Comments on an Electronic Highway—Some Specific Techniques and Suggestions for a Test Roadway

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The potential applications of electronic techniques and devices to highway uses have been investigated by RCA and other workers in electronic research and development for a number of years. It is now appropriate to bring closer together the two disciplines of electronic and highway engineering so that maximum use may be realized at an early date and with a minimum of expenditure. This paper describes some of the factors involved in a cooperative endeavor, some specific techniques used by RCA in its "system approach" to an electronic highway, and a suggestion for a cooperative project on public highways.

• FOR MANY YEARS the subject of automatic control of highway vehicles has been discussed at meetings of associations active in the highway field. RCA, through its research activities, has been studying for about 10 years possible applications of familiar techniques that might be applied to solving some of the needs of highway travel.

Specific developments and tests that have been conducted have already been reported. Therefore, with a background of information now available, and with the progress that has been made in techniques and system considerations, it is time to initiate a full-scale test with participation by highway authorities toward a truly objective evaluation of short-range and long-range potentials.

The situation at this time is similar to that which existed in other fields prior to major advances. Many isolated facts are available, a general realization of the needs are visualized, numerous individual factions are interested in and have worked in the specific fields, and yet there has been no over-all agency pulling together in an effective manner this available information.

This paper attempts to put into perspective the needs, some possible solutions, and the "state of the art" that would permit adopting these solutions. Such review might aid in establishing a practical program for a single agency to provide the necessary leadership in pulling together the available information and considering it in proper context. In the language of the electronics industry, it is proposed to consider the over-all system, rather than separate parts.

The needs, can be summed up in four categories within which there are other individual components:

1. The need for increased safety.
2. The need to reduce total highway expenditures per vehicle-mile of travel.
3. The need to reduce travel time.
4. The need to reduce the effort required to drive a highway vehicle.

No differentiation is made in degree of importance and, furthermore, improvement in any of these areas would be progress.

Recent developments in many technical fields are applicable to highway usage and this is particularly true of electronics. This field has produced many devices for control, navigation, and communication purposes that with modification could provide

assistance in vehicle transportation. The work of RCA, and others, has been concerned primarily with the solution of technical problems. The application of electronic devices originally developed for both military and commercial applications may not be economically justified in some instances without major redesign of the equipment because of the high cost of the product and the amount of maintenance required. Experimentation to date has indicated, however, that many of these techniques may be applied to the construction of highway aids at a cost that would not be prohibitive and yet would provide the degree of reliability required. RCA's work, which has been primarily of a research nature, has studied many individual traffic aids that have been suggested by persons within RCA and outside RCA, and have attempted to visualize the long-range acceptance of these individual aids into a system that could grow by adding features with little or no premature obsolesence of previously adopted devices. RCA has taken the approach that complete control of the vehicle on a highway would be the ideal toward which to strive. Therefore, it has built and demonstrated the operation of full-size vehicles on the test track at its laboratories in Princeton, N.J. This track is equipped with devices permitting complete control of suitably equipped vehicles on a single lane of highway, even in the presence of the usual operator-controlled vehicles running in the same lane. In its simplest form, complete control of vehicles requires the performance of only two basic functions: (a) the vehicle must be maintained in its lane (i.e., provided with guidance) and (b) a means must be provided to maintain a proper spacing behind the vehicle preceding it in the same lane of traffic. These functions are built into the test roadway. The equipped automobile has pickup coils and suitable electronic equipment to provide an electrical signal to operate the car's power steering. It also has electronic equipment to pick up from wires in the roadway signals that measure the distance to and the speed of the car immediately ahead. This thereby provides a signal to permit adjustment of speed by operation of accelerator or brake to maintain proper spacing.

Though such complete control could be installed in any highway and in any vehicle today, the economic problems of justification and growth will not permit such a program to proceed rapidly because of the large standard-road mileage in existence today and the large number of cars not suitably equipped. However, highway authorities should establish a program to study such an ultimate system starting at the point currently reached by RCA and other laboratories.

Of greater practical value, however, for the immediate future is the identification of such a system's elements that could be adopted immediately with little or additional development. Such devices include methods of warning vehicles on portions of highway hidden from view because of blind curves or crests of hills. The application of detection devices developed for the automatic highway to purposes of traffic control at intersections would provide the ability to handle a higher volume of traffic at intersections by eliminating time needlessly used for the purpose of changing signals beyond that actually required for the amount of traffic at the intersection and its rate of movement.

Another application would provide a warning to drivers of vehicles traveling in fog that they were overtaking a slower-moving vehicle ahead that they could not see. Aids to vehicle operators such as those just described would require no equipment in the car. If, however, one is willing to consider the installation of electronic equipment in a car, it is possible to supplement the roadside warning techniques with in-car lights or buzzers actuated by the electronic equipment in the highway to provide an additional degree of warning to the vehicle operator. Such equipment would be similar to that providing the control signals for the fully automated vehicle. In other words, selection of a basically sound system would permit expansion into the fully automatic system on a gradual basis. Therefore, during the period of transition three types of vehicles could be operated in an intermixed manner: (a) standard vehicle (b) the vehicle having in-car warning equipment but not fully automated, and (c) the fully automated vehicle. If it is agreed that there is the need to provide improvements of these types, it appears desirable to consider the feasibility of application of an ultimate system permitting the use of interim devices that will provide the vehicle operator with a useful service immediately and would not be obsoleted when full control is eventually

provided. Also, though work has been directed to the ultimate system, the immediate adoption of this or any other system of full automation is not proposed. However, it is considered in the public interest to initiate now a cooperative program of study and development that considers the ultimate system.

To be specific, RCA has proposed that a suitable project would consist of two lanes (one each way) of a four-lane highway for a length of 5 mi that would include electronic equipment providing complete control and a number of highway aids for fully equipped vehicles. This would provide 10 lane-mi of fully equipped highway. In addition, feeder roads that would by typical non-turnpike roadways should be equipped with warning devices at blind curves, over crests of hills, at intersections that have unique or serious traffic handling problems, at blind junctions where two roads merge into one, at entrances and exits or where roads lead to and from limited-access highways, and electronic-visual aids at locations of "two-level" merge.

Detection coils in the highway may be connected in a very simple manner to provide a measurement of speed. This signal may be used to flash on a warning sign that might read "Slow Down—You Are Exceeding the Speed Limit."

With no vehicle equipment other than the standard car radio, an oral signal could be provided that would permit advising the driver of conditions along the highway, especially in times of accident or disaster, and this could also be used on a localized basis to provide information on availability of food and lodging in the vicinity of that particular broadcast. With lights of a type similar to those used on airport landing strips buried in the center of the roadway lane, it would be possible to have a series of several lights precede a vehicle along the highway which would provide a guidance light during periods of poor visibility. At regular intervals, call boxes would permit a motorist with a disabled car to call for assistance.

A roadway of the type described could be partially equipped and initial testing begun in approximately one year from the date of authorization to proceed. A one-year test should permit elimination of operating bugs, demonstrations to interested parties, establishment of a number of standards, and the preparation of plans for application of some of these services to ordinary highways.

Selection of a test location should consider factors such as accessibility, weather, soil, surface material, width of lanes, number of lanes, fog conditions, volume of traffic, and convenience of availability for testing, including the ability to close at least one lane of traffic at certain times without completely disrupting the flow of traffic.

A cooperative program and test roadway would not only provide a laboratory for development but would also serve the necessary service of a demonstration location. One of the greatest difficulties in establishing a new product or service is to attempt to do so without a sample. A roadway equipped as described should permit the prospective State, local, and Federal highway personnel witness the performance of some of these technical devices and evaluate them in terms of their own possible usage. The electronics industry, because it lacks the intimate familiarity with highway problems, is not able to evaluate the relative worth of the various components of a system of the type described. Such a project as described will provide highway and electronic engineers with a much better knowledge of each other's field and thus produce an effective team of workers.

To equip a roadway in the manner described, considerable equipment will be required. In spite of this, however, the cost of such equipment will be a small portion of the cost of a roadway. It is for this reason that those in the electronics industry believe a cooperative project could develop a type of measurement that would place an approximate value on the potential services that could be provided from which an estimate could be made of the possiblity of achieving the established cost goals and thereby determine which features of a system should receive continued support. Inasmuch as it is not possible to place a value on human life or on personal injuries it may therefore, be necessary to consider the results in safety as a "plus" to the true economic evaluations that can be made.

With a highway toll of approximately 40,000 deaths per year and personal injuries far in excess of that number, there appears to be much less concern on the part of the public than there is for airplane accidents which total in deaths but a small number

compared to the highway deaths. This limited concern may be due to the relatively small number of injuries per accident or the belief that nothing can be done about it. However, through the use of advanced electronic techniques, something can be done about it.

RCA has recently submitted a preliminary proposal to the Department of Commerce that a test roadway similar to that described, be built and a "systems study contract" be provided to a single organization to manage the project which would then include not only that prime contractor's interests but also those of other individual organizations and universities and highway workers generally. Such an approach will avoid wasted effort that is likely to result from a hit-or-miss approach involving individual devices and techniques. With some possible exceptions, elements of immediate highway vehicle automation should be compatible with the long range goals and devices adopted for immediate use should be modified, if necessary, to avoid getting into what could be an untenable position that would never permit consolidation into a system providing maximum advantage.

In conclusion, it is requested that key workers in the highway field take into committee for consideration the problem of how to establish a cooperative program at the earliest possible date. There may be disagreement on precisely what should be done but that should not deter from establishing a small group of knowledgeable individuals who would be able to outline quickly a program acceptable to all interested agencies. There is a great similarity between this situation and that in television about 20 years ago when cooperative projects involved technical development, legislation, program service, equipment service, manufacturing, and financing.

A few months ago, a special committee reported to President Kennedy and Secretary of Commerce Hodges that techniques had been developed for electronic control of highway vehicles and that further development and application to actual roadways should be expedited to hasten the benefits. Experience with large and complex systems has led RCA to the conclusion that implementation of 5 or 10 mi of automated highway, together with devices for installation on ordinary roads, would provide the most realistic next step.

It is of primary importance in establishing a test program that major and equal consideration be given to the objectives and the possibilty of practical use of these devices, rather than merely to prove that a technique can be successful in providing control but at a cost that would be unrealistic.