INTERACTIVE GRAPHICS AS A TOOL IN PLAN EVALUATION

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INTRANS is a man-computer interactive graphics system designed for real-time analysis of transportation and urban data. During mid-1973, INTRANS was used by the Chicago Area Transportation Study as an aid in the evaluation of alternative plans for the 1955 major review. This paper describes the project. INTRANS has been proved effective as a tool for choice and design of figures, as a convenient medium for retrieving planning data, and in analysis of specific problems. A number of problems and difficulties, some of them marginal, have prevented more extensive and effective use of the system. It is concluded that interactive graphics systems in general, and INTRANS in particular, are cost-effective tools for transportation planners. Increases in their effectiveness and capabilities will come mainly through more extensive use by practicing professionals.

•INTRANS is a man-computer interactive graphics system designed for application in transportation and urban planning. INTRANS-BROWSE is a subset of INTRANS; it enables real-time graphical analysis of existing data sets (1). In mid-1973, the Chicago Area Transportation Study (CATS) performed a major review of alternative transportation plans for 1995 (2). INTRANS was used to support the planning and review process. The purpose of this report is to present the experience gained in this project.

INTRANS-BROWSE is an interactive graphics system that enables on-line graphical analysis of existing data sets. The system includes the following features:

1. Data management system—Data sets are structured in three levels: (a) files, one file for each alternative; (b) variables, one variable gives the number of transit trip ends in each zone; and (c) elements, the i th element in the variable is the number of trips from zone i. Variable size is limited to 2,500 elements, and there is no practical limit to the number of files or variables. In the CATS analysis there were seven files, each with approximately 100 variables of 1,700 elements.
2. Display routines—INTRANS enables the display of intensity maps, frequency distributions, and functional relationships of the variables.
3. Computation routines—These routines enable arithmetical manipulations of variables by using FORTRAN types of statements. Variables of different files can be used in the following routines: basic statistic routines, utility routines, such as Data Editor, and peripheral programs for data loading and maintenance.

INTRANS operates on an IBM 360/370 with full OS. It can operate by residing in dedicated core; however, the standard operating mode is under time sharing. The graphic terminal is a storage display tube, such as the Tektronix 4010. The terminal can be either hard-wired to the computer, or connected through a telephone line.

A device that prepares direct hard-copy image of the screen can be installed. Most of the figures in this report were prepared by this device.

The system is extremely inexpensive for both hardware and operation.

USE WITHIN THE MAJOR REVIEW

INTRANS was used in the major review as a tool for data retrieval, manipulation, and display. Various UTP models were run in the conventional batch processing mode;

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relevant input and output data from the runs were transferred into INTRANS files for interactive analysis. Within this scope, the major contribution of INTRANS was its aid in highlighting the differences among the alternatives, in terms of demand and performance characteristics. The amount of information accessible through use of INTRANS was much greater than that previously available (with reasonable effort and time). No less important, the INTRANS data files have become a permanent source for timely and detailed information regarding the Chicago region and the alternatives. Some examples of the use of INTRANS in this context are given in the paper.

Mainly because of administrative problems, INTRANS was available for use only in the evaluation stage of the planning process. Obvious potential applications in input preparation, model calibration, and plan formulation were not tried.

The major conclusion of this project is that interactive graphics systems in general, and INTRANS in particular, are cost-effective, operational tools for transportation planning. However, much work and experience are needed to use these systems to their full potential.

APPLICATIONS

Because of the lack of previous experience in the use of INTRANS within an operational planning process, this project was considered semi-experimental. On one hand, production use of INTRANS was made in rather straightforward and simple applications in which the final product was well-defined and directly usable within the planning process. At the same time, more complicated applications with potential benefits were tried, mainly to gain experience for future projects.

Four features of INTRANS have been of prime utility in the evaluation. First is the ability to produce intensity maps. By observing a map describing a variable, the analyst gets much more information in much less time than by scanning through a listing. For example, Figure 1 shows a map of estimated volume-capacity rates for the region. By examining the map, the analyst immediately sees a picture of location and extent of expected congestion. A second important feature of INTRANS is the computation capabilities. The ability to relate any two variables from the same alternative, or from different alternatives, is extremely useful. Figure 2 shows a map of the (interactively calculated) differences between estimated volumes and capacities. The analyst receives, through such a map, a comprehensive picture of highway deficiencies. As another example, Figure 3 shows differences between two alternatives in the transit travel time to a center of activity. Extent and locations of improvements are immediately apparent.

Another important feature of INTRANS is the organization of data and ease of access to them. In a period of intensive analysis, it is much cheaper and faster to access a specific piece of information through INTRANS than to look it up in a prepared listing. This feature is especially important when, during the analyis, it is necessary to examine carefully a specific issue. Without the use of INTRANS, data preparation for such a problem requires more time and is more expensive. A fourth useful feature of INTRANS is flexibility in designing graphical displays and the ease in their preparation. This feature has been instrumental in preparation of various reports.

It is significant to note that the hard-copy device has been proved essential. As a matter of fact, most of the hard analysis has been done on the hard copies; the interactive sessions have been used to try alternative displays and produce hard copies of those required for the later analysis. Even when interactive analysis has been tried, the hard copies efficiently replace the use of multiple screens.

Data for the Analysis

Most of the data used in the analysis were zonal data. They covered practically all phases of the modeling process. They include land use information, trip ends by purpose, average trip lengths, vectors of trip distributions and skim trees for selected zones, amount of travel generated by and going through each zone, network capacities (by mode) for each zone, mode and submode split information, and more. The information was transferred from output tapes of the model into the INTRANS files by a set

Figure 1. Estimated volume-capacity ratio displayed against expressway skeleton.

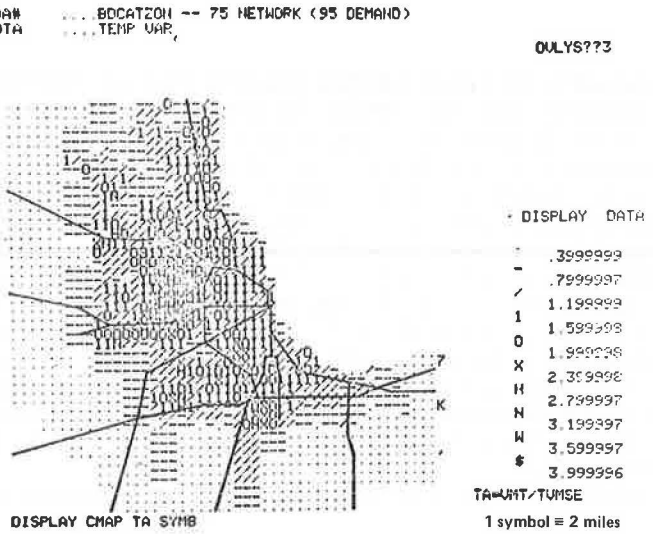


Figure 2. Highway deficiencies displayed against expressway network and major towns.

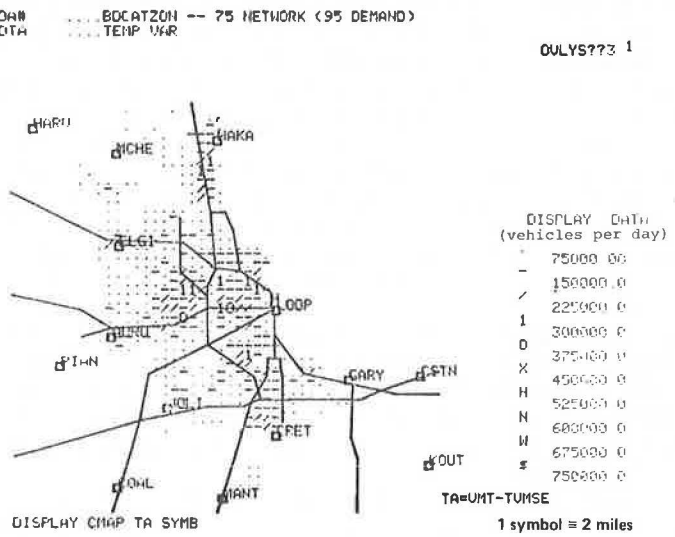
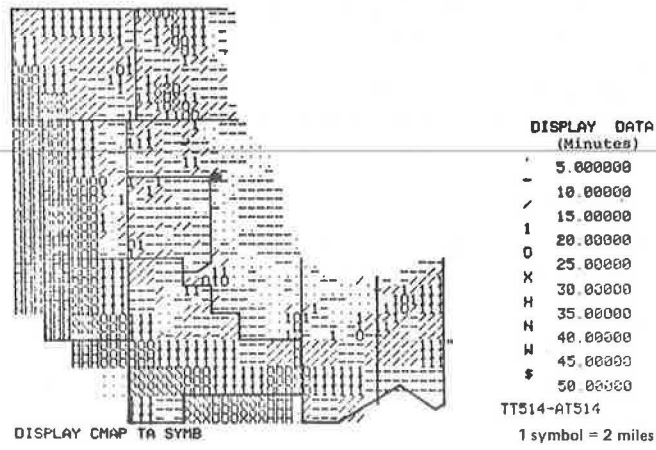


Figure 3. Differences in transit travel time to O'Hare between existing network and alternative D.



of peripheral programs that ensured smooth and fast transfer. It was possible to complete the data transfer process for any model run within half a day after the output tapes were available.

A special set of programs was written to retrieve data from the Department of Housing and Urban Development UTP transit analysis package. One set of programs was used to retrieve skim tree information such as travel times, access times, and priority modes for selected zones. Another set summarized zonal transit volumes (person-miles) and amount of service (seat-miles) by submode.

The INTRANS data files were stored on line for the period of intensive analysis and then deleted. Back-up data files were stored on off-line disks and tapes for future reference.

Types of Applications

Within the CATS major review process, INTRANS was used to prepare a plan reference report, design figures for the final report, and analyze special problems.

Plan Reference Report—A major product of the project was a plan reference report (3). The report included four types of information:

1. Variables describing the region in 1995 (e.g., trip generation rates),
2. Detailed description of demand and network performance for the do-nothing alternative,
3. Key variables describing the performance of each of the seven alternative plans, and
4. Displays of performance differences between each alternative and the do-nothing alternative.

The report described in detail the source and meaning of the variables being displayed, but included almost no analysis of specific displays. It included approximately 200 displays.

The plan reference report has been used as an easily accessible, permanent source of detailed information on the 1995 plan, mainly for internal use. It has also been used as a "shopping list" that summarizes for CATS planners the material and capabilities available to them through INTRANS. Consulting the material in the plan reference report has produced more effective special-purpose interactive sessions. The report might also be considered an alternative to direct use of INTRANS for creating displays that are likely to be needed repeatedly.

Design of Figures and Maps—Once decision to include a map in the report was reached, INTRANS was used for examination and design of the map. First, the maps were reviewed on the screen (or in the reference report) to decide whether they were effective. Second, various alternatives for scaling, group ranges, and so forth were tried to have the most effective design. Once the design was decided on, maps were produced in conventional methods. Use of INTRANS for this function saved a significant amount of manual work. The natural extension, i.e., direct use of INTRANS displays in the final report, was rejected because of the low graphic quality. The more important deficiencies were the coarse grain of the displays and small original size, which prevented reduction for reproduction, and lack of multiple-color capabilities. It should be noted, however, that INTRANS displays have been used extensively in technical reports and memos.

Analysis of Special Problems—During and after the evaluation process, specific questions were raised, in which the information required to answer them has not been readily available. One group of questions is related to subareas, or specific locations: What are the levels of transit service to O'Hare Airport in the various alternatives (Figs. 3, 4, 5)? Another question relates to specific projects or issues: What is the effect of changes in fare policies (alternative F) on rapid transit ridership (Fig. 6)?

The third question is more general: How do the relative levels of service of transit versus highway change among the alternatives (Fig. 5)? INTRANS has proved effective in supporting the analysis of such questions.

Previously, a standard procedure has been followed in the preparation and conduct of such analyses. A list of variables and relations that seem to be relevant to the

Figure 4. Transit travel time to O'Hare on existing network.

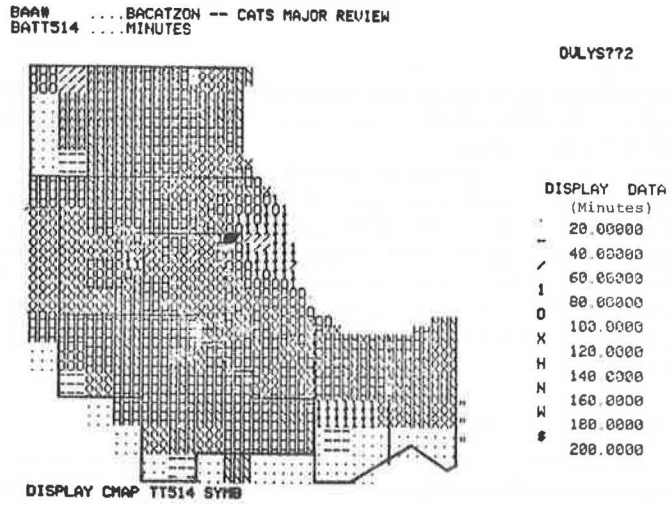


Figure 5. Differences in travel time to O'Hare between transit and car.

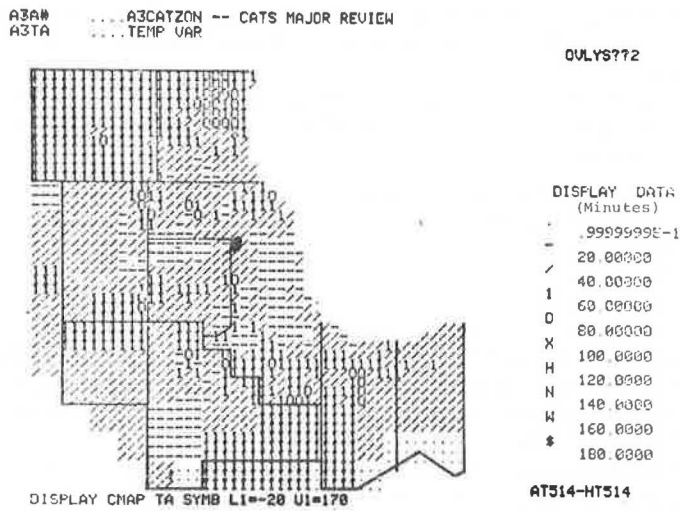
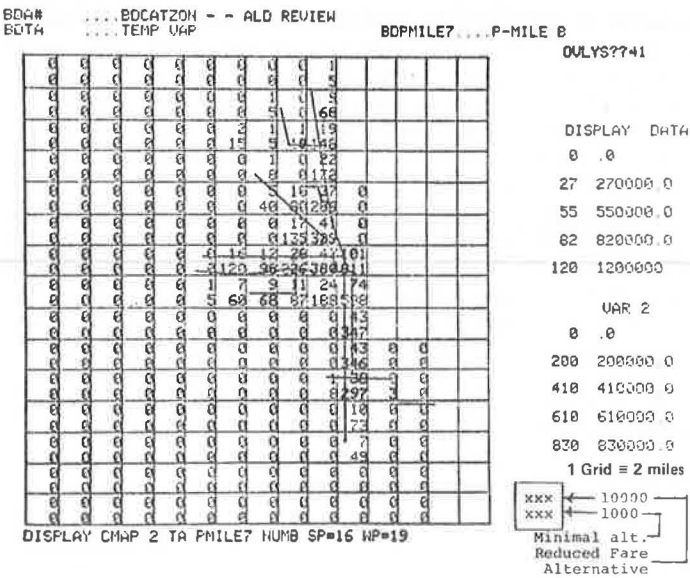


Figure 6. Total person-miles on rapid transit system displayed against transit network.



problem is prepared, together with a set of hypotheses (the plan reference report has been very useful in this stage). In an interactive session, which includes an operator and two or three analysts, the variables are examined, the hypotheses are modified, and the same process is iterated through. Hard copies, used as a skeleton for a short report summarizing the findings, are prepared of significant displays. In cases of more complicated problems, one session is usually not sufficient; when the displays of the first session are analyzed, more questions are raised that must be answered in a second or third session. Experience to date has shown that, unless the problems are extremely simple, a significant part of the analysis is not interactive. During the interactive session only rough ideas are formulated, but they are refined, finalized, and summarized in the relaxed environment of the designer's desk.

PROBLEMS AND DIFFICULTIES

For the CATS major review, the use of INTRANS was limited to a rather narrow range of applications. Within this range, however, the project demonstrated the significant effectiveness of IGS in planning. However the project exposed a set of difficulties that, if resolved, might increase the effectiveness of INTRANS substantially. (During fall 1973, many of the deficiencies discussed here were corrected. In particular, much more flexibility has been introduced to the interactive language and to the geographical ID methods.)

In the following paragraphs, the more significant difficulties are discussed. Part of the discussion is concerned with seemingly minute and uninteresting details that are, nonetheless, an important factor in the success or failure of IGS applications.

Interactive Analysis

Trials to perform a complete problem analysis in an interactive session have not been successful, especially when the problem has required significant amounts of concentration or mental effort. In most cases, the analyses during the interactive sessions have been limited to rough examination and acceptance or rejection of various hypotheses; major portions of the interactive sessions have been devoted to design and preparation of hard-copy displays. Detailed final analysis and drawing of conclusions have had to be done later by using the displays as a reference. Experiments in running complete interactive analysis sessions with the use of dictating machines, different group sizes, and other variables have not been very successful. More experimentation is needed to pinpoint the problems and to find effective procedures for interactive analysis.

Interactive Language

INTRANS gives the user desired flexibility in designing displays. However, to request nonstandard display design requires a lengthy command. The long commands have become quite bothersome in some cases, e.g., when similar displays have to be repeated as for all the alternatives. It is highly desirable to minimize this problem by enabling changes (during interaction) in the default display design.

More generally, it is highly desirable that the commands be as short as possible in terms of the number of characters typed in. The "natural language" commands that are now used by INTRANS make the initial training in the system very easy. However, long command words, with the resulting typing errors, become a drag to the experienced operator. A possible solution to this problem is to give the user freedom in defining his language or, more simply, to implement a number of language levels, including the option of using shorthand.

Geographical ID

The version of INTRANS used for the major review analysis required that area data be identified as a grid. This requirement did not cause many difficulties in treating CATS data. The areal ID of CATS has been based on townships that could be described as slightly distorted 6- by 6-mile grids. For the analysis, CATS zones were defined as squares that were parts of townships with varying sizes of ½, 1, 2, 3, and 6 miles.

When the data were loaded into INTRANS, the zonal data were transformed to a uniform 2-mile grid, which served quite well in most applications. However, in some cases it was found necessary to check data on specific CATS zones—a service that INTRANS could not provide. This capability seems to be useful for data editing, checks for errors, and so on.

A satisfactory solution to this problem is not easy to come by. The problem is complicated by the limitations of screen size, character-screen size ratio, size and number of zones that have to be displayed, and more. [Detailed discussion of the problems involved in creating intensity maps by IGS is given by Gur (4).] However, the problem of compatibility between the analysis zones and the display zones is important enough to justify more research and development. We are now experimenting with possible solutions to this problem. (The second version of INTRANS includes the option to store and analyze data for zones of any shape. Map displays are produced by using the proximity rule.)

Physical Environment of the Graphics Terminal

During an interactive session, analysts need, and are capable of handling, much more information than can be presented on the screen at one time. The environment of the terminal must be designed so that all this reference material can be easily viewed and handled. It seems unrealistic to plan meaningful interactive analyses with exclusive use of the CRT.

The Host Computer

CATS uses the state's computer center for data storage and simulation runs. INTRANS, on the other hand, runs on another computer. (Time-sharing is not available on the state's computer.) Therefore, data must be transferred by tapes between the two computers. This results in time delays, waste of computer time, and duplication of data files with the resulting updating problems. This problem can be best overcome if INTRANS is run on the same computer in which the data are stored.

Location of the Terminal

The INTRANS terminal was not located in CATS offices. This made the overhead on an interactive session rather high. As a result, the use of INTRANS as an occasional reference for a few pieces of information has become unfeasible. [Experience with an INTRANS terminal in the office proves the utility of short (5 to 15 minutes) sessions, which were not feasible when this paper was written.]

CONCLUSIONS

The project's main conclusion is that interactive graphics systems are already cost-effective as an operational tool for transportation planning. At the same time, it is clear that full utilization of this new tool can be realized only through much work and dedication of the people involved. The present contribution of interactive graphics is marginal and by no means revolutionary; at the same time it is apparent that this tool has tremendous potential. It seems that the rate at which the role of interactive graphics as a tool in transportation planning will grow depends mainly on the desire of practicing planners to learn how to use it for their benefit. Gaining experience in its use is now of more importance than trying to improve its sophistication and adding capabilities to systems such as INTRANS.

INTRANS has been proved to be effective mainly in the following areas:

1. Preparation of figures for subsequent use in reports, mainly by sorting alternative displays to choose the more effective ones, and detailed design of the chosen displays;
2. Examination of relationships between different variables and different plans (INTRANS makes it possible to analyze and display many relationships and pieces of information that previously were inaccessible);
3. Supplying a medium for examination and refinement of rough ideas and hypotheses regarding the attributes of the transportation system and of different plans; and

4. Supplying a convenient and fast access to large parts of the modeling data (access is instrumental for response to occasional inquiries on specific issues from within and outside of the agency).

INTRANS has been less successful in a number of areas. First, the graphic quality of INTRANS displays does not meet the standards of a high-quality final report. Manual drafting of figures for the report was required. Also, experiments to conduct complete interactive analysis of moderately complicated problems have not succeeded. The interactive session has been used most effectively to examine rough ideas and to prepare hard copies of relevant displays. Final formulation of ideas and conclusions requires further work after the interactive session.

In terms of logistics and the structure of the hardware system, the following improvements are suggested:

1. The IGS should operate on the same computer in which major data files are stored. Significant delays and inefficiencies occur when it is necessary to transfer data between computers and maintain two data files.
2. The terminal should be located within the agency's offices. Immediate access to the terminal to make fast inquiries on relatively small problems increases the utility of the system significantly.
3. In the interactive session, there should be an operator whose sole responsibility is to push the buttons based on the analyst's requests. If the analyst is required to concentrate on the operating details of the system, he will be prone to make mistakes, slowing down the analysis and ultimately losing much of the effectiveness.
4. An efficient, high-quality, and fast hard-copy device is mandatory. It is doubtful whether the system discussed would have been effective at all without such a device.

It is rather tempting to introduce a long list of new and improved capabilities that would be prestigious to add to INTRANS. Many of these capabilities would most likely be effective and will eventually be added. However, it is not apparent to me that more capabilities are of the utmost importance at present.

It is necessary, now, to study how existing interactive graphics capabilities can be used more effectively. The study has to concentrate on the man side of the man-machine system. How an interactive analysis should be prepared and conducted, the desired attributes, the required training of a good interactive analyst, and the types of problems that can best be analyzed by interactive graphics all must be determined.

Such research, together with increased use and further development in hardware and software, is likely to make interactive graphics a widely used analysis tool in transportation and urban planning in the near future.

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