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Potential of Graphical Information Support for Transit Decision Making and Performance Evaluation

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The objective of this paper is to examine the potential of the graphical information system (GIS) to increase transit operator control over performance by improving decision-making effectiveness. The GIS is based on the distinction between data and information; data are collected facts, but information is only that data useful for a particular purpose and perceived as such by the user. The GIS increases both relevant information and its perception. The GIS is effectively used in semistructured decisions where it enhances the ability of the user to apply creativity and judgment in solving novel problems. An example illustrates the potential of the GIS to convey patterns, trends, and relationships, thereby enhancing the ability of the user to filter relevant information from extraneous data. Several graphic profiles of a bus route are contrasted with the corresponding tabular summary. All are derived from the same data, but because of data format they convey significantly different information.

Inadequate information to support decision making is a fundamental problem in increasing the ability of the transit operator to control performance. Control is exercised through two types of decisions: (a) decisions that identify problems, and (b) decisions that specify problem correction. To increase control, the transit operator must be able to identify and correct problems effectively.

Effective decision making, however, is often constrained by a lack of information. Despite masses of collected data, little true information may be available to support decision making.

This paradox indicates the significant distinction between data and information. Data are a collection of facts, but information is that data subset that is useful for a particular purpose and perceived as such by the user. Information is knowledge for the purpose of taking effective action (1) and is context specific.

Graphical information systems (GISs) offer the transit operator a powerful tool to increase the information available for control decision making.

As referred to in this paper, a GIS is a type of decision support system (DSS) (2).

The GIS is a conversational, interactive computerized system that offers the user the capability to access and graphically interface with the analytical power, models, and data bases held in the computer.

The work in progress at Princeton University in developing a prototype GIS for New Jersey Transit Bus Operations (NJTBO) to support bus route monitoring and evaluation is presented in this paper. The two objectives of this work are to (a) characterize the decision contexts for which GIS is an appropriate technology, and (b) illustrate the potential of the GIS to increase the availability and perception of information.

MATCHING GIS TO DECISION CONTEXT

To increase the availability and perception of information, the GIS must be properly suited to the particular decision context as defined by the decision task and the decision maker.

The GIS is an appropriate technology to support semistructured decisions. These are decisions for which some aspects of the problem can be precisely defined or programmed, although other aspects are inherently intractable to structuring (2).

This type of problem is best solved through some combination of specified rules and subjective analysis. These problems typically require some manipulation or computation on a data set as well as the judgment and reasoning of the decision maker. Such problems are often solved iteratively; the decision maker specifies the necessary computations or modeling, assesses the results, and specifies the next step in the analysis. The process continues until the decision maker is satisfied that an adequate solution has been reached.

The majority of decisions under the control of the transit operator are semistructured. These include decisions involving performance evaluation, routing, scheduling, network planning, and demand analysis and forecasting (3).

Three characteristics of the GIS are particularly advantageous in solving semistructured problems. First, as a computer-based system the GIS can accurately search or manipulate large data sets and perform complex operations, thereby allowing the user to focus on analysis rather than computation. Second, as an interactive system the GIS rapidly interfaces with the user, thus allowing vaguely defined solution strategies or hunches to be pursued with minimal interference.

Finally, as a graphical system the GIS facilitates perception of semiquantitative information. This type of information is often critical in semistructured problems, especially in the problem-finding process. By presenting data in graphical rather than tabular formats, the GIS enhances the ability of the user to filter relevant information from extraneous data and facilitates perception of patterns, trends, relationships, deviations, and conformities.

CASE STUDY: NEW JERSEY TRANSIT BUS OPERATIONS

An example taken from NJTBO illustrates the potential of the GIS to increase the availability and perception of information in semistructured decisions.

Bus schedules are revised quarterly at NJTBO. Problem finding is the first step in this process, and it is primarily based on the trip summary report (Figure 1). This report details total weekday passenger data by trip, differentiated by inbound or outbound direction, for a 3-week period. The manager scans across the rows, attempts to determine trends for each trip, and balances the trends against prior knowledge of the system and external conditions (such as weather). This tabular format requires the manager to focus on detailed numbers; it hinders perception of semiquantitative information for problem finding.

In contrast, Figures 2-10 are examples of graphical formats available with the GIS. These graphs have all been derived from data recorded on the trip summary report, yet they convey significantly different information.

Figure 2 uses a linear time scale in plotting average inbound ridership versus trip time. Each vertical line represents an individual trip, and the line density indicates service concentration. This format allows the user to easily relate ridership to service frequency and may indicate where service could be more effectively timed. For example, the graph suggests increasing the headways between the 5:46 and 5:47 a.m. trips and the 7:40 and 7:43 p.m. trips to increase ridership.

This information would typically be complemented with the corresponding information on outbound trips, as shown in Figure 3. The operator may know that the 5:46 a.m. trip turns around and becomes the 7:00 a.m. outbound trip, which is well patronized; consequently, the operator may decide not to change the 5:46 a.m. trip.

Figures 4-6 contain the same data as Figure 2, but they are plotted by using a nonlinear time scale. As a consequence, these formats facilitate the comparison of ridership between specific trips. Figure 4 uses a bar chart to display totals, whereas Figure 5 uses a scatterplot and Figure 6 uses a lineplot. Although trips are discrete, and thus the line segments in Figure 6 have no inherent meaning, this format is preferable to the scatterplot for many users. The lines focus the user's attention on

Figure 1. Trip summary report. (Note that this is a copy of an original document.)

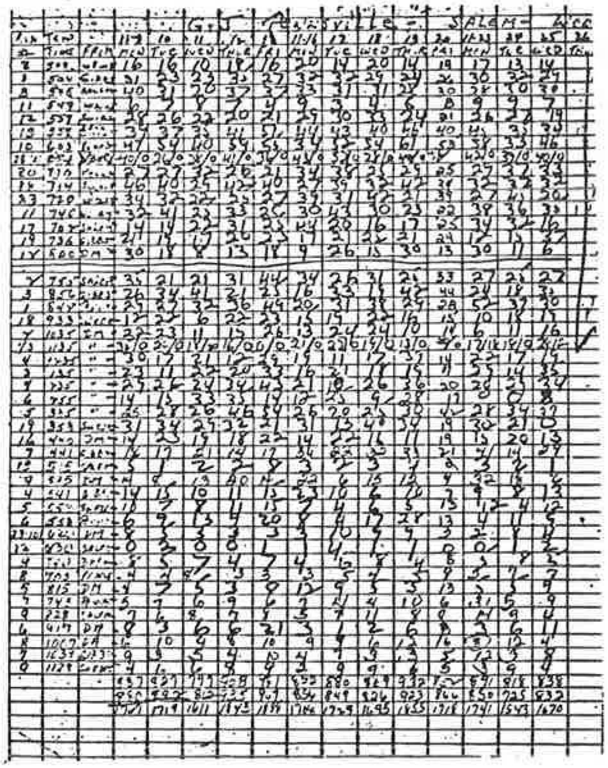


Figure 2. Average inbound ridership by trip.

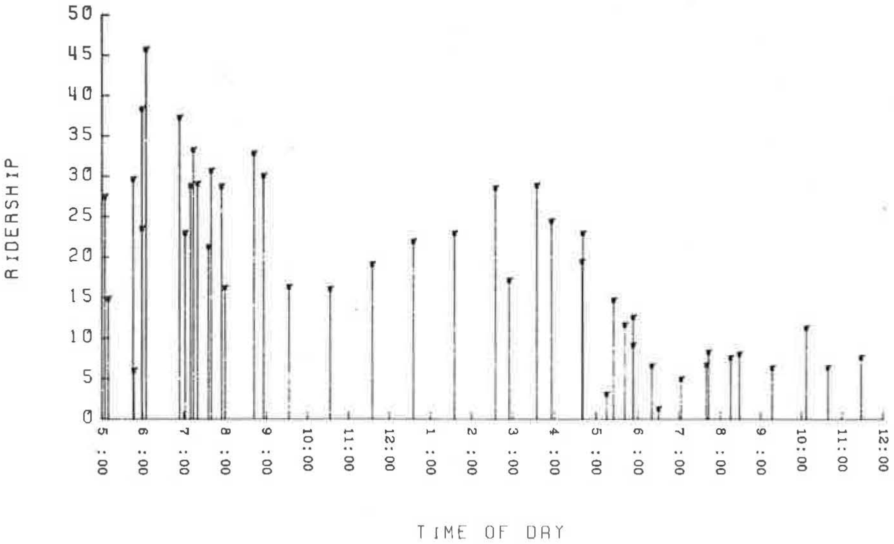


Figure 3. Average outbound ridership by trip.

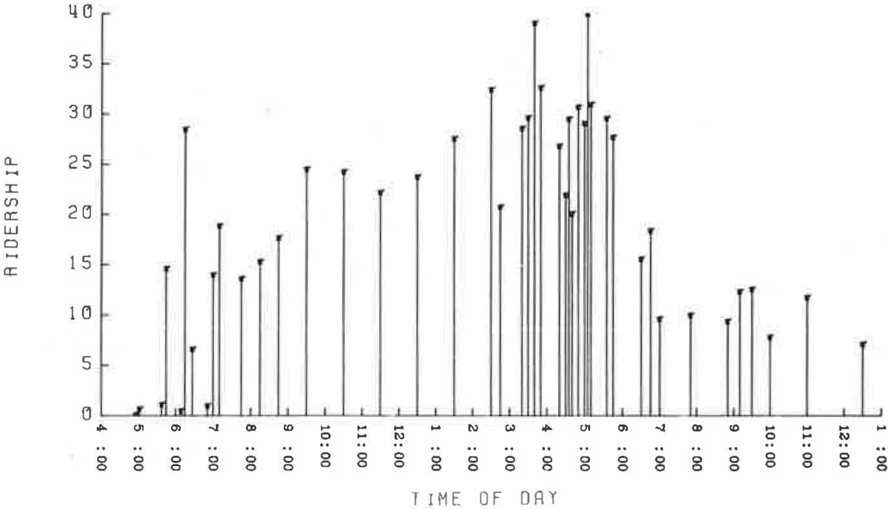


Figure 4. Average inbound ridership by trip (barchart).

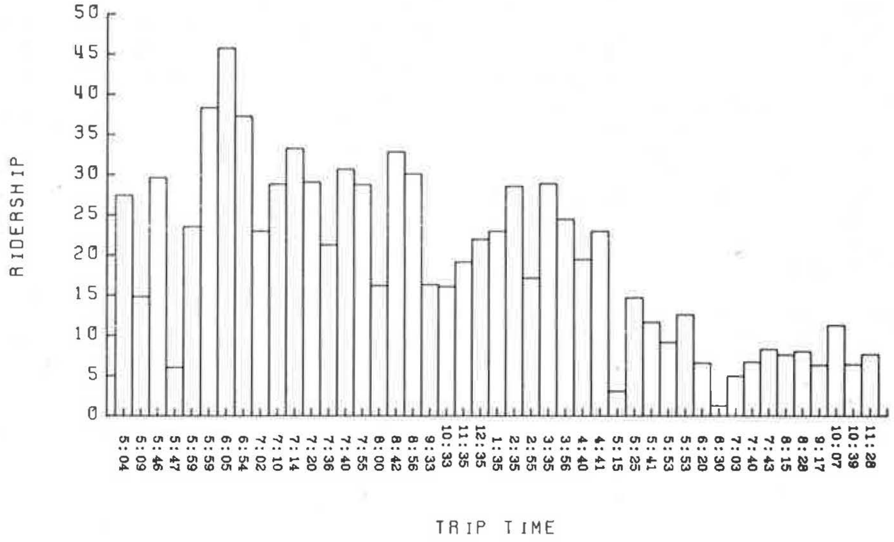


Figure 5. Average inbound ridership by trip (scatterplot).

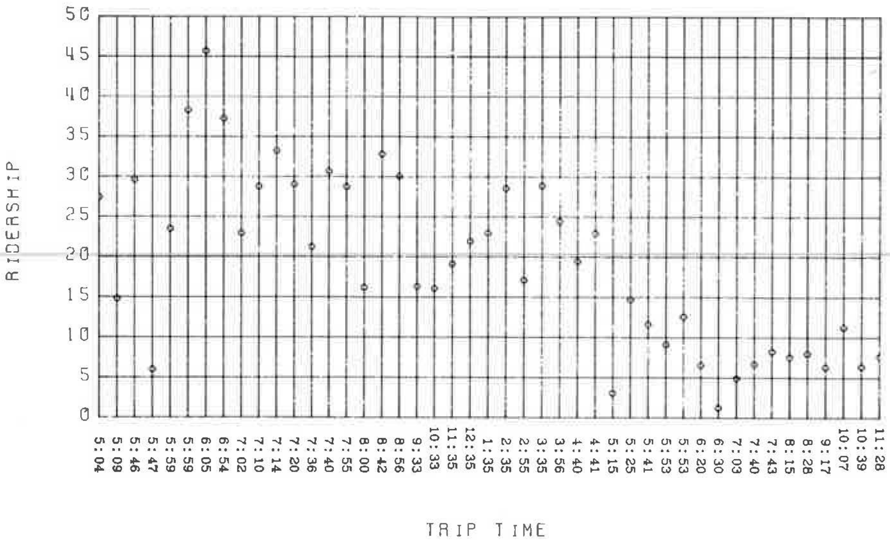
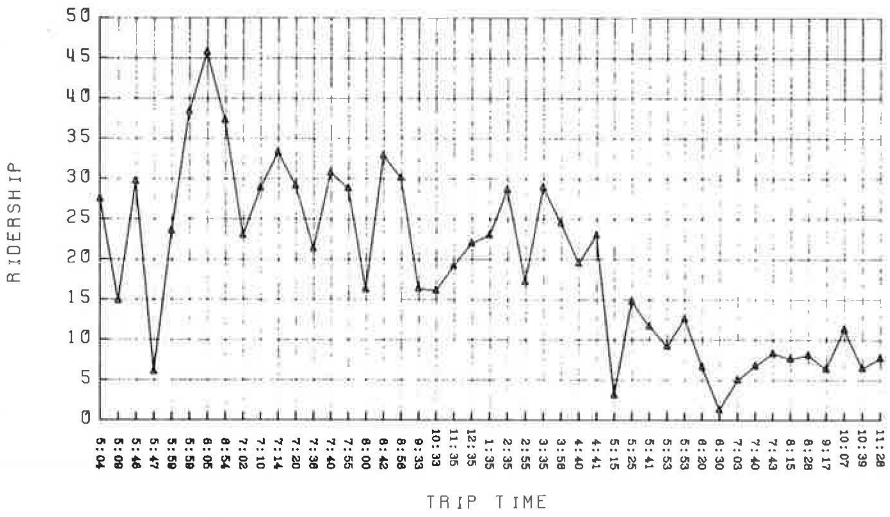


Figure 6. Average inbound ridership by trip (lineplot).



fluctuations as they occur by time of day, rather than permitting the eye to randomly jump around the display. The GIS allows the user to select whichever format is preferable.

Figures 7 and 8 are examples of how the GIS enables the decision maker to examine performance by day of week. Figure 7 plots total ridership by weekday, whereas Figure 8 plots ridership for an individual trip by weekday. This information allows the decision maker to discern cyclical ridership fluctuations; thus it indicates how service should be adjusted. In addition, unusual deviations by trip may suggest problems with on-time performance. For example, unusually high ridership may indicate that the bus was running late and picking up riders who would have normally taken the next bus.

Figures 9 and 10 plot cumulative inbound and outbound ridership versus time of day, respectively. These graphs enable the rate of ridership to be easily related to service frequency, either as an absolute measure or as a percentage of the total. For example, from Figure 9 it is quickly seen that 50 percent of the inbound ridership is achieved before 8:00 a.m. and 90 percent before 6:00 p.m. Service is heavily concentrated between 7:00 and 8:00 a.m., and the rate of ridership is high, with almost one-quarter of the total inbound riders gained in this period. Together these plots of inbound and outbound ridership may be used to indicate how service can be more effectively timed to increase patronage.

CONCLUSIONS

The GIS can greatly increase the decision-making effectiveness and ability of the transit operator to control performance. By increasing both the amount of available information and its perception, the GIS enhances the effectiveness of the decision maker in solving semistructured problems. It permits the user to rapidly access and filter relevant information from extraneous data, thus enhancing the ability of the user to apply creativity, judgment, and reasoning in solving novel problems.

Figure 7. Total ridership by weekday.

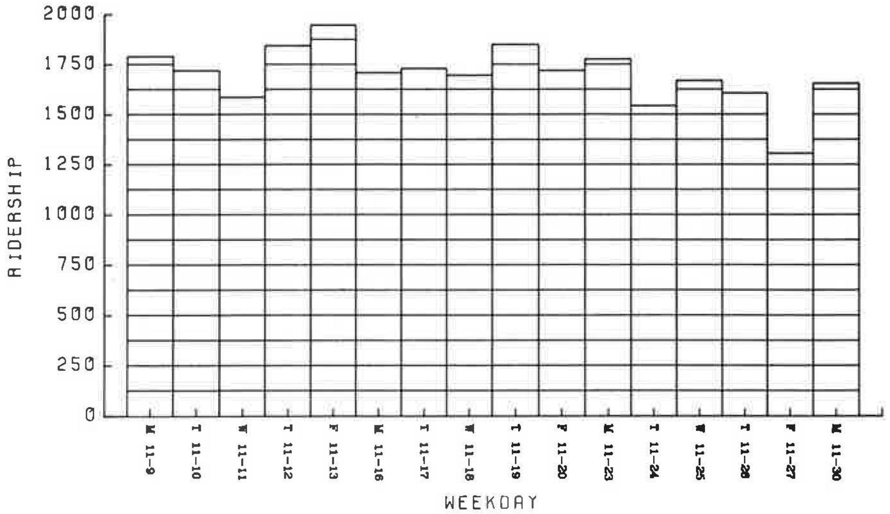


Figure 8. Weekday ridership on the 7:55 a.m. trip.

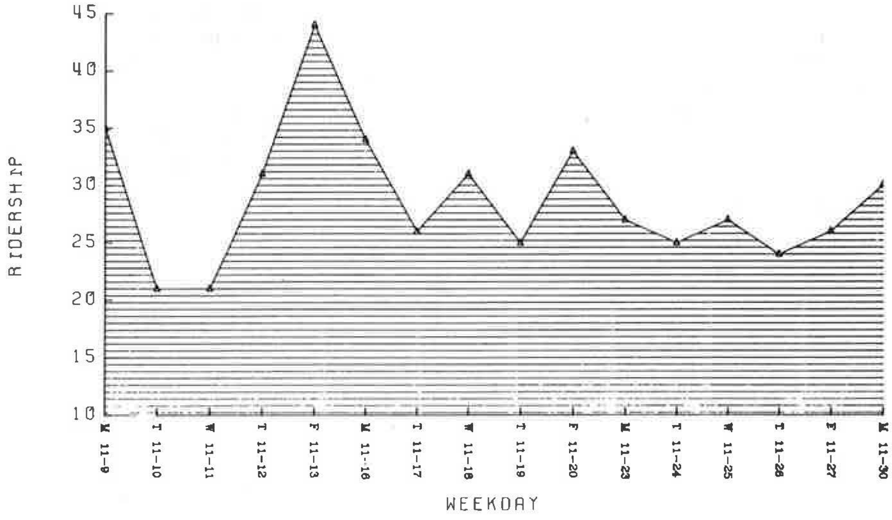


Figure 9. Cumulative inbound ridership.

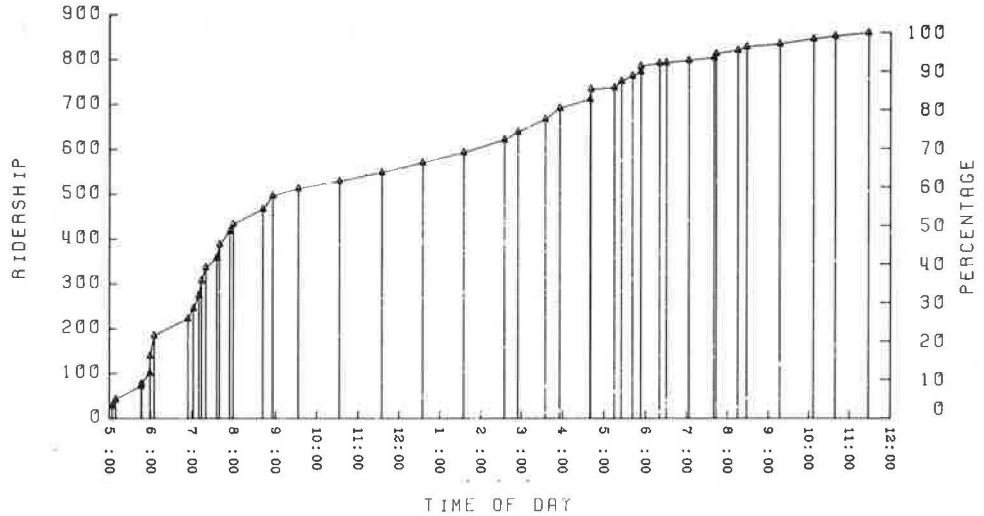
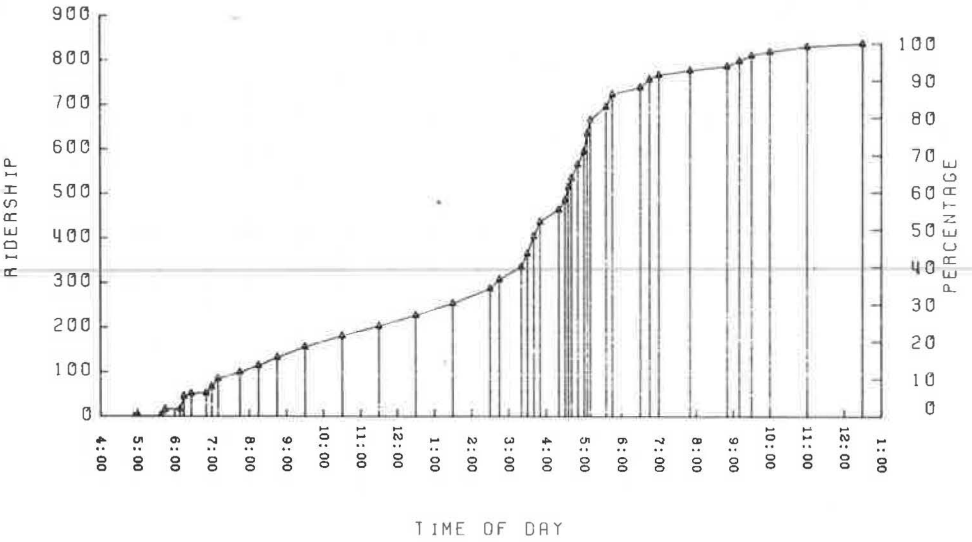


Figure 10. Cumulative outbound ridership.



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The Fare Cutter Card: A Revenue-Efficient and Market-Segmented Approach to Transit Pass Pricing

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Recently, many transit properties have studied or instituted prepaid passes as part of marketing programs designed to retain existing riders and attract new riders. At the same time, transit properties are facing severe financial problems. As a result there can be conflict between the marketing department that wishes to offer an attractive fare mechanism that offers a substantial discount and the financial department that is concerned about lost revenue and free rides. To resolve this conflict, the Greater Bridgeport Transit District (GBTD) has introduced the Fare Cutter Card as part of a comprehensive demonstration of market-based fare policies. This card (actually a permit) has a substantially lower initial cost than an unlimited-use pass but requires a $0.25 cash-drop for each ride. The card is therefore more affordable to low-income users while returning revenue to GBTD for all rides taken. Different approaches to implementing the Fare Cutter Card may enable a major extension of fare prepayment without additional loss or a major reduction in revenue losses allocated with fare prepayment, while maintaining the existing level of use. The GBTD experience to date with the Fare Cutter Card is preliminary, but the card appears to be popular with riders. In this paper the analytical issues associated with the assessment of permits as compared with unlimited-use passes are outlined, the benefits of tailoring prepaid mechanisms to the characteristics of user submarkets are summarized, and marketing-related benefits of the Fare Cutter Card approach are discussed.

Monthly or weekly passes were once quite common in the transit industry. Urban residents who used public transit regularly for work and nonwork travel found the pass efficient and economical. Because most transit users made at least some nonwork transit trips during the month, pass purchasers were not overly concerned with failing to receive full value from a pass if they missed a few days of work during the month.

During the 1950s passes tended to fall into dis-