

Improving Public Transit Schedules – Timetables People Can Actually Read

FINAL REPORT
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Submitted by

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16. Abstract There has been extensive research on effective methods for visual information presentation that has lead to the establishment of useful principles for implementation. In the book Human Factors in Engineering and Design, Sanders and McCormick (1993) discuss a number of important visual display features, including typography (e.g. stroke width, font type, size), layout (interletter spacing, interline spacing, logical grouping and layout of information.), color, and information grouping. In his book titled "The Visual Display of Quantitative Information", Tufte (1983) uses many examples of good and poor designs to illustrate important factors for quantitative visual presentations. Through these and other references as well as feedback from customer focus groups and surveys, the research team proposes to (1) determine how well current timetables serve both bus riders and non-bus users; (2) identify the major deficiencies in the current timetable design and (3) develop more effective layout schemes.			
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SUMMARY

Operating over 200 bus routes, many with complicated patterns and schedules, and frequent changes, New Jersey Transit Corporation (NJ TRANSIT) recognizes that reading transit schedules can be a stressful, frustrating experience for some and in fact may actually deter potential customers. In its ongoing commitment to customer service, NJ TRANSIT, through the New Jersey Department of Transportation's Research Program, has initiated a project to: (1) examine existing literature and research in the area of reading and deciphering transit schedules and other similar forms of information; (2) determine how well NJ TRANSIT's current timetables serve both bus riders and non-bus users; (3) identify the major deficiencies in the current timetable design and (4) develop more effective layout schemes.

A comprehensive review of available human factors and cognitive psychology research in the areas of reading, processing information and interpreting in text and graphical format and we found that several studies were conducted specifically in the area of transit schedules. Some interesting and relevant findings from the literature review that pertain to this project are summarized below:

- One study indicates that time point locations and time points should be displayed on the same axis. NJTRANSIT bus schedules display the time point location and time points on perpendicular axes, thus requiring the user to "flip" the schedule when looking for the arrival departure times for the corresponding location.
- Several studies indicate that the font size should be a minimum of 10 point. We found that many of the current NJ TRANSIT bus schedules employ less than this size font.
- One study indicates that the most effective timetable layout places the time point locations at the top and the time points below. The user then reads boarding and disembarkation times across. This practice is consistent with NJ TRANSIT bus timetable layouts.

Relevant research and literature, a review of other transit agency schedule layouts, and feedback from two customer focus group sessions, two prototypes provided the basis for developing two "prototype" schedules. The existing schedule was then tested against each prototype using a quantitative performance evaluation in which subjects were given a series of written exercises and were then asked to use the timetables to answer questions. Typical questions included what time the subject would need to be at a particular location, where they would need to board the bus and expected arrival times. Responses were given orally and were recorded by the experimenter so as to

minimize potential translation errors. Subjects were also asked to respond to a series of subjective questions to identify problems and timetable preferences.

Error rates were alarmingly high both for the two prototypes as well as the existing schedule. The high error rate (performance based questions were answered incorrectly at least 50 % for the existing schedules as well as the prototypes) may be a strong indication that there is simply too much information on the timetable. Furthermore, in order to include the plethora of information and stay within the practical paper size limits, it was necessary to keep font sizes either right at or below than recommended minimums (the body of research recommends a six-point font size minimum). Therefore, elimination of extraneous information would not only make the schedules less complicated and less intimidating, but would provide the opportunity to increase minimum font sizes.

Other key findings from the performance evaluation and subjective review are summarized below:

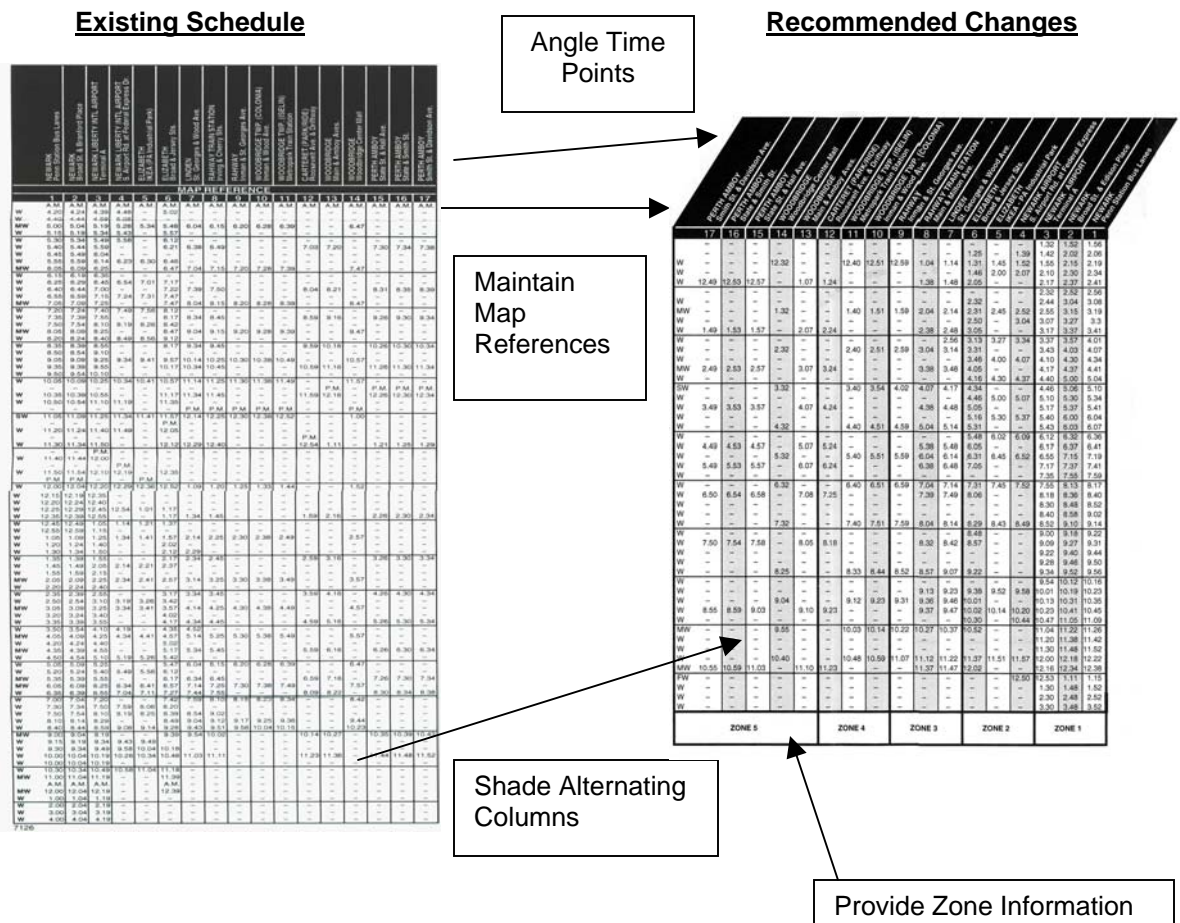
- Inclusion of zone information on the schedule and maps was helpful. This also corresponds to the overwhelming positive response in the subjective portion.
- Splitting the tables into morning/afternoon segments dramatically increases the error rate. It is recommended, therefore that NJ TRANSIT retain the current single table format.
- Application of zebra patterns (i.e. shading alternate columns) was not effective in improving the performance. However, there was a very clear preference for this type of display in the subjective responses.
- The directional format (having the “To” directions on opposite sides), which is consistent with the current schedule format, fared better overall than the weekend/weekday format (having weekdays on one side and weekends on the other). This is also consistent with the subjective rankings.
- Slanted labeling was preferable to the current vertical labeling. However, this feature was not specifically performance tested.
- The overall error rate was high for the current schedules as well as the prototypes, suggesting that the task of using the bus timetable is difficult for a wide range of people.

The findings of the research were reviewed with the research team and were then culminated into a set of recommended changes to bus timetables. They include:

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- Maintain weekday weekend timetables on the same side with the major destination point on opposite sides of the schedule.
- Maintain Map References
- Display the time point location names and time points so that they can be read together without rotating the schedule. This could be achieved by placing the location names at an angle.
- Display AM and PM timepoints in one table but distinguish the AM and PM periods.
- Include zone information on the table.
- Shade alternating columns so that they are more distinguishable.
- Reduce the overall amount of information on the schedule.

Figure 1 Recommended Changes



The recommendations were also discussed with NJ TRANSIT schedule production staff. While implementation of the above would not significantly impact schedule production operations, NJ TRANSIT staff raised some concerns. For example, inclusion of zone information on the timetable would require close interaction with NJ TRANSIT Service Planning staff. Other recommendations, such as displaying the time point destinations at an angle, would require manual input. Further details are provided in the Impact Summary Matrix included at the end of the Recommendations section of this report.

While the recommended changes will make bus schedules more readable and user friendly there were still a considerable number of errors on the performance testing for all categories of subjects. This finding suggests that there may be an overwhelming amount of information on the schedules and that efforts to reduce this information would improve the readability of the schedules. Other potential future research initiatives should include:

- Identification of ways to reduce, consolidate and/or eliminate certain information. For example, use of a “one-call” system should be explored for NJ TRANSIT.
- Development and testing of additional prototype schedules. The two prototypes schedules developed for this research effort were found to be advantageous in some areas, but could certainly be improved upon.
- Development and testing of additional prototype schedules for other bus routes. The study team selected one route for prototype development. However, schedules for other routes could also be examined using a similar research approach.
- Development and testing of prototype schedules for rail routes. A similar research approach could be used to develop prototype schedules for rail routes.
- Investigation of other schedule design software that could help facilitate new and improved concepts for schedule presentation. For example, displaying time point locations at an angle would require manual input using the current software. There may be software graphics packages that could provide this function automatically.

INTRODUCTION

The integration of computers in today's society offers a tremendous number of new and creative ways to present and disseminate information. Transportation schedules are certainly no exception. Many transit agencies now offer websites from which origin and destination points can be entered and precise arrival/destination times can be determined. For example, AMTRAK, the nation's intercity passenger rail provider, has a web-based schedule system where users can enter the location to which they are traveling, the boarding location, dates of travel and time frames. Once this information is entered, a list of trains meeting the criteria is displayed. With a simple click, fare information can be obtained and tickets can be purchased. NJ TRANSIT has a similar web-based computer system. Maps and schedule information can be viewed on-line, manipulated, downloaded and printed. Transit users and potential customers who do not have readily available access to a computer, depend on instructions from customer service representatives, discussions with fellow riders, or the information contained in hardcopy schedules. However, for many, hardcopy schedules are the principal source for obtaining important schedule information.

NJ TRANSIT is one of the few transit agencies that mass-produces hardcopy schedules for all of its 231 bus routes. Furthermore, timetables change approximately four times per year. NJ TRANSIT estimates that it produces between 20-25million schedules per year, making this one of the largest production operations in the country.

The overall layout and design of NJ TRANSIT bus schedules have essentially evolved over the years but initially followed basic standards and guidelines developed in 1972. Thus, the current schedule layout and information contained in them are the result of staff recommendations, legal and liability issues and policy/procedural changes. Bus schedules are also changed on a regular basis to accommodate new timetable changes. Thus, new bus schedules are created and then mass-produced approximately four times per year.

Although schedule information including stop locations and arrival/departure times are changed regularly, NJ TRANSIT still adheres to the same basic layout guidelines developed over 30 years ago. Since that time, however, there has been a comprehensive body of research that has been conducted in the area of human information processing. In its ongoing commitment to customer service, NJ TRANSIT has initiated this research project to examine and evaluate hardcopy format bus schedules and develop recommendations for improving its bus transit schedules.

From a human factors standpoint, reading and deciphering transit schedules consists of a highly complex set of tasks involving many phases of human information processing. According to a well-known human information

processing model (Wickens and Hollands, 1999), the initial searching task requires short-term sensory storage for visual information input while scanning the busy timetable, recognition of symbols and abbreviations on the map from both working and long-term memory, decision making for determining the right bus schedule at the right bus stop, and working memory for memorizing the bus route, bus schedule, and bus stops for getting on and off the bus. These mental processing steps are even more challenging if the user is elderly, has poor vision or not accustomed to reading and processing busy timetables.

There has been extensive research on effective methods for visual information presentation that has led to the establishment of useful principles for implementation. In *Human Factors in Engineering and Design*, Sanders and McCormick (1993) discuss a number of important visual display features, including typography (e.g. stroke width, font type, size), layout (interletter spacing, interline spacing, logical grouping and layout of information.), color, and information grouping. In his book titled "The Visual Display of Quantitative Information", Tufte (1983) uses many examples of good and poor designs to illustrate important factors for quantitative visual presentations. This research project seeks to apply some of these basic human factors principles in identifying current deficiencies of existing NJ TRANSIT bus schedules as well as formulating recommendations.

NJ TRANSIT's bus schedules are composed of several features, including a map, timetable and text notes. The map is not to scale and includes the names of selected streets and towns served. The map also indicates connecting NJ TRANSIT bus routes and passenger rail lines. The timetable consists of selected bus stop locations, or "time point locations", which are shown in white text on a black background. Bus arrival/departure times or "time points" for the corresponding time point locations are listed below in rows below the time point locations. In general, weekdays, Saturdays and Sundays are displayed on separate tables for each direction. Several other pieces of information, including notices, phone numbers and fare information are also provided on bus schedules. Widths of the schedule document are consistently 8-1/2 inches for all routes. The lengths vary between 15 inches and 27 inches depending on the level of complexity. When folded, bus schedules are approximately 8-1/2" x 3". Bus schedules are produced on white paper using black ink. Bus schedules are not colorized.

In addition to a review of prior research as well as other transit agencies' practices, the Research Team solicited input from NJTRANSIT bus customers. Two focus group meetings were held. The first meeting assembled a group of NJTRANSIT employees who are also bus riders. This "internal" focus group not only provided an excellent opportunity for feedback from actual users, but also enabled the study team to modify and adapt the questions to identify what schedule features are effective and what features are not. The second meeting

assembled a group of outside customers that use a selected route. Both focus groups provided an opportunity for interactive dialogue in identifying specific positive and negative features of existing schedules.

The information gathered in the literature review as well as the input and feedback received in both focus groups enabled the project teams to develop a basis for revising the layout of existing bus schedules. Two prototype schedules were subsequently developed for the Route 62 bus line. The 62 was selected as the prototype largely due to its complexity and a relatively high number of transfer points. It was agreed that if the prototypes were successful on a complex schedule, such as the 62, these same principles could be applied to other less complicated routes.

A number of transit schedules were obtained from other transit agencies, many of which adhere to good human factors principles. It may have been sufficient to then just evaluate the prototypes based on the information gathered up to that point. However, the Research Team wanted to use a quantitative test to compare each of the prototypes with the existing schedule. This approach is often used in industrial design applications, where users are given a particular task using a tool or device and then are timed. This same approach was used to evaluate the effectiveness of the prototypes.

From the information gathering activities as well as the quantitative time trials, the Research Team prepared recommendations and guidelines for the design and layout of future bus transit schedules. A relatively small number of prototype schedules were produced using NJ TRANSIT's in-house software and printing equipment. While it is possible that these changes could be implemented on a larger scale basis, initiatives would need to be undertaken to modify NJ TRANSIT's existing schedule software package.

RESEARCH APPROACH

The primary objective of the research project is to develop and improve the understanding of bus schedule information that is conveyed through hardcopy media to existing NJ TRANSIT bus customers. Through enhancements to the layout and design of hardcopy bus schedules, this research is also intended to reduce the reluctance of potential customers in using bus schedules and hence increase the number of new bus transit customers. To this end, we have undertaken a research approach that consists of the following steps:

1. **Assemble the Research Team.** A group of selected NJTRANSIT personnel involved in the design, development, implementation and production of bus schedules was assembled to provide input and overall guidance of the study.
2. **Select a Test Case Route.** Working with the Research Team, a bus route was selected that would serve as a schedule prototype.
3. **Conduct a Comprehensive Review of Available Research.** A comprehensive literature review of relevant research in the area of cognitive behaviors and human factors associated with understanding and interpreting transit information was conducted. Of course, the team did not limit itself to bus transit schedules only. Results of the literature review are presented in the following section of this report.
4. **Obtain, Review and Consider Other Transit Agency Schedules.** NJIT gathered a number of existing rail and bus transit schedules from other transit agencies throughout the country.
5. **Obtain User Feedback.** Input and feedback on existing bus transit schedules was obtained to better identify specific deficiencies as well as recommended modifications to the selected route schedule from the users perspective.
6. **Develop Prototype Schedules.** Two prototype schedules for the selected route were prepared.
7. **Conduct a Quantitative Evaluation.** A series of tasks were developed which required using each of the prototype as well as the existing schedule to evaluate which prototype or prototype features enhance or hinder the schedule legibility and usability.

The results of this research approach culminated into the development of several recommendations for enhancing the legibility, understanding and interpretation of

bus transit schedules. Details describing each of the above steps are provided in the sections below.

Assemble the Research Team.

At the initial phase of the study, a research study team was put together for the purpose of providing input and feedback as well as overall direction in the progress of the study. Edward Kondrath from the New Jersey Department of Transportation Bureau of Research Program served as the Project Manager for the study. Jerome Lutin of NJ TRANSIT served as the Research Project Customer as well as our primary contact for this study. As the study progressed, other NJ TRANSIT representatives were added to the study team. A list of team member names, titles and affiliate agencies are contained in Appendix A. Several students were also involved in the study and provided assistance in developing the prototypes and well as recruiting participants for the customer focus group. The names of the students are also provided in Appendix A.

The research team met on several occasions for the purpose of providing input and feedback as the study moved forward. In addition, members of the research team were instrumental in assembling the focus groups and conducting the focus group meetings. Janice Pepper served as Moderator for both the in-house as well as outside customer focus groups. Representatives from NJIT also met on several occasions with Robert Lilley who is responsible for the overall production of bus schedules. Mr. Lilley's input was extremely valuable in helping to formulate recommendations that could be feasibly implemented. Mr. Lilley's staff was also instrumental in helping the team produce the prototype schedules.

Select a Test Case Route

Several meetings were held with the Research Team to help identify which bus routes would be selected for case study in the focus group meetings, prototype development and quantitative prototype evaluation. The selection of the route was extremely important, as it would influence the specific prototype features to be considered as well as the make-up of the customer focus group. At a meeting held on May 21 it was agreed that the target audience for the focus groups should include customers who use or rely on bus transit schedules. It was initially suggested that Route 1 be selected as one of the study routes. However, after some discussion, it was decided that two routes, and one that serves highly urbanized areas and one that provides primarily suburban commuter service into New York City would be the selected for case study. Hence, two schedules were selected for focus group discussions: Route 62 and Routes 144/145/148/164, which are currently displayed in a single timetable.

The Route 62 bus line runs between Newark and Woodbridge and serves several towns in between, including Edison, Rahway and Elizabeth. The route

also provides connections to several other bus routes as well as rail service. The 62 operates seven days a week, on a nearly hour basis.

The 62 schedule has some unique features that make it an interesting case study. The route is relatively complex compared to other schedules and requires indication of many transfer points. The route serves primarily urban commuters and unlike other bus routes, lacks the typical suburbia to New York commuter pattern. This schedule also contains a unique feature, which links the location on the schedule to a location on the map through a numeric key. Although this was not a selection criterion for the case study, it is a feature that only exists on the 62 schedule.

The Route 144/145/148/164 schedule, as the string of numbers implies, is a combination of four bus routes. Together, they provide service between suburban communities in northern New Jersey and Port Authority Bus Terminal in New York City. The overall schedule is quite complicated. Two buses serve some portions of the general route; only a single bus serves other portions. In addition, the 144, 145 and 148 operate only on weekdays. The 164 bus operates only on weekends with direct stops at the Meadowlands Sports Complex. The schedule also contains a number of transfer points. In addition, schedules for the 144 and 164 buses also are contained on another schedule with the 160 and 163 buses. Not surprisingly, the Route 144/145/148/164, according to NJ TRANSIT, is one of the most complicated schedules. However, users are typically regular, daily commuters.

Conduct a Comprehensive Review of Available Research

A comprehensive review of relevant studies was conducted, the results of which are contained in the following section of this report.

The literature review provided an excellent basis for the study team to begin identifying specific schedule deficiencies and make recommendations for enhancements. For example, one study clearly demonstrates that the information is most appropriately displayed on the same axis. Therefore, time locations should be displayed either in the same plane as the times or at an angle from which times can also be read without having to flip the schedule. A number of other interesting findings from the literature review formulated the basis for recommended changes.

Obtain, Review and Consider Other Transit Agency Schedules

Schedules from other Transit providers in North America were obtained and reviewed. The agencies chosen were based on recommendations made by the full research team. Although layouts from other transit agency schedules are not intended to serve as a basis for developing the prototypes for NJ TRANSIT, it was interesting to note some of the different layout approaches. Obtaining and then presenting these schedules also provided an opportunity for the focus

groups to identify preferences in the layout of the schedules. In addition to obtaining schedules from some of the larger bus transit agencies throughout the country, NJIT gathered schedules that received awards from American Public Transit Association (APTA). In all, NJIT obtained schedules from the following agencies:

- Metropolitan Atlanta Rapid Transit Authority (Atlanta, GA)
- Charlotte Area Transit System (Charlotte, NC)*
- Chicago Transit Authority (Chicago IL)
- Dallas Area Rapid Transit (Dallas, TX)
- Regional Transportation District (Denver, CO)
- Metro Transit (Minneapolis, MN)
- New Orleans Regional Transit Authority (New Orleans, LA)
- Central Florida Regional Transit Authority (Orlando, FL)*
- Bi-State Development Agency (St. Louis, MO)
- King County Department of Transportation (Seattle, WA)
- Washington Metropolitan Transit Authority (Washington, DC)

* APTA award winners

Obtain User Feedback

In addition to the information gathered from the literature review, the team agreed that input and feedback from actual bus transit customer users was essential. However, it was determined that use of customer surveys would not be an effective means of gaining in-depth input and feedback regarding the use and layout of schedules from the customer's perspective. Consequently, the research team decided to employ the use of focus groups to identify schedule deficiencies and develop recommendations from the user's perspective.

The use of focus groups is quite common in advertising and marketing applications. In general, focus groups consist of approximately eight to ten persons who are chosen based on a prescribed set of characteristics. The group is led by a moderator who has a scripted list of questions and discussion points to which group members respond and interact with each other. NJ TRANSIT uses focus groups routinely in identifying key issues for new products and services.

Preparation for the focus group involved several steps. It was first necessary to identify the main topics and issues related to the use of the bus schedules that would be reviewed and discussed. Next, with the assistance of NJ TRANSIT, the NJIT developed a Moderator's Guide, which would serve an overall outline of the meeting discussions. A copy of the Moderators Guide is contained in Appendix C. Once the Moderators Guide was finalized, two focus groups were assembled. The first group consisted of NJ TRANSIT employees who are also regular bus users. This first "internal" focus group meeting provided an excellent opportunity to not only gain input and feedback on the usability of NJ TRANSIT bus schedules, but also helped identify enhancements to the second customer focus group "Moderator's Guide".

The second focus group assembled both NJ TRANSIT bus customers who use the Route 62 and the Route 144/145/148/164 buses as well as non-bus users. The latest list of customers who use both routes was obtained from NJ TRANSIT. Each person on the list was then contacted and asked a series of questions to determine their interest in participating in the focus group and obtain personal information. Based on the information provided, candidates were then selected. In order to encourage participation, a cash reward was given to each of the outside customer participants. Janice Pepper served as moderator for both focus groups.

Develop Prototype Schedules.

Based on the results of our literature review as well as the input and feedback received from the two focus groups, it was decided that two prototype schedules would be developed for the Route 62 bus. NJIT also met several times with Mr. Robert Lilley and his staff who are responsible for the preparation and production of NJ TRANSIT schedules. The purpose of these meetings was to review the overall production operation and identify potential barriers to schedule production as a result of the proposed changes.

An important modification to the current schedule was the adoption of a landscape format, so that the prototype schedules would be unfolded horizontally, instead of vertically. Since all of the text would have the same orientation, it would not be necessary to rotate the schedule. Other changes common to both prototypes included use of graphics for communicating instructions on use of the schedule and simplification of the Holiday Service Guide. Details of proposed changes to the format and layout of the prototypes are described in subsequent sections of this report.

Prototypes were initially developed using AutoCAD software as well as redlined hand sketches. In order to fully understand the potential consequences of the proposed changes, this information was then integrated with NJ TRANSIT's in-house graphics software package. This also provided the opportunity to actually

print the prototypes at NJ TRANSIT's schedule production facilities in Orange. After several iterations, two draft prototypes were produced.

NJIT presented and discussed the two prototypes to the research team. Additional minor adjustments to the prototypes were made and then presented to Mr. Lilley's staff so that the two prototypes could be finalized. The two prototypes were then ready for quantitative testing.

Prototypes differ from each other in one respect only. Prototype "A" provides a single destination point on each side of the schedule. Hence, weekday and weekend timetables appear on the same side. Prototype "B" provides weekday schedules on one side and weekend/holiday schedules on the other. Consequently, two destination points appear on a single side. Prototypes A and B are shown in Figures 2 and 3, respectively.

Conduct a Quantitative Evaluation

From the focus group meetings as well as several meeting with the research team, it is clear that different people have varying opinions as to the layout and information that should be presented in NJ TRANSIT's bus schedules. The approach to the design of the prototypes seeks to be objective by culminating the results of sound human factors and industrial psychology research as well as user input. However, a quantitative evaluation would provide an unbiased viewpoint and verify the potential effectiveness (or ineffectiveness) of the prototype schedules as compared to the existing schedules.

The quantitative evaluation included developing a series of tasks for which test subjects would be required to use the schedule. The subjects were asked to answer thirty questions, ten from each of the three prototypes, which required them to perform certain tasks. The tasks focused on particular elements of the schedule. For example, one of the tasks required the subject to read across the table to test the effectiveness of column shading. The time required to complete each task was then recorded. While different tasks were required for each prototype, the level of difficulty remained consistent. In addition, scenarios were designed to focus on specific elements that were changed. For example, one question focused on trips that transitioned between AM and PM timepoints thereby testing the effectiveness of splitting the timetable. In addition to the performance test, subjects were asked which schedule they preferred to use in performing each of the tasks.

Subjects of varying age, gender and education levels were recruited for the quantitative evaluation. . Overall, a total of 30 subjects participated in the quantitative testing phase of the research study. A small cash incentive was given to encourage participation.

Figure 2. Prototype A

Figure 3. Prototype B

Table 1 Design Features and the Corresponding Question Numbers

Design Feature	Question Group Numbers
Zebra Pattern	1, 5
Morning – Afternoon / Evening Breakup	7, 10
Morning - Afternoon Shift	9
Public Holidays	4
Weekend Schedules	8
Bus Transfer	3
Map	2
Zones	6

Zebra Pattern (Shading Alternate Columns): Answers for questions 1 and 5 fall in the same table of the timetable. The only difference being that for question 1, the answer is in the top few rows, while the answer for question 5 is in the last few rows of the table. This implies that if the subject needs to find the answer for question 5, he / she will have to read all the way down the table. The difference between the times and error rate in finding the answer from the current schedule and the two prototypes would substantiate the effect of the zebra pattern. It is hypothesized that the shading of alternate columns could enhance the readability by avoiding any jumps between columns.

Morning – Afternoon / Evening Breakup: Questions 7 and 10 were designed to test the difference between reading from the straight long table and from the new prototypes where the morning and afternoon / evening times were tabulated separately. The answer to question 7 is positioned in the morning session, which means on the morning table for the new prototypes and in the top few rows in the current schedule. The answer to question 10 is in the afternoon / evening table in the newly developed prototypes and in the last few rows of the long table in the current schedule. *Morning - Afternoon Shift*: In the newly developed prototypes, there were two lines of time in the morning table, which were actually after 12:00 noon, but had to be part of the morning table as they were the continuation of a bus which started before noon. One question was designed to capture any negative effects with this feature. The word “afternoon” was included in the question to test if the participants read a time from the afternoon table, even though the correct answer was in the morning table.

Public Holidays, Weekend Schedule and Bus Transfer. One question was designed separately for the public holiday, weekend schedule and bus transfer information.

Maps: Even though the maps were not modified in the newly developed prototypes, the participants were tested for the general readability and comprehension of the maps.

Zones: In the newly developed prototypes, the zones were marked on the bottom of every table and the maps. In the current schedule they are marked only on the maps. The zones are necessary to calculate the fare for travel between two locations. One question was exclusively designed to capture the effect of the new form of zone representation.

The experimental data was analyzed and validated based on the speed and accuracy of the participant in finding the answer. Since each participant was tested for all three schedules (existing and two prototypes), a within-subject experimental design was used for quantitative analysis. The order of distribution of prototypes along with the question sheets was counterbalanced in order to cancel any sequential effects. Analysis of variance (ANOVA) was used to compare the three designs on performance variables with respect to time. Chi-square analysis was used for the error table to substantiate the design modifications.

The individual times recorded for the thirty participants were analyzed and the separate design features were tested for statistical significance. A cut off rate of sixty percent correct answers in at least one of the tests was kept as the baseline to avoid the noise in the data. Therefore, data from twenty-eight subjects was used for time analysis, which is discussed in the Findings Section of this report.

Based on the results of the above tasks as well as input and feedback from the Research Team, recommended schedule layout and guidelines were developed and are contained in the Recommendations section of this report.

FINDINGS

Overall, it was found that while subjective opinion found the layout of current NJ TRANSIT bus schedules are effective in conveying information to bus customers, there were a considerable number of errors in the subject performance tests. However, it is believed that there are several modifications which would help to improve the readability and understanding of the information presented. The findings of previous research, subjective input from both customers and non-customers as well as the actual performance test results are described below.

Relevant Findings from the Literature Review

A number of studies and research initiatives have been conducted in the area of transit schedule reading and processing with several consistent emerging themes, some of which are reflected in the layout and design features of other transit agency schedules. Relevant findings from the literature review and its applicability to NJ TRANSIT bus schedules are presented below.

1. Time-point reorientation: Bartram, Crawshaw and Sprent conducted a study on bus timetables and the results suggest that the locations and the time should be on the same axis, so that the users do not have to flip the schedule to read efficiently.
2. Proximity: Goettl, Kramer and Wickens (1986), concluded that proximity enhances productivity when a task requires integration of information. Similarly, when the task does not require the integration of information or necessitates selective attention to a subset of the information, nonintegrated displays will be optimal. Hence, in the application of reading and interpreting timetables, distances between the time points and times should be minimized to the extent possible. Also, the proximity of the map to the timetable might be an important factor in making the timetable easier to read and follow.
3. Zebra Pattern: An article by Fisher and Tan (1989), indicates that proper highlighting will grab the attention of the users, and also provide them a reference line, which in turn will also help them read the schedule easily.
4. Decrease column length: According to Fox and Wright (1970), decreasing the column length will fasten up the reading process for the user. It will also decrease the error in reading, which might turn up in the case of long columns.
5. Font size: According to a recent publication by the Transit Cooperative Research Program (TCRP) pertaining to schedule design standards, the minimum font size for printed texts should be 10 point. However, the current Route 62 schedule as well as the prototype schedules use a smaller font size. Increasing the font size may enhance the readability.

6. Zone distinction: A study conducted by Swanston and Walley (1984) suggests that separations between zones should be shown clearly. Showing separate and distinct fare zones may help the user to translate this information more quickly.

Other relevant findings are provided below:

Attracting Attention. It is important to attract a user's attention, particularly, applications that are time dependent or are highly unique. Techniques include use two intensity levels only, with high intensity to draw attention. Special marking features such as underlining, enclosing text in a box, point to with an arrow, or use an indicator such as an asterisk, bullet, dash, plus or "X", use of four sizes of text, with larger sizes attracting more attention and up to three choices of fonts. Highlighting may, under certain conditions, also be an effective technique for drawing attention to important text.

Use of Picture Graphics. Pictures are generally preferable to textual instructions. However however, if memory of the instructions is important and recognition is critical, textual representation was determined to be more advantageous.

Typographical aspects. Typographical aspects are important in designing displays that represent schedule stop locations, times and routes. Better topography and topography can improve the quality of any information display. However, there needs to be minimum congestion, which can make it easier for the people to read and understand the route in one search, rather than in multiple searches. The legibility of displayed letters depends upon their size, or more accurately, their subtended visual angle at any viewing distance (Smith, 1979). There are four types of circumstances in which it may be important to use "preferred" forms of topography: (1) when viewing conditions are unfavorable (as with poor illumination or viewing time), (2) when the information is important or critical (as when emergency labels or instructions are to be read), (3) when viewing occurs at a distance, and (4) poor vision of users.

Maps. Representation of maps has space constraints on many occasions, but the rule of thumb is that there should be minimum congestion and the coding should be used such that it becomes easier for the user to read and understand the map. The presence of arrows and other signs should be able to convey the intended message and needs to be well justified. The maps should not be overloaded with information. Finally, landmarks, such as churches and schools are useful in providing a frame of reference for the user.

Text/Background Contrast. In general, black text on a white background should be thicker (have lower width to height ratios) than white letters on black backgrounds. With reasonably good illumination, the following width to height ratios are satisfactory for printed material: black text on white background, 1:6 to

1:8 and white text on black background, 1:8 to 1:10. As illumination is reduced, thick letters become relatively more readable than thin ones (this is true for both black-on-white and white-on-black letters). With low levels of illumination or low contrast or low contrast with background, printed letters preferably should be boldface type with a low stroke width-to-height ratio (such as 1:5). For highly luminous letters, ratios could be reduced to 1:12 to 1:20. For black letters on a very highly luminous background, very thick strokes are needed.

Width/Height Ratio. The relationship between the width and height of a complete alphanumeric character is described as the width-height ratio and is expressed, as a proportion (such as 0.60). A width to height ratio of 3:5 has come into fairly common use and in general is well supported by research.

Text Size. Appropriate text sizes are generally selected for a corresponding reading distance. In the case of close-up reading, if we accept that the commonly used 9- to 11 point print sizes of newspaper and magazines are suitable, then such sizes (0.09 to 0.11 in; 2.3 to 2.8 mm; 22 to 27 min of visual angle) would be acceptable as a basis for general use printed alphanumeric material. TCRP suggests a minimum 10 point font size.

Capitalization. An important aspect of the word is not the overall shape, but rather the initial letter. If the initial letter were larger than the other letters, the word would be found more quickly (McCormick and Sanders, 1993). Therefore, when type is being designed to help the reader search quickly, the designer should first try to avoid lower case in order to make a typographical distinction.

Grouping. It has been found that when the numbers were grouped in columns, they were located easily. In general, grouping numbers by fives were more effective than grouping in tens (Tinker, 1960). Also, grouping of alphanumeric characters within columns should be done by use of spacing or ruled lines, i.e. splitting columns into blocks of approximately five items. Another factor is the left-right arrangement of columns, so that information is read off to the right of the item looked up (Fox and Wright, 1970).

Presentation Format. It was found that people were slower and more error prone when they had to make four successive binary decisions than when making two decisions, each time selecting among four alternatives. Also, more errors occurred when the presentation format required them to combine decisions along two different special dimensions compared to one-dimensional representation. It was also found out that the reflected format, which represents the route horizontally, was better than the standard format, which represents the route vertically.

Alignment. Proper alignment of the data within the table can improve the overall visual quality. One of the five vital points for data display as suggested by Smith

and Moiser (1986) is that the format should be familiar to the operator and this objective is served by rules for neat columns of data, left justification for alphanumeric data, right justification of integers, lining up of decimal points, proper spacing, use of comprehensible labels and appropriate measurement units and number of decimal digits (Schneiderman, 1998).

Relevant Findings from the Focus Group Meetings

Input from actual bus transit users was gathered by conducting two focus group meetings. The first focus group meeting was held on July 24, 2003, and included NJ TRANSIT employees who are regular bus transit users. A second focus group, consisting of external users and non-bus users, was convened on August 19, 2003. Participants from the second group were solicited from a list of customers who use the Route 62 and the Route 144/145/148/164 bus line as well as non-bus transit users. The results of both meetings are summarized below:

July 24, 2003 Focus Group Meeting Discussions

All of the focus group participants were NJ TRANSIT employees and were regular bus transit users. All indicated that they use the bus principally for commuting purposes.

The moderator distributed two bus timetables: the 62 and the 144,145,148,164. The group was then asked to complete two “scenarios”. The first scenario asked questions about use of the 62 schedule on a weekday to get to a meeting. The second asked about use of the 144,145,148,164 to get to a Giants football game at the Meadowlands Sports Complex on a Sunday. Scenario descriptions are attached.

The group did not have difficulty answering the questions. However, a question came up regarding the use of the 144,145,148,164. Specifically, one of the focus group members pointed out a provision in the schedule that indicates the bus does not travel to the Sports Complex on sporting events. Rest of the group overlooked this.

The moderator asked a series of questions regarding use of the bus schedule. The following summarizes the overall responses:

1. *How critical is the schedule to making your trip?* In general, the group felt that the schedule was very critical for trip making purposes.
2. *How often do you use the bus schedule?* Responses were somewhat varied. Some indicated that they use the schedule few times per week. Others indicated they use it less frequently.

3. *Where do you pick up the bus schedule?* As the focus group members are NJ TRANSIT employees, all expressed they pick up the schedules at work.
4. *Are bus schedules readily available and convenient to pick up?* The overwhelming response was yes.

The group was asked to respond about what information on the schedule is important. To help encourage discussions, a list of information items that are typically on the schedule was provided. The group was then asked to rate each of the items on a scale of “1” to “5” with “1” representing the most essential and “5” representing the least essential. A summary of responses is provided in the Table 2.

Table 2. Internal Focus Group Ratings of Essential Bus Schedule Information

Information Item	High ← Ranking → Low				
	1	2	3	4	5
	Number of Responses				
Holiday Service Guide	2	2	2		1
NJ Transit Information	3	3	2	1	
Reduced Fare Information	3	2	1	1	
NJ TRANSIT Rail Riders	1	2	3	1	
Frequent Riders Information			3	3	1
Customer Service	6	1			
Map	7				
Schedule Directions	4	2	1		
Disabilities Information		4	3		
Receipt Remarks	1	2		3	1

Overall, it was agreed that the map was the most important piece of information on the schedule. The group also indicated that fare information would be helpful. However, most customers reportedly just ask the bus driver. Customer service numbers were also viewed as an important piece of information on the schedule.

The following other essential item information was discussed:

- Connecting bus routes and zone lines need to be shown clearly.
- Fares per zone should be better depicted on the schedules. This is often difficult to explain to customers.

- Information Numbers are critical.
- Web site information is also critical and would help in identifying “point to point” information as well as fare information.
- Schedules should clearly indicate what towns are served.
- It would be helpful to know which schedule applies. For example, sometimes it is not clear whether weekend schedules apply for a particular holiday if the holiday is not specifically listed on the schedule.
- The schedule should clearly state whether the line is an exact fare line
- Multiple leg routes need to be simplified.

The group discussed several features regarding the timetable layout. Handouts of sample timetables from a number of other transit agencies were distributed and the group was asked to comment on the following:

- *Display of AM versus PM.* The group liked having a better distinction between AM and PM times. They liked having the different fonts as well as a physical separation such as a space or a line. The group generally preferred the solid line to distinguish morning and afternoon times.
- *The need to flipping schedules to determine direction and boarding/discharge locations.* The group generally did not have a problem with the flipping of schedules but preferred the use of some type of shading or lines to follow the locations and times. The group generally expressed some difficulty where they were boarding the bus between the locations depicted on the timetable. It was also suggested that the name of the municipality be highlighted.
- *The need to rotate schedules.* NJ TRANSIT typically displays the time point location on one axis and the actual time points on the perpendicular axis. The group was generally favorable to having the time point location angled as depicted on the St. Louis schedules. However, there was concern regarding the amount of space that would be needed to fit this information.

The group was asked to comment on the timetable maps. The moderator distributed a number of samples from other transit agencies and the group was then asked to comment.

The group overwhelmingly responded that the maps from other jurisdictions were far too complicated and that the stick maps depicted on NJ TRANSIT bus schedules do an excellent job in conveying the necessary information. The group expressed that showing additional features, such as school, churches, parks, etc. would be helpful. All agreed that the orientation of the maps was acceptable. The group also liked having the link between the map and the timetable as depicted on the 62 schedule.

The group was also asked to raise any other issues regarding the bus schedules. Some expressed difficulty in folding the schedules, but it was generally agreed that NJ TRANSIT bus schedules are easy to read and follow. However, the group listed the following items that could be improved:

- Font sizes are often too small to clearly read and should be made larger where possible.
- Better display of towns served. The towns that are served should be clearly identified not only on the front of the schedule but also on the maps and timetables.
- Use of lines and / or shading to distinguish AM/PM and make the timetables easier to follow from the location time point to the time.

August 19, 2003 Customer Focus Group Meeting Discussions

Each participant indicated whether he or she is a current bus customer and has experience using NJ TRANSIT buses and bus schedules. Overall, the group consisted of six participants: three currently use NJ TRANSIT bus service (two use the Route 62, one uses the Route 144/145/148/164) three are non-users.

Those not currently NJ TRANSIT bus customers were asked why they do not use the bus. The following reasons were given:

- Concerns over safety (crime) at the bus stops
- Convenience
- Not knowing where the bus goes
- Frustration in waiting for the bus
- Lack of bus schedules

The moderators then distributed two bus timetables: the 62 and the 144,145,148,164. The group was then asked to complete two “scenarios”. The first scenario asked questions about use of the 62 schedule on a weekday to get to a meeting. The second asked about use of the 144,145,148,164 to get to a Giants football game at the Meadowlands Sports Complex on a Sunday. Scenario descriptions are attached.

The group had some difficulty in correctly answering the questions in the first scenario. Specifically, some indicated they did not know which direction (side of the schedule) to use. Others were confused because one scenario did not ask for a specific time point but rather a location between time points. Only four persons indicated that they used the map. The group also provided the following comments:

- The schedule needs to show from/to dates when the schedule is effective
- There is an assumption that the only locations where one could board/disembark are the time points listed on the schedule. There should be an indication that the time points represent “major stops” and that there are locations in between the time points where passengers can board and disembark.
- Several people indicated that for these scenarios, they would just call the toll free number or use the Internet. It was stated that the toll free number and web address should be more clearly indicated on the schedule. Some focus group members suggested that this information be placed on the front of the schedule or in a more obvious location.
- Participants needed to flip the schedule five or six times

Most participants indicated that they responded correctly to Situation 2. However, no one realized the bus would not go into the stadium.

The moderator asked a series of questions regarding use of the bus schedule. The following summarizes the overall responses:

1. *How critical is the schedule to making your trip?* Mr. Boas and Mr. Robinson, regular users, indicated that the schedule is not critical for their trip making. Others indicated that the schedules are helpful but that they often depend on obtaining information from the driver, others waiting or the toll free number.
2. *How often do you use the bus schedule?* Mr. Boas and Mr. Robinson indicated that they use the schedule very infrequently. Others indicated once a week.

3. *Where do you pick up the bus schedule?* Most participants indicated that they pick up the schedules on the bus.
4. *Are bus schedules readily available and convenient to pick up?*
Participants indicated that the schedules are often not available on the bus.

The group was asked to respond about what information on the schedule is important. To help encourage discussions, a list of 14 information items that are typically found on a bus schedule was provided. The group was then asked to rank each of the items in terms of importance with “1” representing the most important and “14” representing the least important. A summary of responses is provided in the Table 3.

Table 3. Customer Focus Group Ranking of Schedule Information

Schedule Information	Importance Level (1=most important, 14=least important)					
	Users			Non-Users		
Serving Towns	1	1	14	1	1	1
Map	5	5	13	2	2	5
Holiday Service Guide	3	2	12	4	6	14
Customer Service Information	2	3	2	8	3	3
Notice to Customers with Disability	11	13	11	5	7	4
Receipt for Ride	12	12	10	13	14	12
Please Note	13	10	4	12	12	8
NJ TRANSIT Information	4	4	1	9	4	13
Security Hot Line	7	6	3	3	9	6
Reduced Fare Information	10	11	9	10	11	7
NJ TRANSIT Rail Riders	8	9	8	14	10	10
Frequent Riders Information	9	7	7	11	8	11
How to Use the Schedule	6	8	6	7	5	9
Please....	14	14	5	6	13	2

Overall, it was agreed a list of towns served was the most important piece of information on the schedule. The group also indicated that fare information would be helpful. However, most customers reportedly just ask the bus driver or use the toll free number. Customer service numbers were also viewed as an important piece of information on the schedule. Receipt information was generally viewed as the least important piece of information.

The group generally agreed that the following is also essential item information:

- How many towns and which towns the bus travels to, or goes through

- Knowing which bus goes to which town
- Departure / arrival times and the ability to determine travel time
- Schedule effective dates
- Toll free customer service number

The group discussed several features regarding the timetable layout. Handouts of sample timetables from a number of other transit agencies were distributed and the group was asked to comment on the following:

- *Display of AM versus PM.* The group liked having a better distinction between AM and PM times. They liked having the bolded font, as displayed on the 317 bus schedule, to distinguish AM and PM.
- *The need to flipping schedules to determine direction and boarding/discharge locations.* The group indicated that they had to flip the schedule often. NJ TRANSIT schedules display the to destination on one side and thus weekday and weekend/holiday schedules are displayed together on one side. It was suggested that weekday timetables all be displayed on one side and weekend/holiday schedules be displayed on the other side.
- *The need to rotate schedules.* NJ TRANSIT displays the time point location on one axis and the actual time points on the perpendicular axis. The group agreed that it was preferable to display the time points horizontally as on the 317 schedule, but recognized this would reduce the number of time points shown on the schedule.

The group was asked to comment on the schedule maps. Generally, it was agreed there is adequate detail on the NJ TRANSIT maps. However, all participants agreed that the linkage between the timetable and map, as displayed on the 62 bus, is essential. The group expressed that showing additional features, such as school, churches, parks, etc. is not necessary. No one expressed concern regarding the orientation of the map (i.e. north up as a convention).

The group was asked to raise any other issues regarding the bus schedules and what could be improved overall. The group indicated the following:

- The font size on the 144/145 was too small and should be increased.

- Weekday timetables should be on one side and weekend / holiday schedules should be shown on the other.
- There should be connection points between the map and the time points (as on the 62 schedule)
- The schedules should include an “effective to” date as well as the effective from date.
- Schedule changes should be highlighted
- Phone numbers and web site information should be displayed on the front of the schedule
- There should be a better distinction between AM and PM
- The towns that are served and the towns through which the bus travels should be clearly identified on the schedule.

Development of Prototypes

Based on the results of the literature review as well as the input and feedback from the two focus group meetings two prototypes were developed. Both of the prototypes represent schedule modifications, which we believe, based on the results of the focus groups meetings and research, optimize the ability to read and interpret the information presented in the schedule.

The design modifications in the prototype schedules and the source of information that motivated it are tabulated in Table 4.

Table 4 Prototype Design Features Implemented and the Source of Information

Design Modification	Source*
Decreased the column length of the timetable	1
Realigned the time point locations, making it slanted instead of vertical orientation	1, 3
Resized the Font	1, 4
Shaded alternate columns / Zebra Pattern	1, 3
Represented the different zones in a bus route, which helps the passengers in deciding the fare	1
Distinction of AM /PM or Morning and Afternoon / Evening	2, 3
Configured the reference time points in the time table to the map	1, 2
Weekday and Weekend distinction / separation	2
Prioritized the display of general information	2

- * 1. Literature Search
- 2. Focus Group
- 3. Other Public Transportation Agencies
- 4. American Public Transportation Association (APTA) standards

The prototypes differ only in one aspect of the presentation. Prototype B, displays all Weekday timetables on one side and Weekend/Holiday timetables on the other side. Prototype A, however displays the timetables for a single destination on one side. Hence, weekday and weekend/holiday timetables appear together on each side. The Prototype A format is consistent with the way in which timetables appear on the current Route 62 schedule. (For graphical depictions of each prototype, please refer to Figures 2 and 3 in the Research Approach section of this report.)

While many of the recommended changes are consistent with other transit agency practices, this was not the basis for our recommendations. However, it was interesting to note which changes each of the selected agencies incorporate into their schedule design, which are summarized in Table 5.

Table 5. Nationwide Comparison

City	Angled Timepoint Locations	Landscape Format	AM/PM Distinction
Dallas	√	√	√
Washington		√	-
New Orleans	√	√	-
Trident California	√	√	-
St. Louis	√	-	√
Seattle	√	-	√
Atlanta	-	-	√
Chicago	-	√	-
Minneapolis	√	√	√
Charlotte	-	-	√
Denver	√	-	√
Orlando	√	√	√

These changes are still not enough to enable time point and time point location font sizes to be increased. However, they do allow other schedule features, identified as important, to be enhanced and emphasized.

Quantitative Evaluation of Prototypes

Each of the ten questions was analyzed using analysis of variance. Since the efficiency of a particular prototype in presenting the required information was our primary concern, the response for each question was modeled on the type of prototype. After using a general linear model of the analysis of variance, no statistical significance was observed for questions 1, 2, 3, 4, 5, 7, 8, 9 and 10. The features that were tested in these nine questions were zebra pattern, morning –afternoon / evening breakup, weekend schedules, public holiday schedules, map reading and comprehension and the transfer information of the buses. Question number six, which dealt with the different zone representations showed statistical significance.

Interpretation of the ANOVA for Questions on Zone Representation: Question number 6, which was designed to capture the efficiency of the different zone representation formats shows statistical significance (see Table 6). The zones have been represented in the map as well as at the bottom of every table in the two new prototype schedules, while it has been shown only on the map in the current schedule. The zone representation is easily visible in the newly developed prototypes compared to the current schedule.

Table 6 Analysis of Variance for the Question on Zone Representation

Source	DF	Sum of Squares	Mean Square	F - Value	P - Value
Prototype	2	45529	22765	12.29	0.000 < 0.01
Error	81	149990	1852		

The errors committed by the participants for the ten different questions were tabulated and a baseline of one-third, or 33% was kept as the cut off mark, to highlight the questions that generated high error rates. The errors committed on each prototype for a particular question is tabulated in Table 7 along with the overall error percentages.

Table 7. Error Rates and Overall Error Percentages for the Three Prototype Schedules

Question Number	Design Feature	Current Schedule		Directional Prototype		Wkday/Wkend Prototype	
		Number of Errors	Percentage Error	Number of Errors	Percentage Error	Number of Errors	Percentage Error
1	Zebra Pattern	5	17.9%	6	21.4%	8	28.6%
2	Map	13	46.4%	12	42.9%	19	67.9%
3	Bus Transfer	2	7.1%	4	14.3%	2	7.1%
4	Public Holidays	6	21.4%	2	7.1%	7	25.0%
5	Zebra Pattern	9	32.1%	7	25.0%	2	7.1%
6	Zones	9	32.1%	5	17.9%	5	17.9%
7	Morning/Evening Split	6	21.4%	5	17.9%	7	25.0%
8	Weekend Schedules	5	17.9%	2	7.1%	3	10.7%
9	Morning/Evening Shift	8	28.6%	19	67.9%	17	60.7%
10	Morning/Evening Split	5	17.9%	2	7.1%	4	14.3%
		68	24.3%	64	22.9%	74	26.4%

From the table, the error rate for questions 2, for both prototypes as well as the current schedule, was found to be high indicating an overall difficulty in using the map. A high error rate is also noted for both prototypes for Question 9, designed

to test the effectiveness of splitting AM and PM timetables. This suggests that completely separating AM and PM timetables hinders performance far greater than a lack of distinction between AM and PM periods. This result substantiates the need to keep the AM and PM timetables together, but does not invalidate the need for better distinguishing AM and PM time points.

Effects of Age and Educational Level on Performance

The effect of age on performance, with respect to the average time taken for a question and the average number of errors committed for thirty questions are shown in Figures 4 and 5, respectively.

Figure 4 Average Time in Seconds Taken by Participants in Different Age Categories

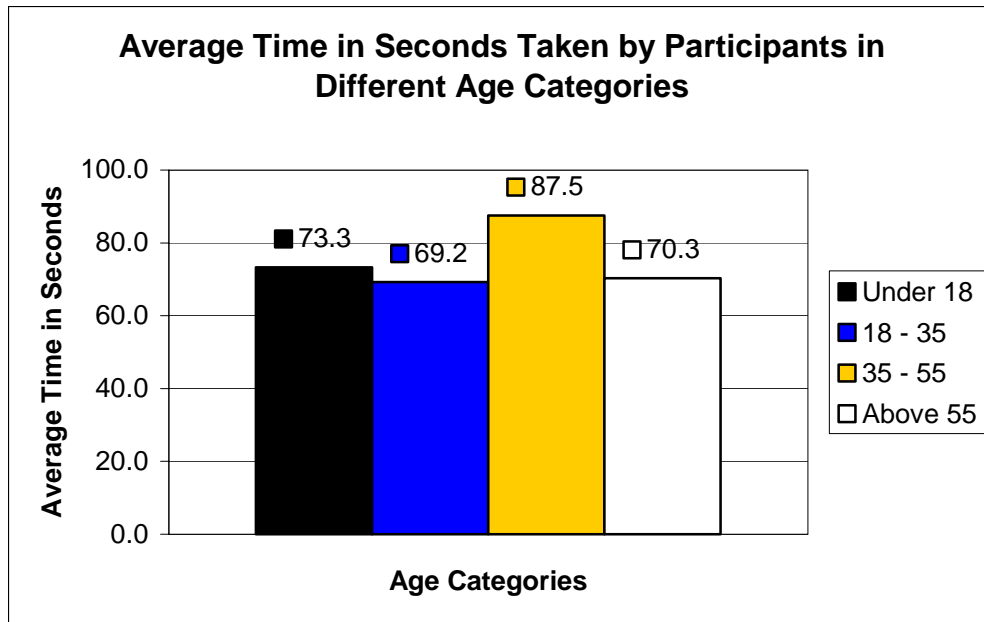
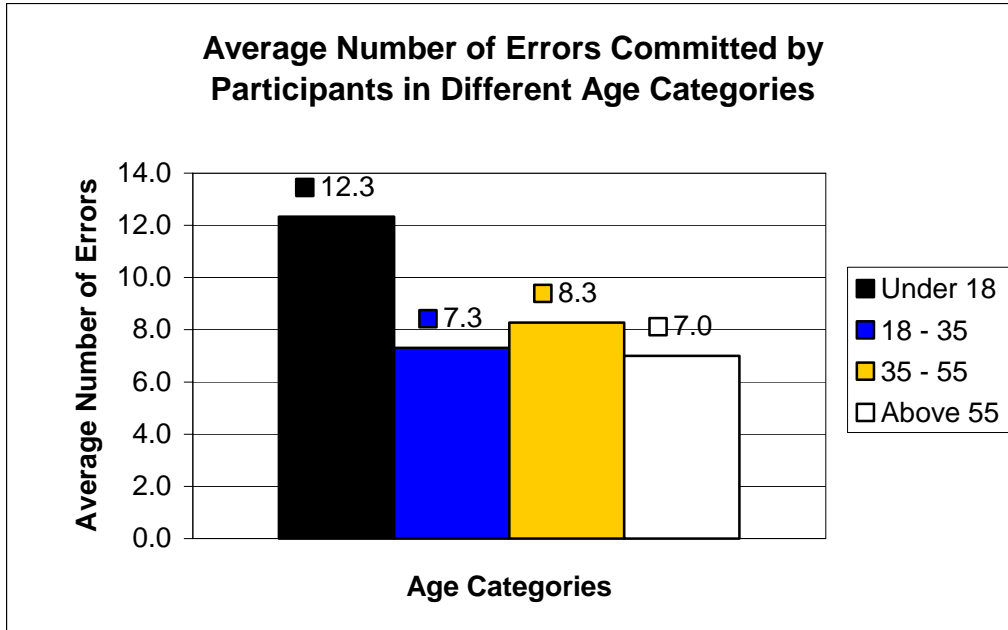


Figure 5 Average Number of Errors Committed by Participants in Different Age Categories



The participants fell into three different educational levels: completion of up to high school, up to college and obtaining an advanced degree. The effect of the educational level on the performance of the participants with respect to average time per question and the average number of errors committed in thirty questions have been shown in Figure 6 and 7, respectively.

Figure 6 Average Time in Seconds Taken by Participants in Different Educational Levels

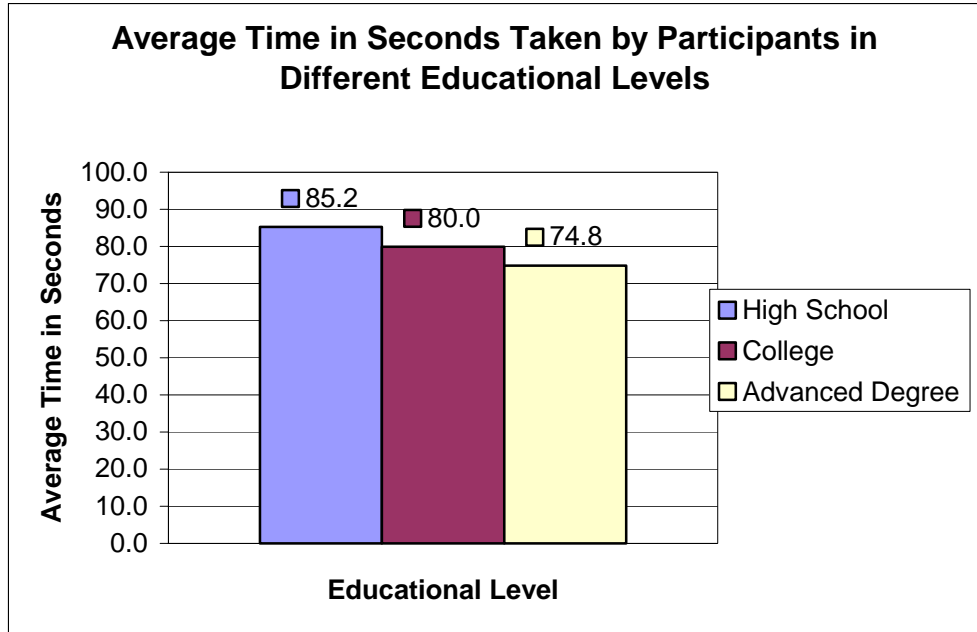
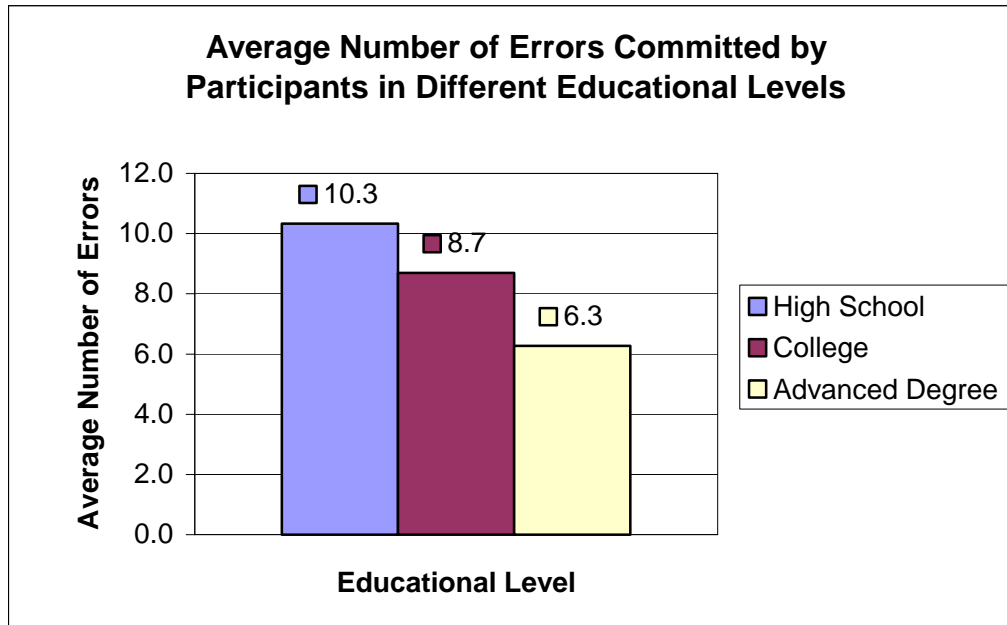


Figure 7 Average Number of Errors Committed by Participants in Different Educational Levels

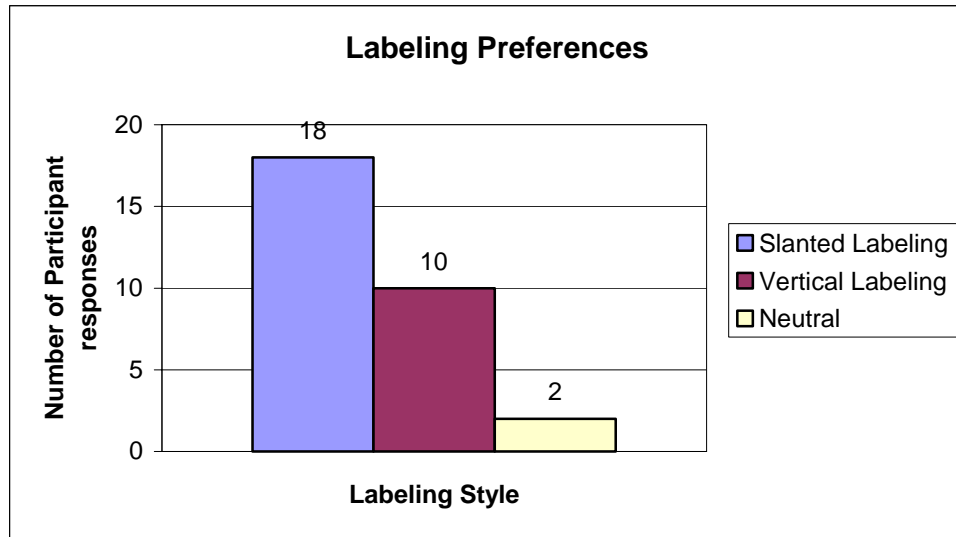


Analysis of Other Subjective Data

Seven questions were designed in the subjective questionnaire to capture the subjective preferences of the participants regarding the readability and general layout of the schedule formats. Questions differentiating the formats were asked and the participants had to pick one format over the other, or had the option of being neutral. The responses of the thirty participants were converted to a bar chart format and are discussed in the following sections.

Labeling Preference: Two styles of labeling were tested, one being the vertical labeling and the other being the slanted style of labeling. Vertical labeling is followed in the current schedule. The bar chart depicting the responses of the participants is shown in Figure 8.

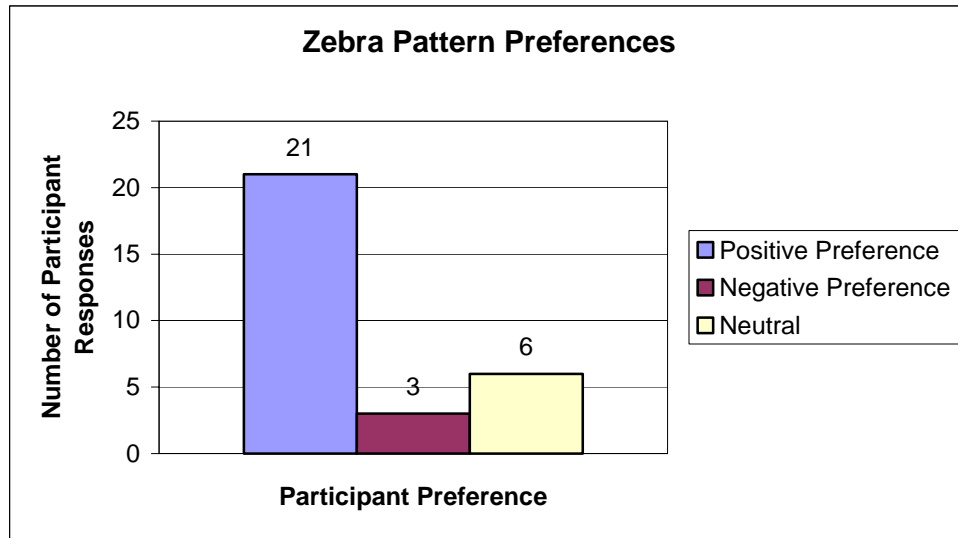
Figure 8. Labeling Preferences of Participants



As it is evident from the bar graph, more than 50% of the participants preferred slanted labeling and two participants out of thirty were neutral and ten out of thirty voted for the vertical format. Therefore, the slanted labeling dominates the vertical format.

Zebra Pattern: In the newly developed prototypes, alternate columns were shaded and this format is named the zebra pattern. The current schedules do not have a zebra pattern. The bar chart showing the subjective preferences of the thirty subjects with respect to zebra pattern is shown in Figure 9. They were given the option of responding positively, negatively or neutral to the zebra pattern.

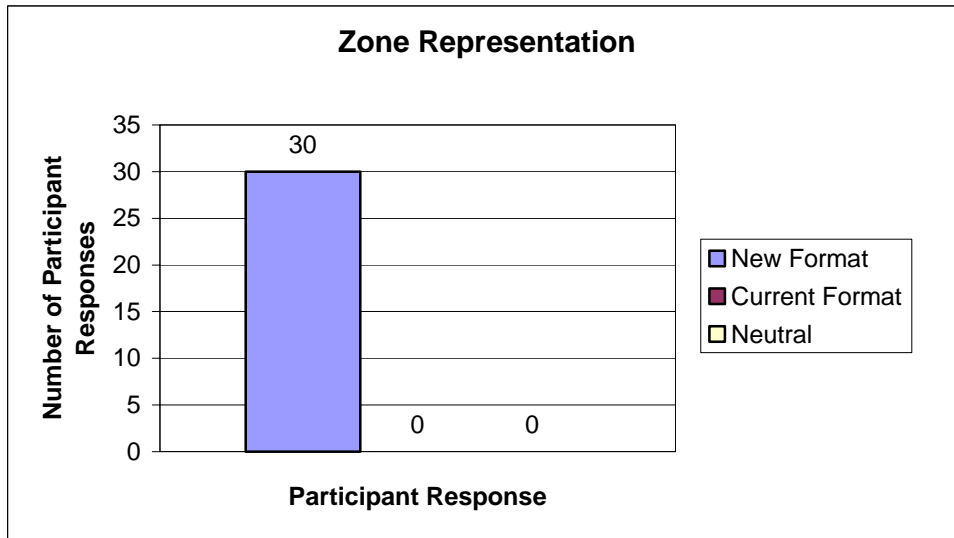
Figure 9. Zebra Pattern Preferences of Participants



More than 50% of the participants voted for the zebra pattern and stated that the alternate shading of columns made the bus schedules more readable. Only three out of thirty subjects voted against the zebra pattern and six out of twenty-eight remained neutral.

Zone Representation: Zones were incorporated at the bottom of every table in the newly developed prototypes in addition to being included in the map, as it is the practice in the current schedules. The participants were given the option of responding positively, negatively or being neutral to the representation of maps at the bottom of every table. Their response has been shown in Figure 10.

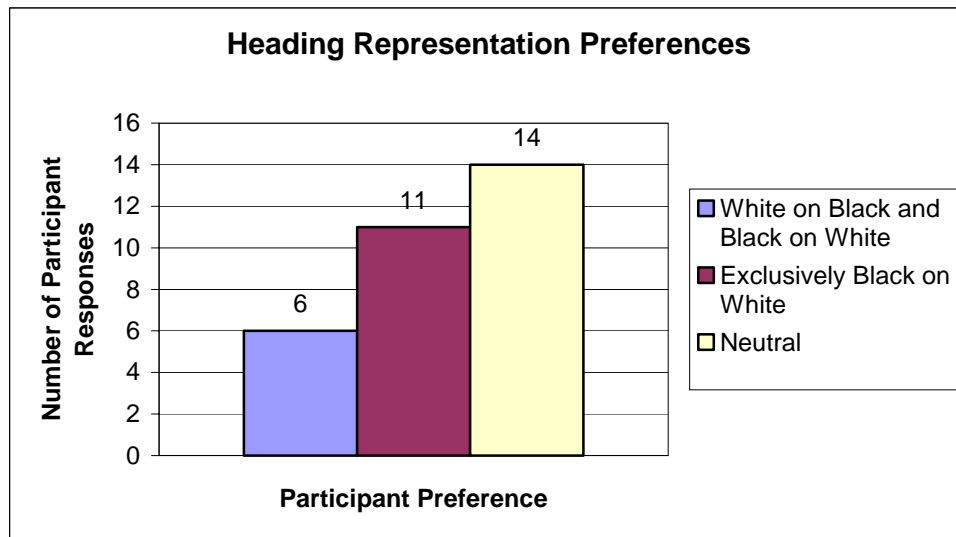
Figure 10 Zone Representation Preferences of Participants



All participants voted for the zone to be represented at the bottom of every table. They stated that this mode of representation is very effective in calculating the fare.

Heading Representation: In the newly developed prototypes, the headings were represented differently with respect to the font and background color. In the current schedules, the headings have been laid out in black fonts on white background. In the newly developed prototypes, on one side of a schedule, the heading was laid out in black fonts on white background and on the other side, it was laid out in white fonts on black background. This was expected to catch the attention of the participants and help them in distinguishing the two sides when they used the timetable. In the subjective questionnaire, they were given the option of voting for either one of the representations or they could be neutral. The subjective responses are shown in Figure 11.

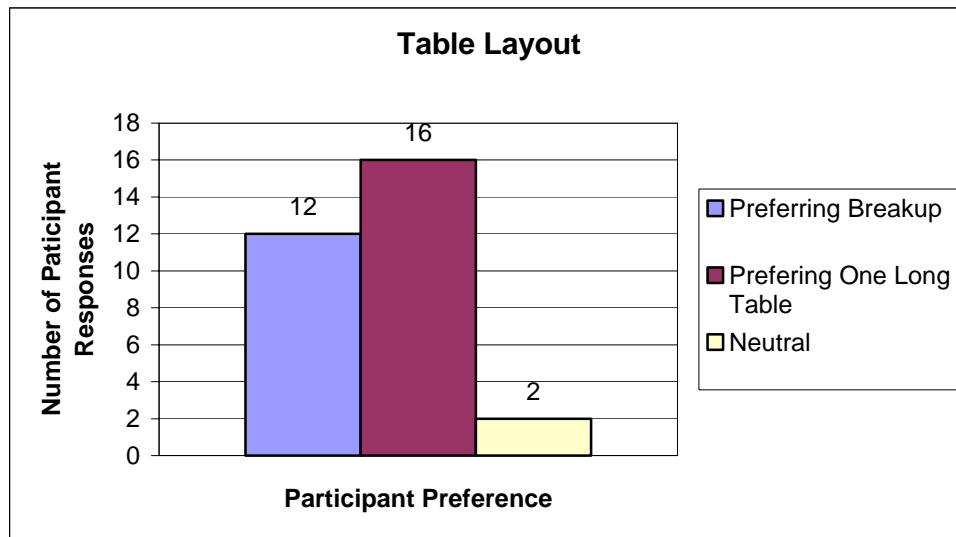
Figure 11 Heading Representation Preferences of Participants



Fourteen out of thirty participants chose to be neutral regarding this issue. They felt that this differentiation in representation neither affected their readability nor did it enhance their speed. Six out of thirty subjects voted for the different representation, while eleven out of thirty subjects voted for the black font on white background.

Table Layout: In the current bus schedule, the timetables are one straight table for weekends and weekdays, irrespective of their length. This in turn makes the participants to read all the way down the table for times, which are in the late evening or nights, especially in the weekday schedules. In the newly developed prototypes, these columns have been optimally divided into two (morning section and the afternoon / evening section). The Sunday schedules were kept as one table, since the frequency of buses is less and hence the overall length of the table is not too long. In the subjective questionnaire, the subjects were given the option of voting for the breakup, for no breakup of the table or they could be neutral. The responses of the participants are shown in Figure 12.

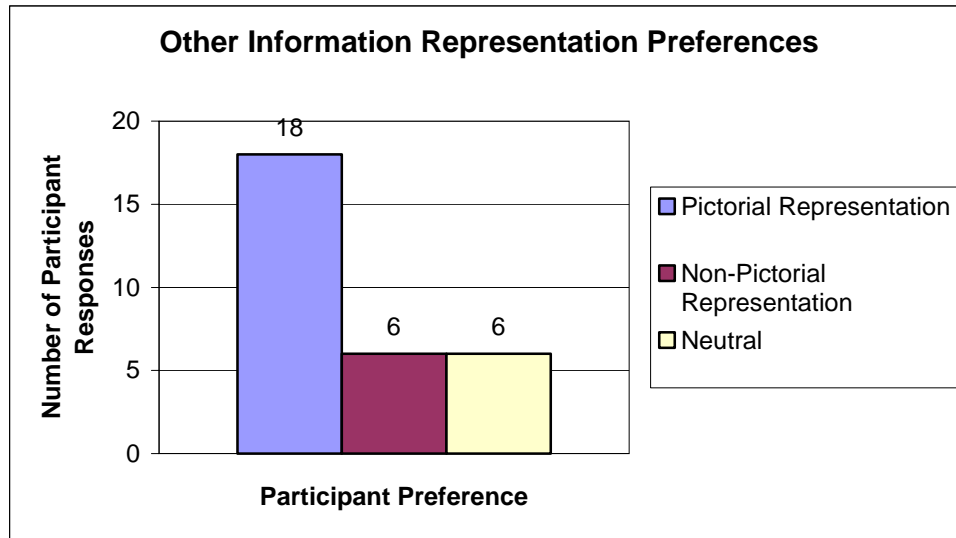
Figure 12 Table Layout Preferences of Participants



More than 50% of the participants voted for the single table, without breakup. Twelve out of thirty participants voted for the breakup of tables into morning and afternoon / evening and two remained neutral.

Other Information Representation: Some additional information like handicap facilities is listed in the current schedules exclusively in the form of text. In the newly developed prototypes, they were represented pictorially. This also saves some space. The participants were asked if they preferred the pictorial format of representation to the textual format. They also had the option of being neutral. Their responses are shown in Figure 13.

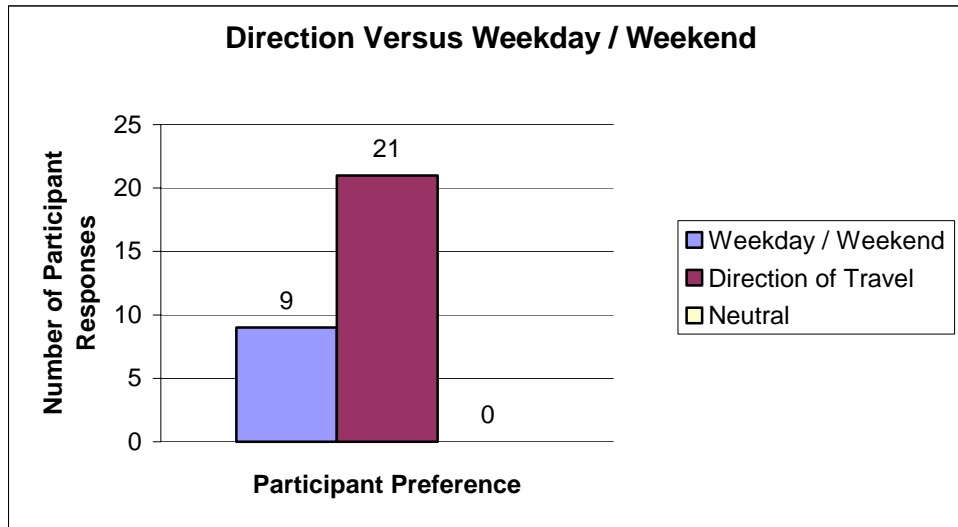
Figure 13. Other Information Representation Preferences of Participants



More than 50% of the participants stated that they preferred the pictorial format of representation. Six out of thirty were neutral and six out of thirty preferred the textual format of representation.

Direction Versus Day of Travel: This particular question was asked only to distinguish between the two prototypes, with respect to their general layout. In the directional prototype, direction of travel was given primary importance, and hence the schedule exclusively had one destination on one side of the schedule, irrespective of the day of the week. Weekday and weekend schedules for the same direction were presented on the same side of the schedule. In the weekday / weekend schedule, the day of the week was given primary importance and hence, this schedule exclusively had weekends on one side of the schedule and weekdays on the other, irrespective of the direction of travel. The subjects were given the option of voting either for the two modes of representations, or they could choose to be neutral. Responses are summarized in Figure 14.

Figure 14. Direction Versus Weekday / Weekend Preferences of Participants



More than 50% of the participants chose the direction of travel over the weekday / weekend type of representation. None of the twenty-eight subjects chose to be neutral. Nine out of twenty-eight chose the weekday / weekend mode of representation.

Ranking Data Analysis

The subjective response of the participants was tabulated and analyzed. The data from thirty subjects were considered for the subjective analysis. The first part of the subjective questionnaire was to rank the schedules with respect to the participant's preference for a particular prototype, with rank 1 being the best and rank 3 being the least liked schedule format. A chi-square test was used on the general ranking data. The general ranking of the schedules by the participants are shown in Table 8.

Table 8 General Ranking of the Three Bus Schedule Formats

	Rank 1	Rank 2	Rank 3
Current Schedule	5	7	18
Directional Schedule	15	12	3
Weekday / Weekend Schedule	10	11	9

Chi-Square Test for Ranking: A chi-square test was performed on the general ranking table for the three different bus schedule prototypes in order to recognize if subjects responded differently for the three different prototypes. The chi-square

table is shown in Table 9. The formula and value of the expected value has been given below the table.

Table 9 Chi-Square Test for the Ranking of the Three Prototypes

	Rank 1	Rank 2	Rank 3	Row Total
Current Schedule	5	7	18	30
Directional Schedule	15	12	3	30
Weekday / Weekend Schedule	10	11	9	30
Column Total	30	30	30	90 (Grand Total)

Expected value for each cell = (Sum of Row X Sum of Columns) / Grand Total
 = (30 x 30) / 90 = 10

$$\begin{aligned} \text{ChiSq} = & 2.500 + 0.900 + 6.400 \\ & +2.500 + 0.400 + 4.900 \\ & +0.000 + 0.100 + 0.100 = 17.800 \\ \text{df} = & 4 \end{aligned}$$

The chi-square value of 17.800 is greater than 9.49, the value for a 95% confidence interval four degrees of freedom. This result shows that there is significant difference in the ranking of the schedules. To attain more clarity about the ranking preferences, the prototypes and ranks were tested exclusively using chi-square test.

The chi-square test shows statistical significance in the ranking of the current schedule as third compared to a ranking of one or two. Statistical significance is also shown for the ranking of the directional schedule as one compared to rank two and three. The chi-square test for the weekday / weekend schedule did not show any statistical significance in the ranking.

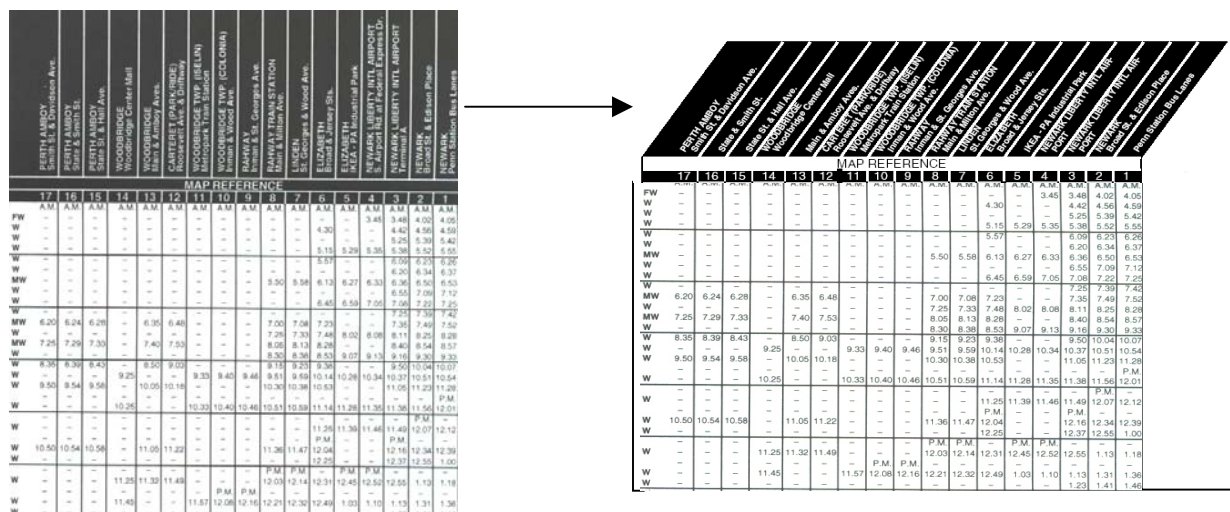
These chi-square test results indicate that subjects would rank the directional schedule as the easiest to read and understand and the current schedule as most difficult. By default, the weekday/weekend schedule would be ranked between the two.

CONCLUSIONS

The literature review and feedback from the research team members revealed that there are a number of potential changes to existing bus schedules that should be undertaken. However, the Quantitative Evaluation confirmed that only some of these changes, if implemented, would improve the overall readability and understanding of bus transit schedules and that there may be a more global problem associated with providing too much information of the schedules. An assessment of the proposed modifications to NJ TRANSIT's existing bus schedules, along with conclusions from the research findings are presented below.

Proposed Modification 1. Re-Orientation of Time Point Locations. Currently, time point locations (selected locations shown on the actual schedule) are oriented such that they are perpendicular to the time points. Consequently, the user must either flip the schedule ninety degrees or tilt their head in order to read them. (See Figure 15). Although there are some inherent space saving advantages to the current format (maintaining the time point destinations perpendicular to the actual time points), the literature review discourages this practice and recommends orientation of the time point locations and time points in the same plane or angling the time point locations such that users can view without flipping the schedule or tilting their head. It is also noted that two-thirds of the other transit agencies surveyed display time point locations so that they can be read without the need to flip the schedule.

Figure 15 Angled Time Point Locations

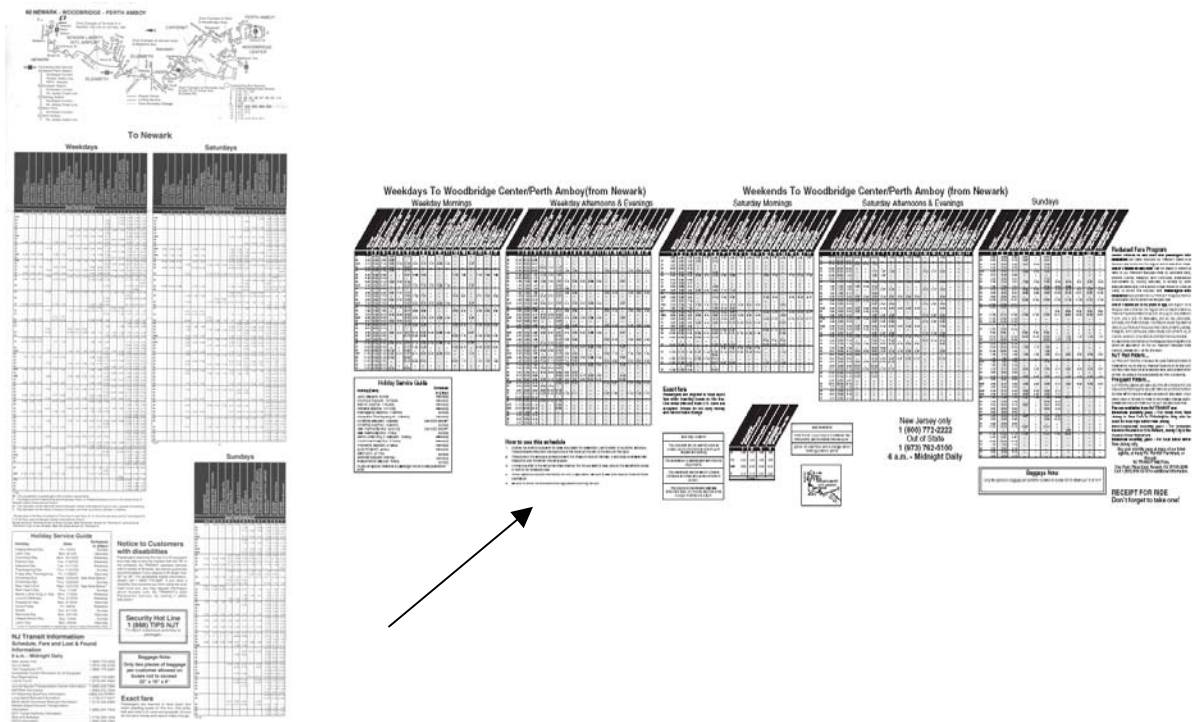


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Participants in each of the focus groups agreed that changing the current orientation enables the schedule to be read much easier. Test subjects also preferred slanted labeling to the current vertical labeling. However this feature could not be specifically tested quantitatively. Furthermore, slanted labeling would increase the paper size and would increase production time. However, the additional space required and increased production time would not be significant.

Proposed Modification 2. Distinguishing AM and PM. NJ TRANSIT bus schedules, including the Route 62 line, indicate AM or PM above each time point where the AM or PM period begins. This distinction is not apparent. Both prototypes address this by providing separate tables for AM and PM periods. (See Figure 16). This modification also decreases the distance between the time point location and the actual time point for PM periods.

Figure 16 Break Up of AM and PM Timetables



Previous research specifically addresses the need to limit the separation distance between time point locations and time points. Feedback from the focus group participants suggest that better distinguishing AM and PM is preferable.

Splitting the current single timetables into two separate AM and PM timetables, clearly resulted in more performance errors in testing this feature, which was unique to the prototypes. Therefore, while a better distinction between AM and PM time stops may be preferable, it is best that they remain in a single table. Furthermore, providing separate AM and PM tables would adversely impact schedule production as changes would need to be made manually.

Initially, consideration was given to having the locations on the vertical axis and the times points displayed across, as on the current Northeast Corridor train schedule. However, NJ TRANSIT officials reported numerous complaints received from train customers regarding this format. Therefore, this option was dismissed early on in the study.

Proposed Modification 3. Displaying Different “To” Directions on opposite sides of the Schedule. Prototype A and Prototype B differ only in this aspect of the presentation. Prototype A displays weekday and weekend/holiday schedules on both sides with one side designated for one “To” location and the other side designated for the other “To” location. This is consistent with the manner in which timetables are displayed on current NJ TRANSIT bus timetables. Prototype B, however, displays weekday schedules on one side and weekend/holiday schedules on the other side. As a result both “To” and “From” schedules appear on the same side.

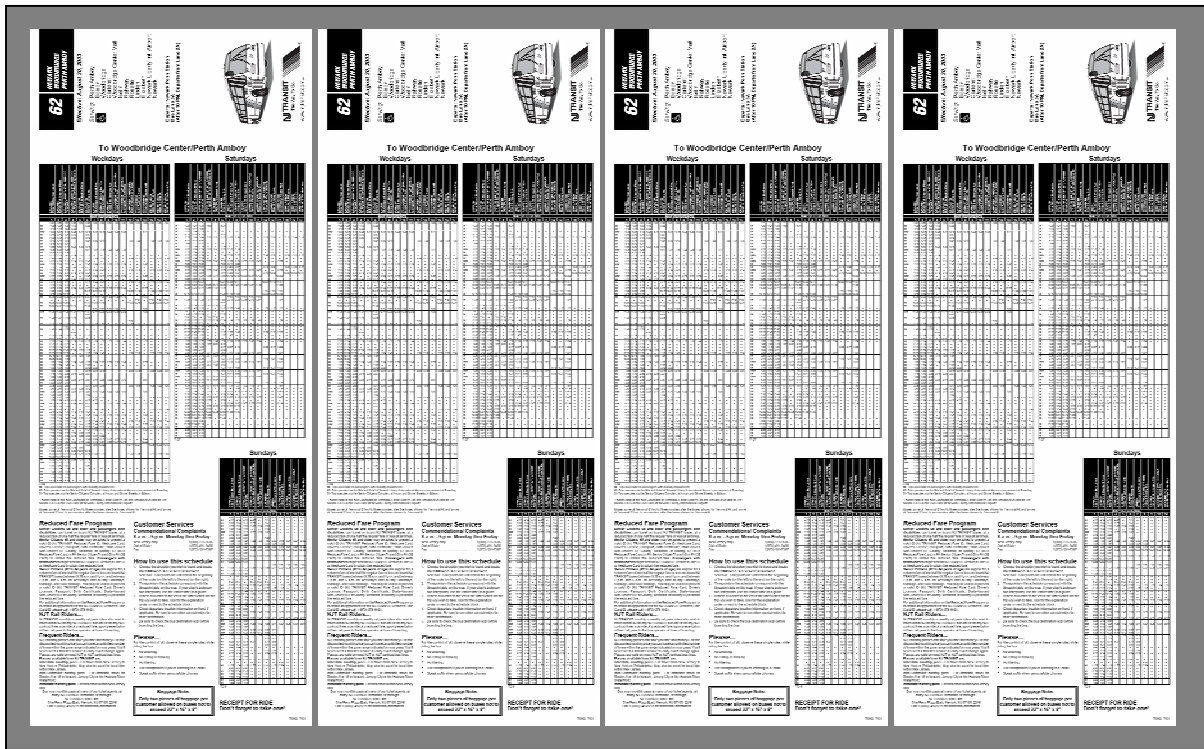
There was no research or literature found on this aspect of the presentation. However, this issue was brought up in the customer focus group meeting. There was no real consensus as to which display technique was preferred. However, the directional format (Prototype A) fared better overall than the weekday/weekend format (Prototype B) in the quantitative testing. The directional format was also preferred in the subjective survey.

Proposed Modification 4. Relate Time Point Locations on the Map. The Route 62 line is the only bus schedule that relates the time point location to a map location through the use of a numeric designation on the schedule and on the map. Each prototype also retains this feature, but also a graphic that instructs the user on what the various codes on the timetable represent. While participants in both focus groups agreed that there should be a link between the time point locations and the map, several expressed that they were unaware that this already exists on the Route 62 schedule. The effectiveness of this feature could not be tested as it appears in both the prototypes and the existing Route 62 schedule.

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Proposed Modification 5. Increase Paper Size. NJ TRANSIT currently uses two paper sizes to produce its schedules: 23" x 35" and 25" x 38". All of the schedules are 8-1/2" wide and vary in length, ranging from 15 to 27 inches, in increments of 3 inches. The optimal arrangement is 4 schedules per sheet or "four up". (See Figure 17). Hence, a schedule that is 21 inches in length, such as the Route 62, could be accommodated "four up" on a paper size of 23" x 35". Going to a 24" schedule would require going to the next paper size, 25" x 38", but schedules could still be produced "four up". The next length increase, 27", however, would require schedules to be produced "two up", or two per sheet. From a production standpoint, therefore, it is concluded that schedule lengths for the Route 62 be limited to 24 inches.

Figure 17 "Four Up" Production



As indicated previously, the Route 62 schedule is currently 21 inches in length. An additional 3 inch increment would enable the proposed changes to be made and would still enable the schedules to be produced “four up”, although the larger paper size must be used. However, increasing schedule sizes to accommodate the proposed changes globally could have significant impacts to the production operation. Presently, 24” schedules lengths are used for 16 different bus routes. For these 16 routes, 2,793,000 schedules are produced annually. By producing these schedules “four up” (or four per sheet), 698,250 (2,793,000/4) sheets are required. Increasing these 16 schedules to 27”, which may be necessary to accommodate the proposed changes, would allow only 2 schedules per sheet to be produced, thus requiring 1,396,500 sheets. Furthermore, approximately one-third of the paper would be wasted and the production time would be increased by an estimated four weeks.

Increasing the size of the paper would provide an opportunity to increase the font size, which would likely improve the readability of the schedules. In addition, elimination of extraneous information would also potentially enable font sizes to be increased. Future initiatives to improve readability of transit schedules should therefore focus on these aspects.

Proposed Modification 6. Column Shading. Although not explicitly cited as a recommended practice, a striping pattern was introduced to help distinguish and guide the various columns. The shading was an effort to enable users to follow time points with locations. Each of the prototypes included this change.

While not showing any marked effectiveness in the quantitative testing, column shading was clearly a preference in the subjective rankings.

Figure 18 Column Shading

	PERTH ANDY Smith St & Davidson Ave	Stiles & Smith St	Stiles St & Hill Ave	WOODBRIDGE Woodbridge Center Mall	Main & Ancey Ave	CHRYSLER Roosevelt Ave & Highway	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	WOODBRIDGE Woodbridge Center Mall	
W	-	-	-	6.32	-	-	6.40	6.51	6.59	7.04	7.14	7.31	7.45	7.52	7.55	8.13	8.17
W	6.50	6.54	6.58	-	7.08	7.25	-	-	-	7.39	7.49	8.06	-	-	8.18	8.36	8.40
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.30	8.48	8.52
W	-	-	-	7.32	-	-	7.40	7.51	7.59	8.04	8.14	8.29	8.43	8.49	8.40	8.58	9.02
W	-	-	-	-	-	-	-	-	-	-	-	8.48	-	-	9.09	9.18	9.22
W	7.50	7.54	7.58	-	8.05	8.18	-	-	-	8.32	8.42	8.57	-	-	9.09	9.27	9.31
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.22	9.40	9.44
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.28	9.46	9.50
W	-	-	-	8.25	-	-	8.33	8.44	8.52	8.57	9.07	9.22	-	-	9.34	9.52	9.56
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.54	10.12	10.16
W	-	-	-	-	-	-	-	-	-	9.13	9.23	9.38	9.52	9.58	10.01	10.19	10.23
W	-	-	-	-	-	-	9.12	9.23	9.31	9.36	9.46	10.01	-	-	10.13	10.31	10.35
W	8.55	8.59	9.03	-	9.10	9.23	-	-	9.37	9.47	10.02	10.14	10.20	10.23	10.41	10.45	
W	-	-	-	-	-	-	-	-	-	-	-	-	-	10.44	10.47	11.05	11.09
MW	-	-	-	9.55	-	-	10.03	10.14	10.22	10.27	10.37	10.52	-	-	11.04	11.22	11.26
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.20	11.38	11.42
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11.30	11.48	11.52
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW	-	-	-	10.40	-	-	10.48	10.59	11.07	11.12	11.22	11.37	11.51	11.57	A.M.	A.M.	A.M.
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.00	12.18	12.22
MW	10.55	10.59	11.03	-	11.10	11.23	-	-	-	11.37	11.47	12.02	-	-	12.16	12.34	12.38
FW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A.M.	-	-
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12.50	12.53	1.11
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.30	1.48	1.52
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.30	2.48	2.52
W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.30	3.48	3.52

Proposed Modification 7. Reduction of Other Information. NJTRANSIT bus schedules contain large amounts of information in addition to the map and timetables. For each of the focus group meetings, participants were asked to rate various items in terms of their usefulness. Overall, results were somewhat mixed. However, there were a limited group of items that were considered to be essential for trip making. These are:

- List of towns the route serves
- Map
- Customer Service Information
- How to use the Schedule

Each of the prototypes includes modifications to the manner in which the above information is displayed. For example, Customer Service Information is shown in larger bold font and is shown on a more obvious location on the schedule.

Overall error rates in answering the questions correctly was high for all age and education levels, suggesting that the task of using the bus schedule is difficult for a wide range of people. This only confirms an issue raised early on in the study that there is just too much information on the schedule! Eliminating some of the clutter also provides an opportunity to potentially increase the font size, which on the Route 62 schedule, is less than the suggested minimum size of 10 point.

RECOMMENDATIONS

Recommendations for transit schedule modifications come from our review of current literature, input from NJ TRANSIT staff, feedback received at the focus group meetings and the results of the performance and test subject evaluation.

In general, bus transit users believe that NJ TRANSIT bus schedules are effective in accommodating their schedule information needs. Both focus groups, for example, indicated the map is useful and provides an adequate level of detail for establishing locations. Furthermore, other information provided on the schedule is also useful. While some of the recommendations listed below are clearly warranted, others are simply suggested, and cannot be specifically supported through the research conducted in this study. Recommended transit schedule modifications are listed and described in text and graphics below.

- **Reorient time point locations.** Reorienting the time point locations at an angle or having the time point locations along the same axis as the time points would enable the user to view the time points without the need to flip the timetable document. However, this recommendation would need to be carefully balanced against the need to increase paper size and the additional labor required to implement these changes.
- **Relate time point locations to the map.** This feature is already incorporated into the Route 62 schedule. However, the Route 62 schedule is the only one that takes advantage of this feature. It is recommended that all of the bus routes relate the time points to the map through some alphanumeric coding. It is also recommended that the schedule clearly indicate the meaning and use of this link.
- **Maintain AM and PM timepoints on a single timetable.** It is recommended that AM and PM time points be retained on a single timetable. Consideration should be given to distinguishing AM and PM periods, however, physically separating them is not recommended.
- **Maintain the display of weekday and weekend the same sides of the schedule.** Presently, NJ TRANSIT displays weekday and weekend/holiday schedules on both sides with each side designated for a "To" location. This display option fared better both in the quantitative evaluation as well as the subjective ranking.
- **Eliminate extraneous information.** Much of the "other" information on NJTRANSIT bus schedules has reportedly been added in response to customer feedback as well as concerns raised from NJ TRANSIT legal and administrative staff. Some of this information needs to remain, regardless of

relevance to the user, but it could be consolidated or reduced. Other information should be eliminated. For example, use of a one-call automated information number would enable many of the phone numbers on the schedule to be eliminated. In other cases, information can be reconfigured to increase the amount of usable space on the schedule. Other information identified as important, such as the list of towns served and customer service information should be emphasized. This could be accomplished in two ways: 1) increasing the size of the fonts; 2) placing the information in a more obvious location.

Regardless, the quantitative testing shows poor overall performance in using the schedules for a range of education levels and ages. Efforts to reduce the amount of information on the schedule and enhancing other aspects, needs to be seriously considered.

- **Consider Shading Alternating Columns.** It is recommended that adjacent columns be distinguished from each other through shading. However, shading should only be considered where it would not conflict with shading used on the schedule for other purposes such as demoting peak hours or special exceptions.
- **Graphically depict the schedule use directions.** The current schedules provide text instructions on how to use the schedules. It was agreed that this information should be retained. However, it is recommended that the schedule provide a graphic to show the various timetable features as well as emphasize the link between the timetable and the map.
- **Enhance the visibility and placement of the Customer Service Number.** Focus group members agreed that the Customer Service Number was an important piece of information and should be emphasized on the schedule. It is recommended that the font width and size be increased and that the number be placed on the cover, a much more visible location on the schedule.
- **Add fare zone information to the bottom of the timetables.** Focus group members commented that fare information was not clear and that the zone information, which correlates to fare, was difficult to decipher on the map. The subjective ranking also indicates that inclusion of zone information was helpful. However, adding this information would require NJ TRANSIT Service Planning input and the additional information would need to be manually entered, potentially slowing production and adding labor cost.
- **Reduce the size and layout of the Holiday Service Schedule.** The current configuration of the Holiday Service Guide is somewhat inefficient in its use of space. Therefore, it is recommended that the current Holiday Service Schedule be modified, which would free up additional space on the schedule.

- **Make the front and back cover more distinctive to facilitate easier folding.** Many of the focus group members as well as the research team commented on the difficulty of folding the schedules once they were opened. Making the front and back covers more distinct from the rest of the schedule and placing them next to one another provides greater clarity for folding. The user can then fold in the remaining portion of the schedule into the front and rear covers.

The above changes have been discussed with NJ TRANSIT staff. Implementation of these changes would impact production operations and would likely require additional resources. However, the extent is relatively insignificant and could be phased in over time. A Recommendations Impact Summary Matrix is provided in Table 10.

While the recommended changes may improve the readability of bus schedules, the considerable number of performance errors suggests that there is an overwhelming amount of information on the schedules. Therefore, additional immediate future steps NJ TRANSIT should consider to improve the readability of bus transit schedules should include:

- **Meeting with NJ TRANSIT staff to identify what information could be eliminated.** The overall poor performance of tasks strongly suggests that the schedules are difficult to use regardless of how the existing information provided on the schedule is reformatted and/or re-manipulated. This study solicited input from two focus groups to identify what information is critical from a customer perspective. A similar effort should be initiated to identify what information is critical from an internal perspective.
- **Developing of a “one-call” system.** NJ TRANSIT should consider using the current AT&T contract to develop a “one call” phone number thereby eliminating the extensive list of phone numbers on the current schedule. The results of the focus groups suggest the importance of retaining a phone number as well as other key pieces of information such as how to use the schedule and fare information. Establishing a one-call system where users could receive recorded messages, for example, would reduce the amount of information on the current schedule as well as free up customer service personnel on responding to routine questions.

Other potential future research initiatives include:

- **Development and testing of additional prototype schedules.** The two prototypes schedules developed for this research project were found to be advantageous in some areas, but could certainly be improved upon. Reducing the amount of information currently contained in the schedules, and

taking the lessons learned from this study provide an excellent basis for developing new prototype schedules. And in addition to eliminating extraneous information and revising the overall format, increasing font size must be included in the development of future prototypes.

- **Development and testing of prototype schedules for additional bus routes.** The study team selected one route for prototype development. While this route was selected because of its high level of complexity, other schedules may have equally complicated issues. Therefore, schedules for other routes should also be examined using a similar research approach.
- **Development and testing of prototype schedules for rail routes.** The research team explored bus transit routes, but a similar research approach could be used to develop and test prototype schedules for rail routes.
- **Investigation of other schedule design software that could help facilitate new and improved concepts for schedule presentation.** Current schedule production software has certain limitations in quickly and easily making certain recommended schedule changes. For example, displaying time point locations at an angle would require manual input using the current software. Modifications to NJ TRANSIT's existing schedule development software or use of other software graphics packages that could facilitate changes more easily and cost-effectively should be explored.

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Table 10. Recommendations Impact Summary Matrix

	Verified by Performance Testing	Verified by Subjective Ranking	Additional NJ TRANSIT Staff Time Required	Additional Technology / Software Required	One-time Setup Cost / Continuous Cost	Comments
Re-Orient Time Point Locations	Yes	Yes	Yes	No	One-Time Set-up Cost	Would increase the required printing area and would require manual graphical input and editing
Provide map and timetable tie-in	N/A	N/A	Yes	No	One-Time Set-up Cost	This feature is unique to the existing test schedule.
Include Zone Info. On Timetable	Yes	Yes	Yes	No	One-Time Set-up Cost	Would require input from Service Planning as well as manual input from production staff
Keep AM/PM Times Together	Yes	Yes	No	No	No Cost	Consider better distinguishing AM and PM times.
Maintain Directional Format	Yes	Yes	No	No	No Cost	
Shade Alternating Columns	N/A	Yes	Yes	No	No Cost	Should only be considered where shading is not used to identify other unique schedule features.
Eliminate Extraneous Info.	Yes	N/A	Yes	Unknown	One-Time Set-up Cost	Potential use of existing AT&T contract for developing a one-call system.

Appendix A

Project Team Members and Students

Project Team Participants

- Edward Kondrath, NJDOT
- Jerome Lutin, NJ TRANSIT
- Rob Lilley, NJ TRANSIT
- Alison Demyanovich, NJ TRANSIT
- Janet Clark, NJ TRANSIT
- Janice Pepper, NJ TRANSIT
- Rick Mariana, NJ TRANSIT
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- Darius Sollohub, NJIT
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Student Participants

- Anand Tharanathan
- Sahana Rao
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Appendix B

Literature Review

LITERATURE REVIEW

Intuitively, as well as from the body of research, it has been found that the effect of visual displays depends upon both human physiological and cognitive aspects. Visual displays must be readily visible and the design must make it possible for the viewer to correctly perceive the meaning of the display. Displays designed for specific work situations, of course may require some level of worker training, but the design should capitalize on those display features that enable people to correctly perceive what they sense. (McCormick and Sanders, 1993).

Attracting the user's attention is also very important in any visual display. In certain typical situations, since substantial information maybe presented to users for the normal performance of their work, exceptional conditions or time-dependant information must be presented so as to attract attention (Wickens, 1992). In general multiple techniques exist for getting attention (1) Intensity: use two levels only, with high intensity to draw attention. (2) Marking: underline, enclose in a box, point to with an arrow, or use an indicator such as an asterisk, bullet, dash, plus or "X". (3) Size: use up to four sizes, with larger sizes attracting more attention. (4) Choice of fonts: use up to three fonts. (Schneiderman, 1998).

Researchers have also identified four important characteristics of display formats: overall density, local density, grouping and layout complexity. When objective measurement techniques for these characteristics were proposed and applied to two different display formats, the results suggested that these measures could provide the basis for objectively evaluating a display without collecting performance data (Tullis, 1983).

Recently, researchers have shown that on an average, subjects are quicker to find a target option in a highlighted display than in a display without highlighting. However, other related research has demonstrated that subjects are slower to find a target in a highlighted display than in a display without highlighting. In an attempt to resolve this paradox, a set of experiments was performed. The results suggested that in order to determine whether highlighting will be of benefit, one must know the type of highlighting, the level of highlighting validity, and the probability that subjects attend first to the highlighted options. The mode of highlighting might be different for different kinds of representations. The designing has to be done accordingly (Fisher and Tan, 1989).

Pictures were also found to play an active role in conveying the intended message. If performance speed is important, then pictures are generally preferable to textual instructions; however, if memory of the instructions is important and recognition is critical, textual representation was determined to be more advantageous. It was concluded that was due to the greater flexibility in usage text can provide over pictures (Fisk, Kobylak and Serbo, 1986).

Researchers found that complex cognitive tasks can be accomplished using one of several different strategies. Experiments conducted in the domains of bus schedules, medication instructions, and text-editing all led to the same basic conclusion: alternative representations of the same information have clear and often dramatic effects on cognition. This was found for the following comparison conditions:

- The amount of information to be learned is relatively heavy (bus schedules) or light (text editing)
- The domain occurs in everyday situations (*bus schedules*, medication instructions) or more specialized settings (text editing)
- A list representation is compared with another type of list (*bus schedules*), a matrix (medications), or a spatial format (text editing)
- The cognitive processes examined were memory (*bus schedules*, medications, text editing), comprehension (medications, text editing), or problem solving (text editing)

Despite all these differences, some representations always facilitate performance while others hindered it (Day and Ruth, 1989).

Critical determinants of performance in a visual scanning include location and reading of digits, the time to perform such a task is constant for differing vertical locations of the target numerals and the initial fixation point within the display screen. When the size of displacement of fixation is increased with the display at a fixed distance, there is a significant increase in reaction time. However if viewing distance is altered, reaction time does not depend upon the resulting angular separation of the fixation point and the target. Rather the physical separation of the two determines the performance, over the range of viewing distance examined. The increased time required looking between and responding to widely separated data fields cannot be compensated by increasing viewing distance. This may be the result of a trade-off between the effects of scan angle and of peripheral acuity (Swanston and Walley, 1984). As per the principle of compatibility of proximity, when a task requires the integration of information, the display should present the data in close proximity. Similarly, when the task does not require the integration of information or necessitates selective attention to a subset of the information, nonintegrated displays will be optimal. Information displays should match the mental representation of the information particularly in tasks that rely heavily on large amounts of data (Goettl, Kramer and Wickens, 1986). Therefore the presence of a schools or churches and other landmarks on transit schedule maps would help the user to process information faster as they compare it with their existing mental models. The proximity of the timetable to the map would also improve the speed of reading the schedule, especially if they need to read both to plan a trip.

Research was also conducted on the spatial characteristics of successive lines of printed text. The spatial characteristics of these patterns were measured and

were found to be similar to those of patterns that induce discomfort, anomalous visual effects and even seizures. Researchers argued that the inherent striped property of horizontal text provokes "eye-strain" and seizures to the reader. It was further argued that by covering the lines of text above and below those being read would reduce the occurrence of headaches and seizures.

The clarity and readability of a printed display can be manipulated with the available space and existing constraints. For example, subjects were asked to judge the clarity of text. It was shown that judgments of clarity are affected by the spatial characteristics of the text pattern and in particular, the spacing between the lines. It was found that the average area of the page occupied by a letter (i.e. the product of the separation between the lines and the mean horizontal spacing between the centers of letters) accounted for less variance in clarity than the separation between the lines of text. It was concluded that within the constraints of conventional typography and without increasing costs that the clarity of text could be improved by reducing the typical spacing between the letters in order to increase the spacing between the lines. (Nimmo-Smith and Wilkins, 1987).

On many occasions, changes in the schedule go unnoticed creating another difficulty for bus schedule users. Transit Time Internet Access (TTIA) is a World Wide Web application that delivers real-time bus schedule information to users of the Internet. TTIA allows a bus rider to request and receive schedule deviation information about a specific bus at a specific time. It was concluded that there needs to be a more efficient system for the representation of the changes in schedule was felt (Dueker and Vorvick, 1998). Even though this study deals with online schedules, this study demonstrates that the representation of effective dates needs to be more appropriate.

Typography and Topography:

Typographical (font size, stroke width, font type) and topographical (character spacing, line spacing, justification) aspects are important in designing displays that represent schedule stop locations, times and routes. Better typography and topography can improve the quality of any information display. There needs to be minimum congestion, which can make it easier for the people to read and understand the route in one search, rather than in multiple searches. Casual examination of several mathematical or statistical tables will reveal great variation in the typographical arrangements employed. From table to table the reader may find variation in type size, type face, use of additional leading at periodical intervals, number of decimal places employed, etc. To a reader with some background in scientific topography, it is obvious that some of these factors should influence the readability of tables. In some tables, economy of space seems to be the sole consideration with no attention to readability factors. Where readability is mentioned, choice of typography depends upon opinion rather than upon experimental findings (Tinker, 1954).

The legibility of displayed letters depends upon their size, or more accurately, their subtended visual angle at any viewing distance (Smith, 1979). The term typography refers to the various features of alphanumeric characters, individually and collectively. For everyday practical purposes, most of the variations in typography adequately fulfill the human factors criteria like visibility, legibility and readability. However there are four types of circumstances in which it may be important to use “preferred” forms of typography: (1) when viewing conditions are unfavorable (as with poor illumination or viewing time), (2) when the information is important or critical (as when emergency labels or instructions are to be read), (3) when viewing occurs at a distance, and (4) poor vision of users.

Representation of maps has space constraints on many occasions, but the rule of thumb is that there should be minimum congestion and the coding should be used such that it becomes easier for the user to read and understand the map. The presence of arrows and other signs should be able to convey the intended message and needs to be well justified. The maps should not be overloaded with information.

Regarding typography, the following primary conditions apply:

Stroke width: The stroke width of an alphanumeric character usually is expressed as the ratio of the thickness of the stroke to the height of the letter or numeral. A phenomenon called irradiation causes white features on a black background to appear to spread into adjacent dark areas, but the reverse is not true. Thus, in general, black text on a white background should be thicker (have lower width to height ratios) than white letters on black backgrounds. With reasonably good illumination, the following width to height ratios are satisfactory for printed material: black text on white background, 1:6 to 1:8 and white text on black background, 1:8 to 1:10. As illumination is reduced, thick letters become relatively more readable than thin ones (this is true for both black-on-white and white-on-black letters). With low levels of illumination or low contrast or low contrast with background, printed letters preferably should be boldface type with a low stroke width-to-height ratio (such as 1:5). For highly luminous letters, ratios could be reduced to 1:12 to 1:20. For black letters on a very highly luminous background, very thick strokes are needed.

The relationship between the width and height of a complete alphanumeric character is described as the width-height ratio and is expressed, as a proportion (such as 0.60). A width to height ratio of 3:5 has come into fairly common use and in general is well supported by research.

Styles of Type: Style types fall into four major classes: Ariel, Roman, Gothic, Script and Block lettering. Some styles can also vary based on the use of serifs or small segments added to each letter. For example, serifs are incorporated in the Romantic text, shown here. Ariel text, however, does not have

serifs and is hence referred to as “sans serifs” from the French word “sans”, which means “without”.

Size: Text size is defined by the term “point” which corresponds to hundredths of inches. So, for example, “9 point” text would measure 9 one-hundredths or 0.09 inches, 11 point would measure 0.11 inches and so on. Appropriate sizes are generally selected for a corresponding reading distance. In the case of close-up reading, if we accept that the commonly used 9- to 11-pt print sizes of newspaper and magazines are suitable, then such sizes (0.09 to 0.11 in; 2.3 to 2.8 mm; 22 to 27 min of visual angle) would be acceptable as a basis for general use printed alphanumeric material.

Case: Philips (1979) suggests that for certain tasks, such as looking for a particular label on a control panel, the important aspect of the word is not the overall shape, but rather the initial letter. If the initial letter were larger than the other letters, the word would be found more quickly (McCormick and Sanders, 1993). Therefore, when type is being designed to help the reader search quickly, the designer should first try to avoid lower case in order to make a typographical distinction. For example, to distinguish on a map country names from city names, the use of small capitals with a large initial capital is recommended since this retains emphasis on the capital letter. Secondly, when setting proper names with more than one word, it is perhaps only necessary to use a capital on the first word as normally it is only this first initial which is processed in a search task (Philips, 1979).

Grouping: The great variation in typographical arrangements found in published tables in the field suggests that such factors as convenience, amount of space taken and specific use for which the table was designed have led to arbitrary choice of the printing arrangement employed. In many cases, economy of space seems to be the sole consideration in determining the topographical arrangement with little or no attention to legibility. A study was conducted on the type size, arrangement of numerals in columns, and space versus space plus rules between columns. The study measured the speed and accuracy at which the correct numbers were located and tabulated. It was found that grouping numbers helps the user in directing their line of vision and more easily located than numbers not in groups. In general, grouping numbers by fives were more effective than grouping in tens (Tinker, 1960).

Timetable Design

Comparatively few studies have been conducted on timetable design, with the significant studies being in the seventies and early eighties. More studies have been conducted on other kinds of tables such as currency conversion tables, spreadsheets and shopping lists. However, study findings may be applied to the timetables because the pertinent criterion is the optimal information representation and display. The speed and accuracy with which people obtain

information from numerical tables were examined for a variety of presentation formats. It was found that people were slower and more error prone when they had to make four successive binary decisions than when making two decisions, each time selecting among four alternatives. People also made more errors when the presentation format required them to combine decisions along two different special dimensions compared to one-dimensional representation (Wright, 1977). Another factor, which affects the speed of finding the target, is the visual field. There exists a relationship between the size of the visual fields of the observer and time required to locate the target on static displays. People with large visual fields can find targets more rapidly than observers with small fields (Johnston, 1965). Speed of search also depends on the visual lobe area (Bellamy and Courtney, 1981).

In one study, a hypothesis concerning the appropriateness of alternative forms of graphical display for the presentation of particular properties of data was tested. It was found that there are significant differences between the alternative forms of presentation in terms of effectiveness for communicating major features of data. Representation of data in spreadsheet form was included in the study as a reference point for establishing the additional contribution that graphical representation offer. As per the findings, there is no single form of data display, which has proved to be the most appropriate in displaying numerical data along two dimensions. Compared to bar charts and pie charts, spreadsheets can be used very effectively to convey specifics, trends and accumulation. This is because of freedom within the format of comparisons by educated perceivers. It is however especially poor at drawing attention to conjunction and will need augmentation if this data aspect is to be conveyed. It is clear that different basic forms of representation influence the recall of information abstracted from data sets. The same data, if represented in a different manner, tends to convey a different meaning. There is always an optimal way of representation, which will best suit the needs (Sparrow, 1989). Regarding the selection of the time system, studies have been conducted on the twelve-hour and twenty-four hour systems. It has been proved that the twelve-hour system is more efficient and productive than the latter (Bartram, Crawshaw, and Sprent, 1980).

In spite of the variety of circumstances in which tabulated information is used, little has been known about the relative effectiveness of different formats. But it has been found from studies that some types of table are incomprehensible to many people, and that aspects of presentation, which were intended to help the user can in fact turn out to be a detriment. There has to be an optimal design for tabulated information. There are certain guidelines given with respect to factors within columns, between columns and on total display style, which might be helpful in properly designing any table for public use. For instance, within columns, grouping should be done by use of spacing or ruled lines, i.e. splitting columns into blocks of approximately five items. Another factor is the left-right arrangement of columns, so that information is read off to the right of the item looked up (Fox and Wright, 1970).

There are two typical styles of timetables: one (which is used extensively) represents the route vertically and is known as the standard format; the other (which occurs less frequently) represents the route horizontally and is known as the reflected format. These styles of representations were assessed in their basic versions and were then modified with the intention of making them easier to use. It was found out that the reflected format was better than the standard format and evidence suggested that the main reason for the superiority of the reflected format is that, it is easier to scan. An intuitively attractive feature of the reflected design is that the super ordinate route dimension is represented in the orientation, which corresponds to probably the most powerful population stereotype of direction of motion or progression-horizontally, from left to right (Bartram, Crawshaw and Sprent, 1983).

Comparisons between matrices and tables were made in one study, which gave interesting results. The investigations reported are undoubtedly little more than tentative explorations of the problems that arise when people are required to use tabulated information. There is no information that a given information can be easily handled by a certain proportion of the population, and furthermore that this population can be increased by suitable training; nevertheless there appears to be a sizeable subgroup who meet with difficulties when trying to use certain types of tables. From considerations of the factor of locating the information, it might be expected that matrices will be more difficult to handle than tables that are basically list of pairs of values, since a matrix involves locating two entry points (vertical and horizontal) (Wright, 1968).

With respect to performance with currency conversion tables based on two alternative principles of tabulation, in a simulated shopping situation there was an initial speed advantage for the table, which explicitly listed all pairs of equivalent prices. The other table, which gave conversions of shilling separately from the conversion of pence, was not only slower to use, it was more often incorrectly used. Data from a modified market survey technique showed that many of the general public incorrectly used this more difficult 'implicit' format even when given an illustrative example. Presenting school children with both numerical and non-numerical tables indicated that the difficulty of the implicit format was not caused by the mental arithmetic involved, although it was associated with combining separate items of information. Juxtaposition of the items was more easily achieved than a synthesis. The idea is that, the table should be simple to use and should have the least complications. All the information should be available in one search, rather than combined searches (Fox and Wright, 1972).

Within the table, there lies much importance in the representation of the words and numerals for better understanding and visual quality. An optimum blend of graphical elegance, text representation and information display needs to be present for a good timetable. Graphical elegance is often found in simplicity of design and complexity of data. What can be suggested, though, are some guides

for enhancing the visual quality of the more routine, workday designs. Attractive displays of information:

1. Have a properly chosen format and design.
2. Use words, numbers and drawings together.
3. Display an accessible complexity of detail.
4. Are drawn in a professional manner, with the technical details of production done with care.
5. Avoid content free decoration including chart junk (Tufte, 1983).

Lines in data graphics should be thin. One reason eighteenth and nineteenth century graphics look so good is that they were engraved on copper plates, with a characteristic hair-thin line. The drafting pens of the twentieth century mechanical drawing thickened linework, making it clumsy and unattractive. Likewise, data graphics can be enhanced by the perpendicular intersections of lines of different weights. The heavier data should be a data measure. The contrast in line weight represents contrast in meaning. The greater meaning is given to the greater line weight; thus the data line should receive greater weight than the connecting verticals. The logic here is reinstatement, in different language, of the principle of data-ink maximization. This is an important tool during the phase of the general table outlay design (Tufte, 1983). Researchers have proposed that graphical efficacy may be determined, in part, by the nature of perceptual interactions that exist between attributes used to create graphical displays. One extreme type of interaction is integrability, in which two or more physical dimensions are represented as a single psychological dimension in the observer. An alternative type of interaction is configularity, in which a global emergent dimension is available to the observer in addition to the component attributes.

In one study, thirteen stimulus sets, each composed of attributes commonly used in design of graphs, were submitted to the performance-based diagnostics of integrality and configularity. The analysis showed a continuum of configularity among the present stimulus sets with little evidence for integral graphical attributes. The configural pattern of result was more common when two identical dimensions were paired (homogenous stimuli) than when two different dimensions were paired (heterogeneous stimuli). However, there seems to be no evidence that pairs of dimensions belonging to single object (object integration) were any more configural than dimensions belonging to different objects. Object integration however consistently relates to inefficient performance in tasks requiring the filtering of one of the two component dimensions. (Carswell and Wickens, 1990).

Proper alignment of the data within the table can improve the overall visual quality. One of the five vital points for data display as suggested by Smith and Moiser (1986) is that the format should be familiar to the operator and this objective is served by rules for neat columns of data, left justification for

alphanumeric data, right justification of integers, lining up of decimal points, proper spacing, use of comprehensible labels and appropriate measurement units and number of decimal digits (Schneiderman, 1998). On a larger outlook, tables and graphics can be classified as friendly and unfriendly. There are specific differences between friendly and unfriendly graphics:

Friendly:

1. Words are spelled out, mysterious and elaborate encoding avoided.
2. Words run from left to right, the usual direction for reading occidental languages.
3. Brief messages help explain data.
4. Elaborately encoded shadings, cross hatching, and colors are avoided; instead labels are placed on the graphic itself; no legend is required.
5. Graphic attracts viewer and provokes curiosity.
6. Type is clear, precise and modest lettering maybe done by hand.
7. Type is upper and lower case with serifs.

Unfriendly:

1. Abbreviations abound, requiring the viewer to sort through text to decode abbreviations.
2. Words run vertically, particularly along the Y-axis; words run in several different directions.
3. Graphic is cryptic, requires repeated references to scattered text.
4. Obscure coding requires going back and forth between legend and graphic
5. Graphic is repellant, filled with chartjunk.
6. Type is clotted, overbearing.
7. Type is all capitals, sans serif (Tufte, 1983).

Appendix C

Focus Group Moderator's Guide

NJDOT Project 2002-22 Improving Public Transit Schedules – Timetables People Can Actually Read Focus Group Moderator’s Guide

PART 1. INTRODUCTION BY MODERATOR **5 minutes**

Moderator thanks everyone for coming. He/she then presents the purpose of the research project and will be asking questions about the readability of the current bus time timetables. This information will be used to enhance the bus schedule layout and prepare guidelines for future bus schedules.

Moderator explains how the focus group works:

- Facilitator will present topics
- Participants will be encouraged to give their opinions
- No right or wrong answers
- Basic ground rules:
 - Don’t interrupt speakers
 - No side conversations
 - Moderator may need to cut off discussion at different points in order to cover all of the topics
 - Feel free to get up and eat, use the restroom, etc.
- At the end of the focus group, each participant will receive his/her payment.

Moderator hands out an agenda of topics to be discussed.

Participants will be told that the meeting will be audio taped so that a summary can be written. For the same reason, the staff will be taking notes as the focus group is conducted. There will be no attribution of any comments to a specific person and nowhere in the summary will the names of the participants appear.

Also, the participants are told that the additional people in the room are observers from the New Jersey Institute of Technology and NJ TRANSIT who are interested in the project. The moderator explains that the observers are here to gain immediate, first-hand knowledge of what is said, but that they will not be participating in the discussion.

The moderator asks if there are any questions.

PART 2. INTRODUCTION OF THE PARTICIPANTS **5 minutes**

Participants are asked to introduce themselves, telling the moderator:

1. Name
2. How they commute to work.
3. What bus route they most commonly use or how they travel
4. How often they use the bus and for what purpose (commuting, shopping, etc.)

PART 3A. USE OF THE BUS SCHEDULE

20 minutes

The moderator indicates that the next topic will focus on use of the bus schedule. The moderator will ask the following general questions to the full group to elicit discussion:

For those of you who ride a bus,

1. How critical is the schedule to making your trip?
2. How often do you use the bus schedule?
3. Where do you pick up your bus schedule?
4. Are bus schedules readily available and convenient to pick up?
5. How would you learn about **schedule 62** changes (Local Bus Route) or **schedule 144,145,148,164** changes (Interstate Bus Route)?

For those of you who don't ride a bus,

1. Why don't you? – Probe for reasons
2. Have any of you used a bus schedule?

PART 3B. PART 1 of the handout

The moderator will now distribute **PART 1 of the handout** along with the appropriate NJ TRANSIT bus schedules to the group. The Moderator will now ask the participants to complete the questions regarding the two scenarios presented to them. The moderator will ask the participants to try to complete each part of the question as best they can. They should skip any part question that they cannot complete. The Moderator will briefly discuss the exercise. (Also, provide the correct answers if needed).

PART 4. ESSENTIAL INFORMATION

15 minutes

The moderator then asks the following:

1. What information on a bus schedule is essential for you to have other than the map and timetable portions of the schedule? The group will then brainstorm a list and the responses will be displayed on a tablet.

PART 2 of the handout, which lists the information NJ TRANSIT typically shows on a schedule, will be distributed. The moderator asks the group to rank each of the items.

When the group is finished completing the handout, the moderator will ask the following:

2. What were the types of information that you felt was not essential to have in the bus schedule?
3. Is there any information that you feel should be added to the bus schedule?
4. Ask about the importance of **fare information** if it was not brought up already.

The moderator lists the group's responses on a large tablet or a location that can be seen by all of the participants.

PART 5. TIMETABLE LAYOUT

30 minutes

This portion of the meeting focuses on the timetable layout of the schedule. The moderator asks the group the general question of what difficulties they may have in using

the timetable portion of the schedule. The moderator lists the responses on a large tablet or a location that can be seen by all of the participants. Once these are listed, the moderator should get feedback on the following questions, if they have not been covered already:

1. What is it about the layout of the timetable section of the schedule that works and makes it easy to use? (Moderator lists out items on a large tablet)
2. What is it about the layout of the timetable of the schedule that doesn't work and makes it difficult to use? (Moderator lists out items on a large tablet).
3. What would you suggest for improving the timetable section of the schedule? (The moderator lists the responses on a large tablet or a location that can be seen by all of the participants.)
4. How do you feel about the way the schedule displays AM vs. PM? Any suggestions or criticisms? (The moderator will show 2 examples of other mass transit schedules – **Metro 317** and **Metro Bus 16**). Obtain likes/dislikes of examples.
5. Do you know and is it clear which side of the schedule to use? For example, for **schedule 62**, would you know when to use the side that indicates “To Newark”? For **schedule 144,145,148,164**, “To Midland Park”. (This is referring to the bolded heading above the timetables).
6. What is your opinion about the font size?
7. Do you find a need to keep rotating the schedule to read the destinations and times? (The moderator will show 2 examples of other mass transit schedules – **Metro 317** and **Metro Bus 16**). Obtain likes/dislikes of examples.

PART 6. MAP LAYOUT

30 minutes

This portion of the meeting focuses on the map layout. The moderator asks the group the general question of what difficulties they have in using the map portion of the schedule. The moderator lists the responses on a large tablet or a location that can be seen by all of the participants. Once these are listed, the moderator should get feedback on the following questions, if they have not been covered already:

General

1. What is your overall impression of the map?
2. How many use the map? (Moderator asks for a show of hands)

Map Schedule

1. Can you easily make a connection between the map and the timetable section of the schedule? Schedule 62 has reference numbers on the timetable that correspond with the stick map; schedule 144/145/148/164 does not. Do reference numbers help?
2. Who uses the codes? (Moderator asks for a show of hands)
 - Time Point
 - Ⓣ Transfer Point
 - Regular Service
 - Express Service

- — — (144) Limited Service
 - ##■## Railroad Station
3. Do you understand or have a difficulty following the coding on the map?
 4. Test other mass transit schedules. (**Metro 317** and **Metro Bus 16**)

Direction/Landmarks/Legends

1. What types of common conventions would be helpful in using the map? For example, does it matter if north is up, as is commonly done on street maps, or does this not matter?
2. What physical features, if any, should be shown on the map? (Moderator may want to suggest examples, such as schools, churches, parks, office buildings)

Overall

1. Do you have any suggestions to make the map easier to use? (Moderator shows some examples of maps from other jurisdictions).

PART 7. OTHER ISSUES

5 Minutes

The moderator asks the group if there are any other issues or suggestions for improving the bus schedules that should be addressed. To initiate discussion, the moderator may want to bring up the following:

- How could NJT make it easier to read?
- Folding of the schedules. Make the participants try to fold their schedule. We might want to time them to see how long it takes.
- Are there any other transit agencies that you think have good schedules? What are some of those features?

The moderator lists the responses on a large tablet or a location that can be seen by all of the participants.

PART 8. CONCLUSION

5 minutes

At the conclusion, the facilitator thanks the participants and gives them their honorariums. Make sure all questionnaires are complete.

Total Time: 115 minutes

Appendix D

Performance Based Questions

QUESTION SHEET 1

1. On a Friday you are at Broad Street & Branford Place in NEWARK. The time is 5:30 am. What time does the next bus to State Street and Hall Avenue in PERTH AMBOY leave?
2. On a Wednesday, you are at the intersection of Chestnut Ave & Rahway Ave in ELIZABETH Township. The time is 11:45 am. What time will the next bus to Woodbridge Center Mall arrive (Considering that the bus would stop at the intersection of Chestnut Ave & Rahway Ave)?
Hint: Use the map & Select the earlier / previous time point along the particular desired direction of bus route for this question.
3. On a Friday you are at Terminal 'A' of the NEWARK AIRPORT. If you board a bus from there towards WOODBRIDGE/PERTH AMBOY, at which stop would you get off to transfer to bus number 810?
4. On Thanksgiving Day, a holiday, you are at IKEA -PA Industrial Park in ELIZABETH. Your final destination is Inman and Wood Ave in WOODBRIDGE and you have to reach there before 5:30 pm. What is the last bus you could take to reach Inman and Wood Ave in WOODBRIDGE TWP. (ISELIN) before 5:30 pm?
5. On a Tuesday you are at Penn Station Bus Lanes in NEWARK. The time is 11:00 am. If you board the next bus going to Woodbridge Center Mall, what time would you arrive at your destination?
6. If the fare is \$1.10 within one zone (2 zones is \$2.20 and so on), and you want to take a bus from S. Airport Road at Federal Express Drive in NEWARK AIRPORT to Inman and St. Georges Ave in RAHWAY, how much would you pay?
7. On a Wednesday, you are at Woodbridge Center Mall. If you want to take the last bus from there that drops you at Terminal 'A' of the NEWARK AIRPORT before 11:00 am, what time would you board the bus?
8. On a Sunday, you are at Penn Station Bus Lanes in NEWARK. The time is 10:30 pm. What time does the next bus to Irving and Cherry Streets (RAHWAY TRAIN STATION) leave?
9. On a Wednesday Afternoon you are at S. Airport Road at Federal Express Drive in NEWARK AIRPORT. The time is 1:00 pm. What time does the next bus to Penn Station Bus Lanes in NEWARK leave?
10. On a Monday, you are at Metropark Train Station in WOODBRIDGE TWP. (ISELIN). What would be the latest time you could board a bus from there, so that you reach Penn Station Bus Lanes in NEWARK before 11:30 pm?

QUESTION SHEET 2

1. If the fare is \$1:10 within one zone (2 zones is \$2.20 and so on), and you want to take a bus from Penn Station Bus Lanes in NEWARK to St. George Ave and Wood Ave in LINDEN, how much would you pay?
2. On a Wednesday, you are at the intersection of Milton Ave & Jacques Ave in RAHWAY Township. The time is 9:00 am. What time will the next bus to Penn Station Bus Lanes (Considering that the bus would stop at the intersection of Milton Ave & Jacques Ave) arrive?
Hint: Use the map & Select the earlier / previous time point along the particular desired direction of bus route for this question.
3. On a Saturday afternoon you are at Terminal 'A' of NEWARK AIRPORT. The time is 12:00 pm. If you take the next bus to Broad and Jersey Streets in ELIZABETH, what time will you arrive at your destination (Broad and Jersey Streets in ELIZABETH)?
4. On a Monday you are at Penn Station Bus Lanes in NEWARK. The time is 6:15 am. What time does the next bus to Main and Amboy Avenues in WOODBRIDGE leave?
5. On a Friday you are at State St and Hall Ave in PERTH AMBOY. If you want to take the last bus from there that drops you at Penn Station Bus Lanes in NEWARK before 11:00 am, what time would you board the bus?
6. On a Saturday you are at Woodbridge Center Mall. The time is 6:45 pm. What time does the next bus to IKEA -PA Industrial Park in ELIZABETH leave?
7. (Q8) On a Tuesday, you are at Smith Street and Davidson Ave in PERTH AMBOY. What would be the latest time you could board a bus from there, so that you reach Terminal 'A' of the NEWARK AIRPORT before 10:30 pm?
8. On Columbus Day, a holiday, you are at IKEA -PA Industrial Park in ELIZABETH. Your final destination is Main & Amboy Aves in WOODBRIDGE and you have to reach your destination before 9:00 pm. What is the last bus you could take to reach Main & Amboy Aves in WOODBRIDGE before 9:00 pm?
9. On a Thursday you are at Broad Street & Branford place in NEWARK. The time is 11:30 am. If you board the next bus going to Smith Street and Davidson Avenue in PERTH AMBOY, what time would you arrive at your destination?
10. On a Tuesday, you are at S. Airport Road at Federal Express Drive in NEWARK AIRPORT. If you board a bus from there towards WOODBRIDGE/PERTH AMBOY, which stop would you get off to transfer to bus number 112?

QUESTION SHEET 3

1. On a Sunday, you are at Penn Station Bus Lanes in NEWARK. The time is 7:00 am. What time does the next bus to Irving and Cherry Streets (RAHWAY TRAIN STATION) leave?
2. On a Friday, you are at IKEA -PA Industrial Park in ELIZABETH. What would be the latest time you could board a bus from there, so that you reach Main and Amboy Aves in WOODBRIDGE before 8:30 pm?
3. On a Thursday you are at Broad St & Jersey Street in ELIZABETH. The time is 6:30 am. What time does the next bus to Woodbridge Center Mall leave?
4. If the fare is \$1:10 within one zone (2 zones is \$2.20 and so on), and you want to take a bus from State & Smith Aves in PERTH AMBOY to Roosevelt Ave and Driftway in CARTERET (PARK/RIDE), how much would you pay?
5. On a Thursday afternoon you are at Broad and Jersey Streets in ELIZABETH. The time is 1:00 pm. What time does the next bus to Penn Station Bus Lanes in NEWARK leave?
6. On a Tuesday, you are at Broad and Jersey Streets in ELIZABETH. If you board a bus from there towards WOODBRIDGE/PERTH AMBOY, which stop would you get off to transfer to bus number 804?
7. On a Monday, you are at State St & Hall Ave in PERTH AMBOY. If you want to take the last bus from there that drops you at Broad Street and Edison Place in NEWARK before 10:00 am, what time would you board the bus?
8. On a Wednesday, you are at State St & Hall Ave in PERTH AMBOY. The time is 10:30 am. If you board the next bus going to Terminal 'A' of the NEWARK AIRPORT, what time would you arrive at your destination?
9. On a Friday, you are at the intersection of Main Ave & West Ave in PERTH AMBOY Township. The time is 5:45 am. What time will the next bus to Terminal 'A' of the NEWARK AIRPORT arrive (Considering that the bus would stop at the intersection of Main Ave & West Ave)?
Hint: Use the map & Select the earlier / previous time point along the particular desired direction of bus route for this question.
10. On President's Day, a holiday, you are at Penn Station Bus Lanes in NEWARK. Your final destination is Metropark train station in WOODBRIDGE TWP. (ISELIN) and you have to reach your destination before 8:00 pm. What is the last bus you could take to reach Metropark train station in WOODBRIDGE TWP. (ISELIN) before 8:00 pm?