty-six pictures to the top of the tree

Easily the most fascinating experiment in the current search for a comprehensive method is the graphic technique proposed last year by Marvin Manheim, an M.I.T. researcher, and Christopher Alexander, then a Harvard Fellow. Although it has only been applied so far in the form of the preliminary solution shown overleaf (to the problem of locating a stretch of the Interstate Highway System near Springfield Mass.), it has opened up some exciting new paths for the planner. The most intriguing aspect of the graphic approach is that



Relationship of elements in the total transportation planning process



Source: M.I.T. Report No. 38, by Martin, Memmott and Bone.

Technology: new graphic method gives highway planners a much needed tool for comprehensive design

it eliminates the staggering task of deriving formulas needed for the mathematical model described above.

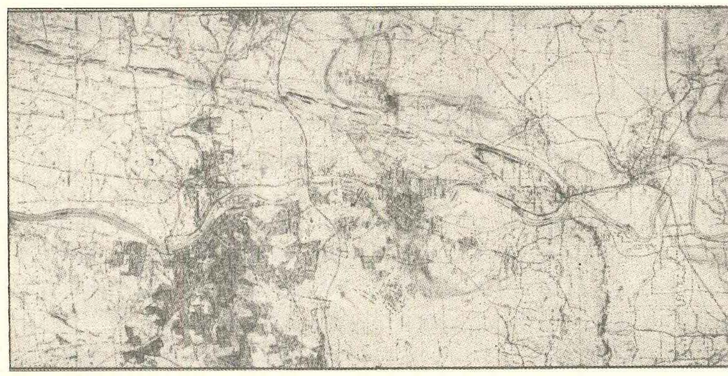
The designer's first step in applying the graphic technique is to isolate all of the requirements he wants to satisfy in working out his solution. In the example shown, 26 separate requirements are considered—a far broader approach to the problem of location design than current engineering methods are able to provide. For each of the design requirements, a graphic representation of relative desirability is made on a transparent overlay placed on the base map of the area. A simple scale of shading is used, from white for the least desirable locations to black for the most desirable. The result is the series of 26 symbolic maps shown on the opposite page.

Organized by electronics, solved by eye

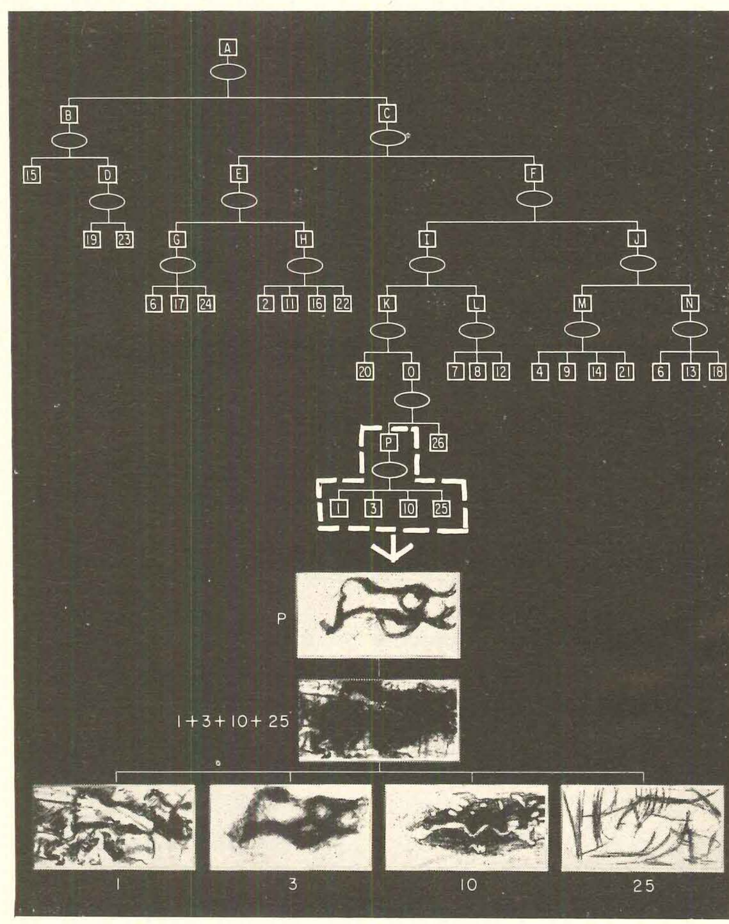
The next step seems almost magical, but is based on "set theory," a well established branch of advanced mathematics which Alexander applied to design problems for the first time in his doctoral dissertation at the Harvard School of Design. According to Alexander, the key to the design problem is "a set of conflicts which restrict the possible ways in which the requirements can be met simultaneously." If the designer can establish which of the requirements have inherent conflicts and which do not, he can then use Alexander's computer program (which has the imposing title: "The Hierarchical Decomposition of Systems Which Have an Associated Linear Graph") to sort out sub-groups of requirements which have the least conflict with each other. This produces the "tree" of related groups of requirements shown immediately at the right. If the designer's judgement of conflicts is correct, each of the sub-groups on the tree should be relatively easy to combine into a single solution. The difficulty of combination, of course, increases as one works his way up from the lowest level to the final solution at the top.

The least conflicting requirements in this problem (numbers 1, 3, 10 and 25) were combined graphically by making a composite photographic print of these four transparent overlays (oval symbol in diagram, right). By projecting this muddy combination on a drawing board, the resultant pattern of desirability was clarified in a new drawing ("P" in diagram).

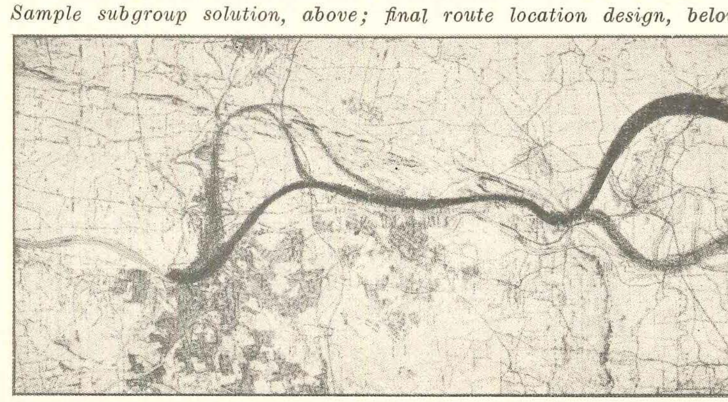
Manheim and Alexander found that it was remarkably easy for the human eye to detect the underlying common pattern in the composite print even though at first glance it might seem to be just a confusion of tones. According to the authors, the eye thus becomes in effect a "special-purpose computer" actually more powerful than any electronic device yet built. Continuing in this way, resolving a new composite photograph for every oval in the diagram, the top of the tree, pattern "A," was finally reached. This optimum location for the proposed highway, representing the simultaneous solution of all 26 requirements, is shown as a black path (along with grayer alternates) in the final area map at right.

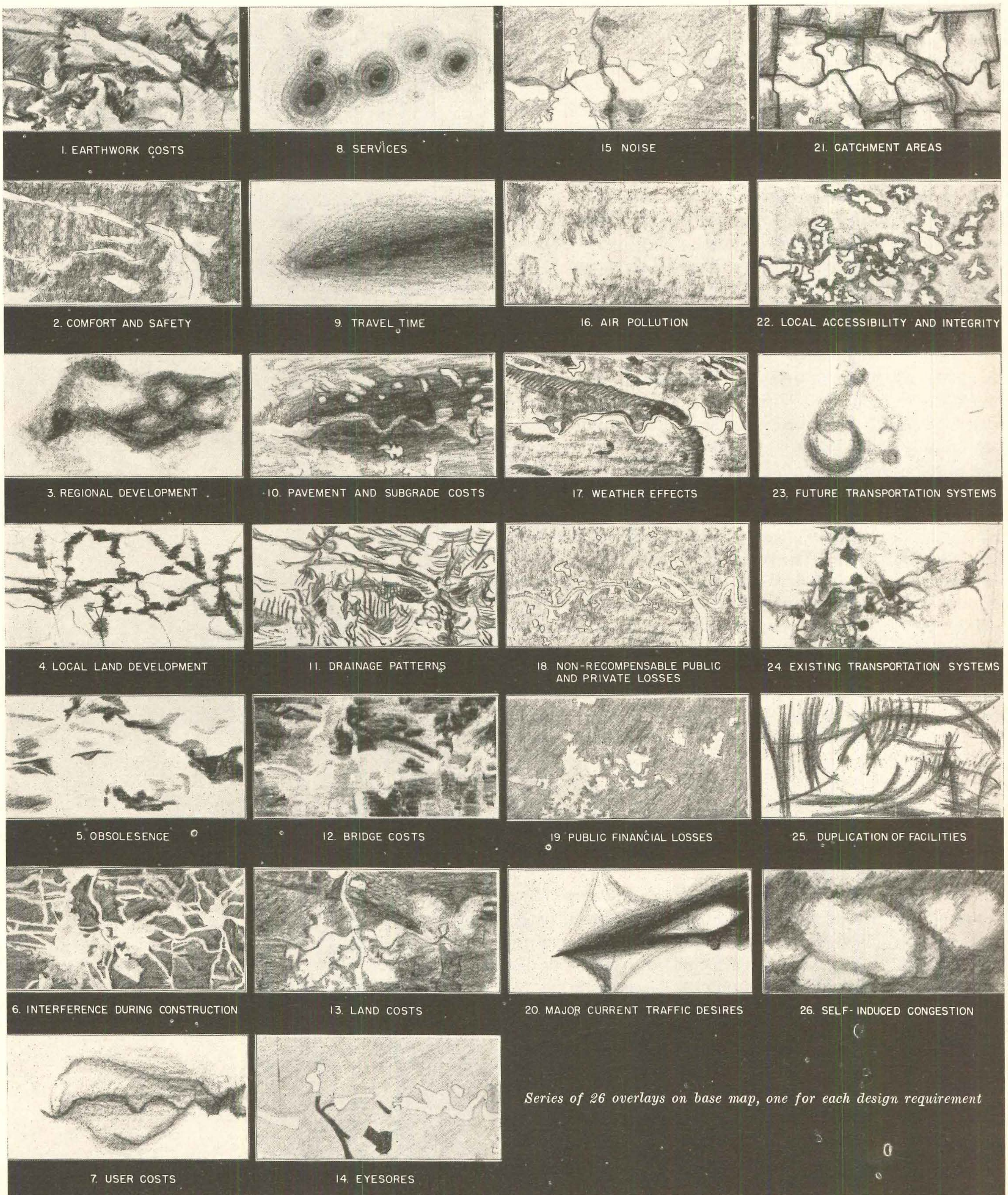


Base map of area studied, above; diagram of design process, below



Sample subgroup solution, above; final route location design, below





Series of 26 overlays on base map, one for each design requirement

Technology: automatic pilots to boost road capacity —and vehicles that may make highways obsolete

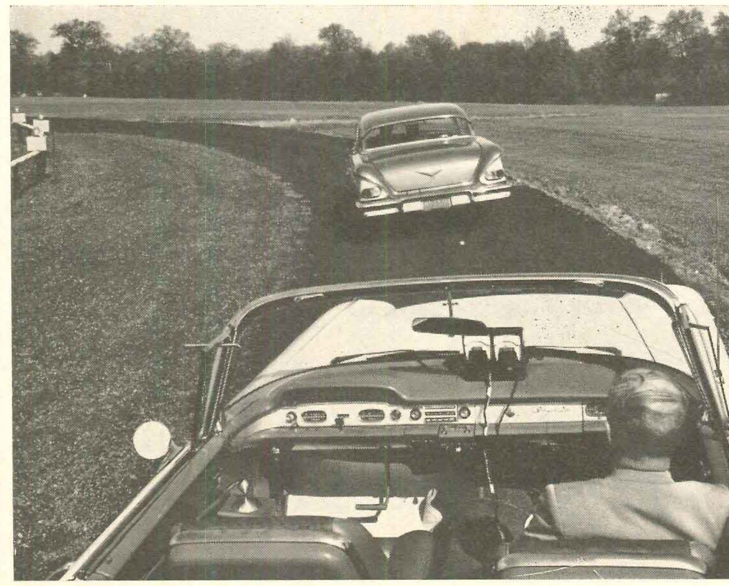
Fifty years ago, had computer planning techniques been available, most of the transportation modes fed into the machines would have had bushy tails and four hooves. The automobile, which was to revolutionize the American way of life and travel, was a relatively new invention, a plaything of the wealthy. No one can say for sure that another new device won't come along to work a similar revolution in the next half century. If this should happen, it might well be the offspring of one of the inventions on these pages.

This time the device might not be a new vehicle, if only because of the huge investment America already has made in the automobile and its highways. A significant part of the current technology of transportation hardware, in fact, is concerned with increasing the capacity of existing routes.

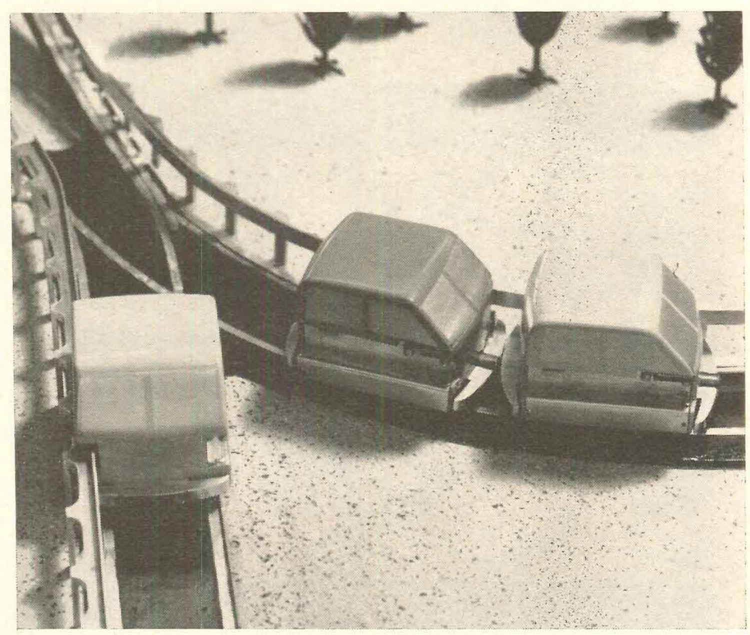
General Motors and Radio Corporation of America already have worked out prototype automatic-pilot systems that let the motorist sit back and relax as his car speeds along at 100 miles an hour in absolute safety. Both would take heavy new public and private investments, however: RCA's, for instance (top, right), would require the highway engineers to tear up miles of pavement for installation of control wires and millions of motorists to buy little black boxes to guide their cars. Just last month Westinghouse Air Brake Co. announced its automatic control system, designed for public transit vehicles with their own rights of way. The Westinghouse computer network, also costly, would allow buses or trains to run at 100 miles per hour with only 90 seconds headway between them.

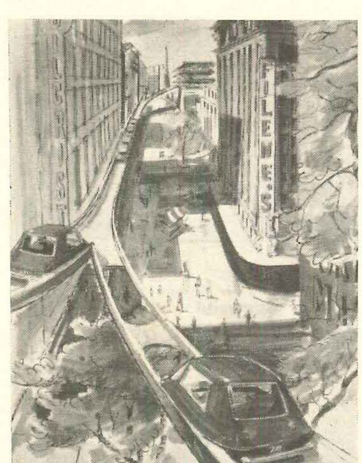
One virtue of the automated roadway, of course, is that it allows existing vehicles to use existing streets for local travel, then hook onto the speedy trunk lines for longer hauls. Inventor William Alden has taken the idea a step further with his StaRRcar (for Self Transit Rail and Road), a tiny compact that can transform itself into a train. The StaRRcar (lower right) putts along the streets just like a normal auto. But when the driver wants to take the main line, he simply drives up a ramp to a special track, pushes a button on his dashboard to set his course—and automatically joins a 60 mile per hour train of other StaRRcars until he is automatically ejected at the preselected exit.

In the end, however, metropolitan congestion may force the opening of whole new transportation corridors through use of new air and water vehicles like those shown opposite. The helicopter already has attained popularity faster than did the auto in its early days; the number of heliports in the nation has doubled in the past two years and helicopter "taxis" (as well as "buses") are in regular service. New York and Seattle are experimenting with hydrofoils, the high-speed ferry boats of tomorrow, and Buenos Aires has them in daily use. Several prototypes of the GEM (ground effect machine) have been built; it moves over land or sea on a bubble of high pressure air, requiring no expensive rights of way. Even the "Buck Rogers" rocket pack is not such a wild dream, as the planeless pilot at right can testify.—BERNARD P. SPRING



COURTESY RCA LABORATORIES



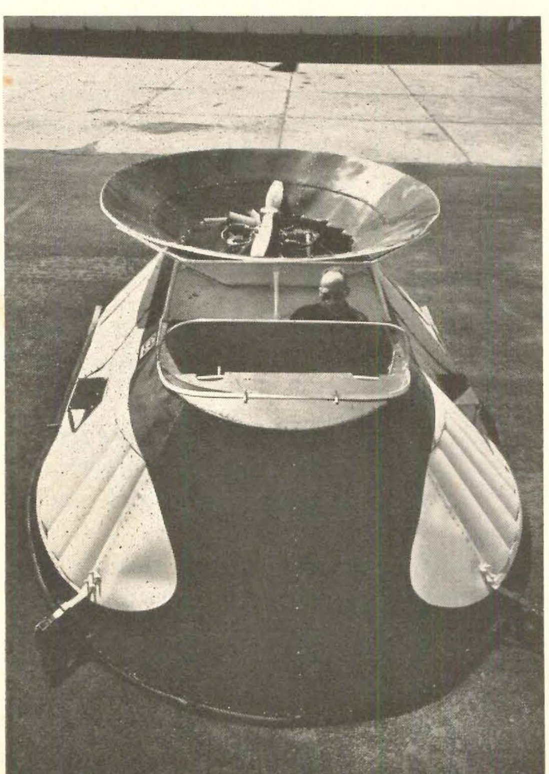


True auto-mobility: On RCA's test track (top), a driverless car is guided along by impulses from wires beneath the highway. Behind it is an invisible "electronic tail," which would automatically reduce the speed of a car following too closely behind. StaRRcar model (center) whips off its main track onto an exit ramp, obeying electronic instructions. Left: artist's conception of how a StaRRcar system might look in Boston. The light, narrow StaRRcar roadway saves on both cost and land utilization, and can be underground, surface, or elevated as shown here.

F. MILLER—LIFE

1

Prospects for everyday vehicles of the future include the individual propulsion pack (1); "GEMs" like Curtiss-Wright's Air-Car (2) and Britain's Hovercraft ferry (3); the new Sikorsky S-64 helicopter carrying its detachable "people pod" (4); the speedy Buenos Aires hydrofoil ferry (5).



ART BLEICH—LIFE

2

KEYSTONE

3

COURTESY SIKORSKY AIRCRAFT

4

FRANCISCO VERA—LIFE

5

ARCHITECTURAL FORUM THE MAGAZINE OF BUILDING OCTOBER 1963

FORUM