CONCLUSIONS

The process developed achieved the objective of the analysis. By using negligible computer modeling and relying on accepted relations, specific information was produced that detailed the probable effects of each modification on travel movements.

The process appears most appropriate for analyzing the many alternatives that often result from the EIS process, as in the case of I-476. Its rational as well as computational simplicity allows for a clear presentation of impacts to the public, which facilitates development of an alternative that will achieve the desires of the community and its decision makers.

For I-476, the effect of the modified design plans at both interchanges will be predominately restricted to the localized area around each interchange. At Lancaster Pike, the probable diversion of 600 vehicles is relatively minute and should be considered negligible. The prime concern at this interchange should focus on alleviating the intersection problem expected at the terminus of the northbound off-ramp from the Mid-County Expressway. It is the magnitude of the associated congestion that will dictate the acceptability of the design and determine the extent to which travel through the interchange is altered.

For the Baltimore Pike, less severe modifications combined with smaller daily demand result in no travel diversion from the Mid-County Expressway. Here, capacity can adequately accommodate anticipated demand with only two movements below normal design standards.

In essence, the modifications do not measurably divert traffic, but a lower quality of service is provided to the users.

After the completion of the study, improvements were introduced by PennDOT at the Lancaster Pike interchange to eliminate the level F service cited in the analysis. Additional left-turning lanes have been introduced for movements G-F and H-E (Figure 4). In addition, widening of Lancaster Avenue to accommodate an additional lane of through travel from the east is assumed (6). These modifications improve the level of service to D in all cases.

ACKNOWLEDGMENTS

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Interactive Computer Graphics for Station Simulation Models

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A model developed for the Urban Mass Transportation Administration (UMTA) as an aid to the designers of transit stations—the UMTA Station Simulation (USS) model—was originally designed to give tabular output of numeric data on a batch-process computer. The potential for interactive running of the program with graphic as well as tabular output is studied. The 22 output reports of USS are examined for their ability to answer basic design questions. The following four types of computer graphics presentations are discussed as means of improving the ability of USS to answer such design questions: station animation and three types of static displays—histograms, station diagrams, and performance charts. Prototype graphic displays have been developed for each of the three static presentations and matched to present USS output.

A computer program developed for the Urban Mass Transportation Administration (UMTA) as an aid to designers of transit stations—the UMTA Station Simulation (USS) model—is a discrete-event, Monte Carlo type of simulation model programmed in FORTRAN for use on IBM 360/370 computers. A semi-interactive version of USS was developed at Princeton University by using the IBM virtual machine (VM) operating system on an IBM 370/158 computer. A conversational monitoring system (CMS) EXEC program was written to create a user-oriented dialogue to handle language for file manipulation and job control. The semi-interactive version of USS reduced the cost of running the program by 95 percent in comparison with the conventional version (5).

The semi-interactive version of USS has made the program a more responsive part of the designer's creative process. Current research at Princeton and Aviation Simulations International is aimed at improving the program in the areas of data input and program capabilities to make USS more flexible and easier to use.

USS currently provides tabular output on times, volumes of people, and areas per person for the station being simulated. The development of graphic displays of data will improve the ability of USS to provide readily usable information and answer basic design questions. Data must be presented in a manner that not only answers these design questions but also allows the designers to perceive the performance of individual elements relative to the performance of the entire station network. Since designers communicate their ideas graphically, graphic display of information and ideas is the best way to communicate the "whole picture" and relate individual elements within their context. Thus, if a simulation model is to communicate effectively with designers, it should do so in a graphic form. This paper discusses several interactive computer graphic displays developed by the authors for incorporation in USS.

BASIC DESIGN QUESTIONS

Designers of transit stations need answers to basic design questions such as the following:

1. How many turnstiles or fare-collection devices are required? In determining the proper number of devices, designers try to maximize passenger convenience while minimizing cost. This trade-off has become especially critical with the increasing use of automatic fare-collection devices, e.g., in the Washington, D.C., Metro system where magnetic card readers are required for both entry and exit.
2. How many escalators or stairs are needed? The provision of vertical circulation, particularly by mechanically assisted means such as escalators or elevators, also requires designers to balance passenger convenience against increased cost. Deep stations, although sometimes considered cheaper to build than cut-and-cover stations, increase the necessity for adequate vertical circulation capacity and also increase the cost per unit of vertical circulation.
3. Where might congestion occur and what will be the level of service? The area per person in a given space determines the level of service for pedestrian movement and comfort (3). Designers need to identify potential points of congestion that might cause low levels of service, and they also need to know the duration of the low levels.
4. How long does it take to walk through the station? Travel-time penalties imposed on the passenger by station design can influence the decision of an individual to use transit. The user should be able to walk as directly to his or her destination and as close to desired walk speed as possible.
5. How much area is needed for the platform? In sizing a platform, especially in a station that has a high volume of people, overdesign of the platform area can be avoided if the dynamics of passenger flow and crowding are examined over a time period.
6. What is the overall station performance? The proper arrangement of individual elements determines the overall performance of transit stations. This is true even though the design may contain a sufficient amount of space and number of devices for the design volumes.

Designers wish to know answers to the above questions under three station conditions: (a) high volume of inbound transit users (arriving at a constant rate, in groups, or both); (b) high volume of outbound transit users (departing in groups); and (c) high volume of inbound and outbound transit users (at platforms). The use of the term inbound has been chosen by convention to represent generally the direction taken by pedestrians who enter a transit station and proceed to a platform to board a transit vehicle or train. Outbound is the opposite direction (2).

USS OUTPUT

USS produces up to 22 different reports of station operations. The first 8 are standard reports produced for every simulation run; the remainder are optional reports requested by the user. Each report is summarized here from the USS user's guide (2).

Standard Output Reports

Report 1—link statistics in numeric order—shown in Figure 1 (2), provides summary statistics for each link, or pathway, of the network (in ascending numeric order), including the maximum number of people on the link at any one time, the minimum square feet per person (occupancy) in the link movement area (link length × link width) at any one time (because the model discussed here is calibrated for U.S. customary units of measurement, no SI equivalents are given), and the total volume of people who traversed the link.

Report 2—link statistics in ascending order by oc-

Figure 1. USS report 1: link statistics in numeric order.

USS REPORT 1

LINK STATISTICS IN NUMERIC ORDER

LINK	MAXIMUM PEOPLE	OCCUPANCY	TOTAL VOLUME
1- 6	11	10.7	56
1- 31	5	15.4	22
2- 4	6	44.3	78
23- 3	10	17.5	30
24- 3	12	10.5	32
25- 3	13	9.1	39
26- 3	14	12.5	39
4- 8	6	29.0	53
4- 28	3	39.3	22
6- 9	10	27.4	45
8- 9	6	20.5	53
8- 28	3	33.3	22
8- 31	3	42.6	22
9- 10	4	23.7	36
9- 11	3	28.3	34
9- 12	4	23.7	27
10- 13	4	18.0	35

cupancy—is identical to report 1 except that the links are listed in ascending order of minimum square feet per person to aid in the quick identification of the worst spots of congestion in the station.

Report 3—node statistics in numeric order—provides a summary description of queuing and queuing-device activity at each node. Statistics are given for both inbound and outbound sides of the node including maximum number of persons in queue, the maximum recorded use of the queue area expressed as percentage of queue area capacity, the total volume of persons passing through the node, and the percentage of time that the device representing the node was in actual use (utilization).

Report 4—node statistics in descending order by use—is identical to report 3 except that the nodes are ordered in descending percentage of use of the queue area.

Report 5—total walk time for station—is a histogram that shows the distribution of walk time for passengers from the time they enter the station until they leave. Histograms are discussed in more detail later in this paper.

Report 6—total time in queue for station—is a histogram that shows the distribution of time in queue for passengers from the time they enter the station until they leave.

Report 7—total time in system for station—is a histogram that shows the distribution of the total time passengers spend in the station, walking and in queue, from the time they enter the station until they leave.

Report 8—overall station impedance by access-egress mode—shown in Figure 2 (2) has two parts. Part 1 gives for each station origin-destination pair the number of persons who arrived at the given origin and were assigned to leave at the given destination and the number of these who actually left the station. Part 2 gives the corresponding station impedance (minimum, mean, and maximum walk time, queue time, and total time in the system) in seconds as experienced by travelers who left the station.

Detailed Output Reports (Optional)

Report 9—link occupancy report—lets the user see the dynamics of individual link activity at discrete intervals. The report is divided into two parts. Part 1 gives the number of persons who enter and leave the link movement area for both inbound and outbound directions, the number in the link movement area, and the proportion of persons on other links who shared part of their movement area with the subject link, all during the last time interval. Also included are the total number of persons and the area per person in square feet in the movement area. Part 2 gives the observations for the A-node and B-node queue areas inside the link (A-B) at the end of each time interval for the number of persons inside the queue area, the area in square feet required for those in the queue area, and the number of persons outside the specific queue area.

Reports 10 through 18—link occupancy histograms—show the distribution of individual link data in report 9:

1. Report 10—number of arrivals at link,
2. Report 11—number of departures from link,
3. Report 12—number in movement area on link,
4. Report 13—people from other links that compete on link,
5. Report 14—total people in the area associated with link,
6. Report 15—area per person in area associated with link,
7. Report 16—number in queue at node,
8. Report 17—required queue area for node, and
9. Report 18—people outside queue area at node.

Reports 19, 20, and 21—path impedance histograms—show the distribution of walk time, time in queue, and total time respectively along a path between a specified pair of nodes.

Report 22—individual path analysis—is a link-by-link trace of a single passenger as he or she moves from zone of station access to zone of station egress. This report is described in more detail later in this paper.

Table 1 gives the 22 reports provided by USS and indicates the ability of each report to answer specific design questions. Despite the tremendous amount of information available in these reports, in many cases the data are presented in a form designers cannot readily use. The time and uncertainty involved in transforming the vast amount of data into a readily usable form—especially for reports 9 through 21, which must be specified for each pair of nodes for which the designer wants information—may discourage the regular use of USS in the design process.

POTENTIAL GRAPHIC OUTPUT

If data produced by USS could be graphically displayed

Figure 2. USS report 8: overall station impedance by access-egress mode.

USS REPORT 8

OVERALL STATION IMPEDANCE BY ACCESS/EGRESS MODE (PART 1)

ORIG NODE	DEST NODE	ARRIVALS MODE/LINE		ARRIVALS PEOPLE	DEPARTURES MODE/LINE		DEPARTURES PEOPLE
1	2	BUS	1	0			0
1	3	BUS	1	56	RAIL	1	36
2	1			0	BUS	1	0
2	3			56	RAIL	1	42
3	1	RAIL	1	31	BUS	1	22
3	2	RAIL	1	31			22

OVERALL STATION IMPEDANCE BY ACCESS/EGRESS MODE (PART 2)

ORIG NODE	DEST NODE	WALK TIME MEAN	WALK TIME MIN	WALK TIME MAX	TIME IN QUEUE MEAN	TIME IN QUEUE MIN	TIME IN QUEUE MAX	TIME IN SYSTEM MEAN	TIME IN SYSTEM MIN	TIME IN SYSTEM MAX
1	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	3	58.1	39.2	95.8	42.7	8.5	85.2	100.8	63.5	159.4
2	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	3	54.7	39.6	83.0	42.3	5.4	92.2	97.0	46.3	166.6
3	1	56.9	38.0	109.0	30.7	4.6	86.3	87.6	42.6	156.4
3	2	56.9	38.6	96.4	18.2	4.4	47.4	75.1	44.2	113.4

Table 1. USS reports: ability to answer design questions and form of graphic output.

Type of Report	Report Number	Title	Design Question: Number of Devices	Vertical Circulation	Platform Area	Walk Time	Congestion (level of service)	Overall Station Performance	Form of Graphic Output
Standard output	1	Link statistics (numeric order)	X	X	X		X		D
	2	Link statistics (ascending order)	X	X	X		X		D
	3	Node statistics (numeric order)	X	X	X		X		D
	4	Node statistics (ascending order)	X	X	X		X		D
	5	Total walk time (station)				X		X	H
	6	Total queue time (station)						X	H
	7	Total time in system (station)				X		X	H
	8	Station impedance				X		X	
Detailed occupancy	9	Link occupancy	X	X	X		X		2
Link occupancy histogram	10	Number of arrivals at link	X	X	X		X		H
	11	Number of departures at link	X	X	X		X		H
	12	Number of movements on link	X	X	X		X		H
	13	People from other links who compete on link			X		X		H
	14	Total people in link area			X		X		H
	15	Area per person in link area	X	X	X		X		H
	16	Number in queue at node	X	X	X		X		H
	17	Required queue area for node	X	X	X		X		H
	18	People outside queue area at node	X	X	X		X		H
Path impedance histogram	19	Walk time, node A to node B	X	X	X	X	X		H
	20	Queue time, node A to node B	X	X	X	X			H
	21	Total time, node A to node B	X	X	X	X	X		H
	22	Individual path analysis	X	X	X	X	X	X	1
Potential graphic aid			H	1	2	H	1,2	1,2	

Note: D = station diagram, H = histogram, 1 = individual path analysis chart, and 2 = area performance chart.

Figure 3. USS report 5: total walk time for station.

```
                              USS        REPORT  5

TOTAL WALK TIME FOR STATION

     0    4    8   12   16   20   24   28   32   36   40
     +----+----+----+----+----+----+----+----+----+----+ P.C.  CUM.  COUNT
  0.                                                     0.0   0.0     0
  5.                                                     0.0   0.0     0
 10.                                                     0.0   0.0     0
 15.                                                     0.0   0.0     0
 20.                                                     0.0   0.0     0
 25.                                                     0.0   0.0     0
 30.                                                     0.0   0.0     0
 35.                                                     0.0   0.0     0
 40........                                              5.7   5.7     7
 45..........                                            7.4  13.1     9
 50.........................                             19.7  32.8    24
 55..............................                        23.8  56.6    29
 60.......................                               18.0  74.6    22
 65...........                                           8.2  82.8    10
 70..........                                            7.4  90.2     9
 75...                                                   1.6  91.8     2
 80....                                                  2.5  94.3     3
 85..                                                    0.8  95.1     1
 90..                                                    0.8  95.9     1
 95...                                                   1.6  97.5     2
100...                                                   1.6  99.2     2
105.                                                     0.0  99.2     0
110..                                                    0.8 100.0     1
REMAINING COUNTS ARE ALL ZERO
NUMBER OF OBSERVATIONS=      122.,   SUM=      7145.,   MEAN=   58.566,
VARIANCE=        165.361,   STANDARD DEVIATION=   12.859
```

in a form more easily used by designers, USS could be used more readily and be more valuable. The potential types of graphics discussed in this paper are (a) station animation, (b) histograms, (c) station diagrams, and (d) performance charts (individual path analysis chart and area performance charts).

Table 1 gives the graphic form that can summarize the information in each USS report. The graphic form that potentially can aid in answering the basic design questions is also indicated. One or two charts can do the job of many reports by combining the information contained in several reports and displaying it in a form that designers can readily perceive and use.

Station Animation

Animation is a useful cognitive tool for visualizing and aiding in the comprehension of complex processes. Integrated with an interactive computer simulation model, computer animation can be created and viewed in real time directly at an interactive terminal. A demonstration project that applied computer animation to a station simulation model showed that, despite current high cost, time consumption, and program rigidity, animating a model enables designers to visualize intricate spatial and temporal relations of transit station-vehicle activities (1).

Aviation Simulations International is currently investigating the potential of USS results for animated computer graphics (4). Potentially, station animation can be very valuable. Currently, however, it requires sophisticated computer hardware and software beyond the capacity of most users for whom USS is intended. For the near future, therefore, any graphic presentation by USS should be within the capabilities of the most readily available output device—a line printer or simple cathode ray tube (CRT) terminal. Ultimately, however, station animation will provide valuable assistance in the visualization and comprehension of transit station designs.

Histograms

Histograms that show the distribution of particular simulation data represent the most common output format of the original USS program (see the last column and the bottom line of Table 1). Figure 3 (2) shows an example of a USS report that uses a histogram as graphic output. In this histogram (report 5—total walk time for station), the distribution of simulated walk time for passengers from the time they enter the station until they leave is shown. The vertical scale on the left is total walk time in seconds divided into 5-s interval groups. The horizontal scale is the number of observations for each interval group.

Station Diagrams

Diagrams that represent the station network could be produced by USS on a line printer or other output device to display the data from several USS reports (see the last column of Table 1). USS reports provide data on individual elements of the station but not on total systems or networks (except report 22). The performance of individual elements is not of much value to the designer unless it is easily related to the whole station network. One reason is that poor performance of one element may not be a problem of the element itself but may actually be the result of the poor performance of an adjacent element. Another reason is that an element may appear to be performing poorly when isolated from the station network and yet within the network may actually be performing properly. Finally, representation of individual elements is open to bias because of subjective judgments by the analyst in coding the station network. Station diagrams allow the designer to view the performance of an individual element relative to the station network as a whole.

Figure 4 (6) shows a computer-drawn plan of a typical transit station with a platform, concourse, and several corridors. In Figure 5 (6), this station layout is shown as a computer-drawn network representation with 22 nodes as required for analysis by USS. Node numbers are circled. The train is represented by node 1, the train doors by nodes 2 through 9, and the station exit by node 21.

Figure 6 (6) is a diagram of the station network that shows the percentage of the total passenger volume that used a particular link. Numerical results posted on the links are the percentage of total passenger volume that used each link. Rectangles are drawn to the right of link centerlines to indicate direction. The widths of the rectangles are proportional to link volumes (single lines represent trip volumes less than 1 percent of total origin-destination volumes).

Viewing this picture of the network annotated with numeric results provides an easier means of interpreting data than scanning through tables of numbers. Link volumes are shown here, but a similar diagram can show node volumes.

Performance Charts

Two types of charts that will aid the designer in evaluating station performance have been developed: the individual path analysis chart (1 in Table 1) and area performance charts (2 in Table 1).

Individual Path Analysis Chart

The individual path analysis chart is a graphic representation of the data produced in USS report 22—individual path analysis. Report 22 is a link-by-link trace of a single passenger as he or she moves from station entrance to exit or transit vehicle. When the passenger exits, the program begins tracing another individual beginning at a different entrance. A separate report is printed for each person traced. A sample report is shown in Figure 7 (2). The report shows the individual's exogenous attributes, i.e., an identification number, origin-destination nodes, desired walk speed, and mobility status (handicapped or nonhandicapped). The endogenous attributes, which are printed as the passenger completes travel along each link defined by the From Node and To Node columns, include a series of time measurements related to the simulation clock time printed under the Time column. All times are in seconds. The link time measurements include time in queue, cumulative time in queue, link walk time, cumulative walk time, time on link (sum of walk time and time in queue), and cumulative time in system. As shown in Figure 7, it took the passenger 76 s to travel from node 3 to egress node 1 (2).

To establish a graphic display of these tabular data, it is assumed that perceived travel time is more often used for evaluation of travel time by a transit user than actual travel time. Time spent walking is, within certain limits, perceived as making progress or time well spent. Therefore, it has a speed equal to the slope of a line defined by distance and time (speed = distance/time). Time spent in queue is not perceived as making progress or time well spent. Therefore, its slope is equal to zero.

The individual path analysis chart (Figure 8) is

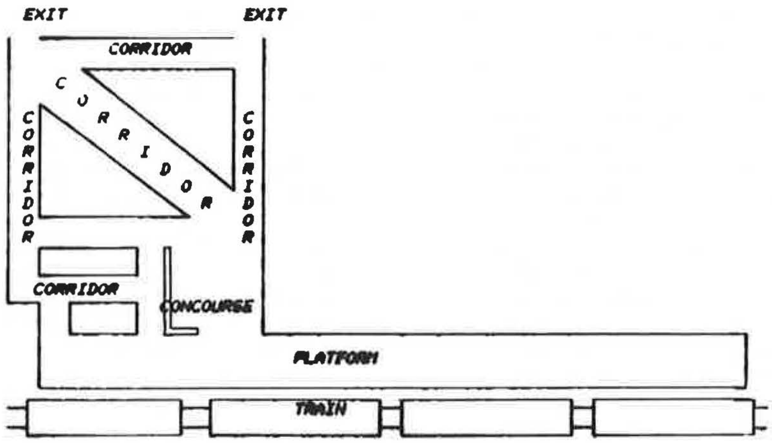


Figure 4. Transit station plan.

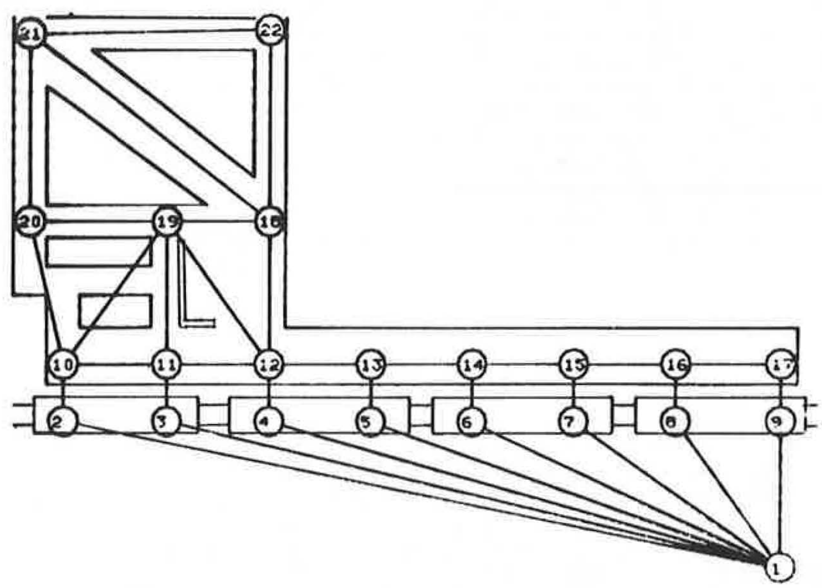


Figure 5. Network representation of transit station.

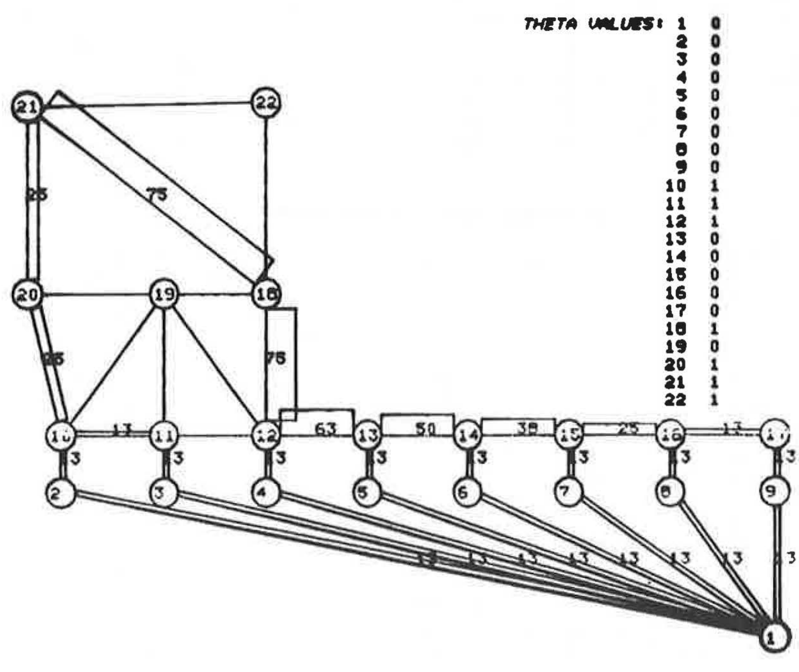


Figure 6. Percentage of total passenger volume using each link.

readily constructed from the information given in report 22 and is a graphic representation of the data shown in the report. Chart 1 consists of a planar graph in which the horizontal axis plots time in seconds from start (point 0) to finish and the vertical axis plots distance in feet from origin (0 feet) to destination (X feet away). The slope of any line is equal to the speed of the individual whose progress is being plotted: Slope = (ΔX ÷ ΔY) = (ΔFT/ΔSEC) = speed (feet per second). Thus, the steeper the slope is, the faster is the speed. When the slope equals zero, the person is standing still (i.e., in queue). This chart plots the speed between the nodes along a desired path between two zones. The designer can now graphically view the progress of an individual from origin to destination, noting where queues occur and where speed is reduced because of congestion or some other factor. To facilitate the analysis, the node numbers are indicated adjacent to nodes along the path at their appropriate distance and time. On the right side of the chart, the link speeds (SP) of the individual are listed. When link time consists of walk time and queue time, walk time is plotted up to the node distance (slope = speed), and then the queue time is represented as a flat line (slope = 0) that graphically shows the amount of time spent in that queue (QT). This graphically reinforces the assumption that a person perceives time spent walking (progress) differently from queue time (no progress). The individual path analysis chart, accompanied by a printout of report 22, allows quick examination of the performance of a passenger's path through the station.

Area Performance Charts

One measure of platform, or area, performance with a high volume of people is area per person. The measure determines the level of service for pedestrian movement and comfort (3). The less the area per person is, the poorer the level of service is. However, area-per-person criteria alone are not sufficient for evaluating the performance of a transit station platform (or area). Periods of platform crowding are tolerable if their duration is relatively short (perhaps less than 10 s). In the case of a transit station that has a high volume of passengers entering (inbound) and exiting (outbound) a transit vehicle during a given time period, extremely low values of area per person will exist while the inbound and outbound passengers are on the platform together.

The platform performance charts consist of two parts: The platform population chart plots the number of people on the platform (or other area) over time; platform area per person is the result of the total fixed area of the platform divided by the total number of people on the platform over time. Currently, USS does not have the ability to simulate the platform as an area, but future modifications should allow this.

Part A–Platform Population Chart

The platform population chart (Figure 9) has along its Y-axis the number of people on the platform and along the X-axis time in seconds. The graph plots the number

Figure 7. USS report 22: individual path analysis.

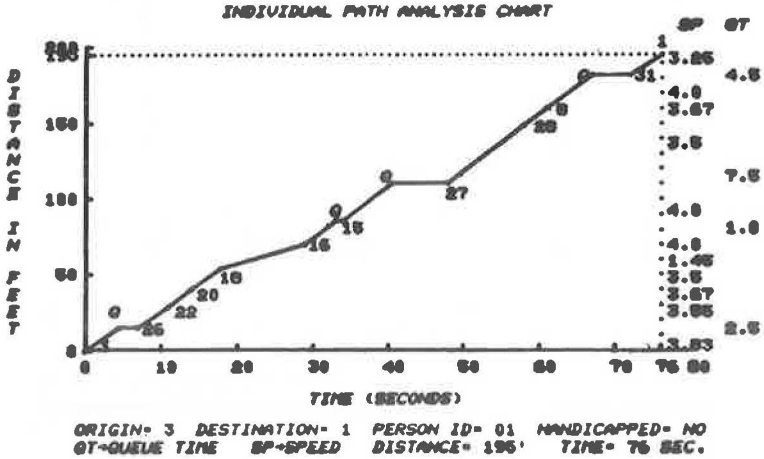
USS REPORT 22

INDIVIDUAL PATH ANALYSIS

PERSON ID = 1 ORIGIN = 3 DESTINATION = 1
DESIRED WALKING SPEED = 215 HANDICAPPED =NO

FROM NODE	TO NODE	TIME	TIME IN QUEUE	CUM TIME IN QUEUE	WALK TIME	CUM WALK TIME	TIME ON LINK	CUM TIME IN SYSTEM
3	26	7	2	2	4	4	6	6
26	22	11	0	3	4	8	4	11
22	20	14	0	3	3	11	3	14
20	18	18	0	3	4	15	4	18
18	16	29	0	3	11	26	11	29
16	15	34	1	3	4	30	5	33
15	27	48	7	11	6	36	13	47
27	28	58	0	11	11	47	11	58
28	8	62	0	11	3	50	3	61
8	31	72	5	16	6	56	11	72
31	1	76	0	16	4	60	4	76

Figure 8. Individual path analysis chart.



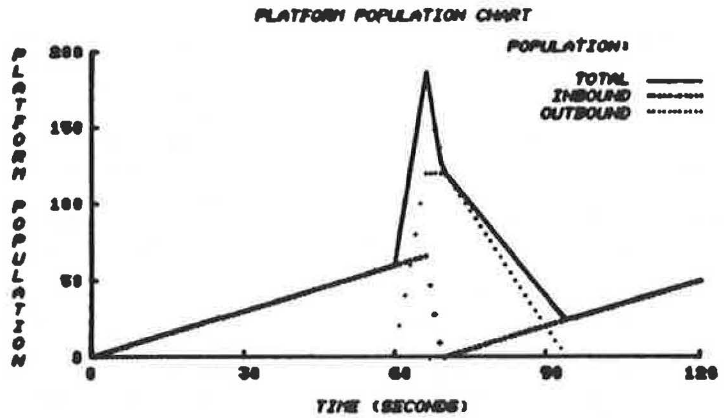


Figure 9. Area performance chart: part A—platform population.

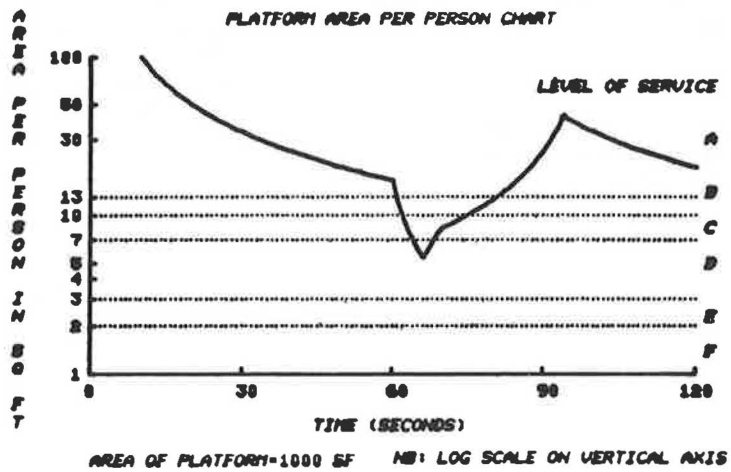


Figure 10. Area performance chart: part B—platform area per person.

of people on the platform at any one time—total, inbound, and outbound populations. Inbound passengers arrive either at some rate (people per second) or in groups at specific time periods (Y_1 people at T_1, Y_2 people at T_2, and so on). The train arrives at a specified time and discharges its passengers (outbound) at some rate (people per second). When the outbound passengers are off the train, those passengers who were on the platform (inbound) board the train at some rate (people per second). When all those who desired to board the train have done so, the train departs. Meanwhile, those who exited the train (outbound) are leaving the platform at some rate (people per second) after taking a specified number of seconds from time of exiting the train to reach the exits of the platform.

Part B—Platform Area per Person Chart

The platform area per person chart (Figure 10) has along its X-axis time in seconds and along its Y-axis area per person in square feet. This chart allows the designer to see the area per person at any time during the simulation. The total population of the platform at each second in part A is divided into the total fixed area of the station platform. The lowest value plotted on the chart is the minimum area per person during the simulation. This allows the designer to see the minimum area per person and when it occurred. The chart also allows the designer to examine the duration of low values of area per person. Low values are acceptable if their duration is for short intervals. Because the area of the platform is fixed, the change in area per person from X people to X + 1 people has a diminishing rate of significance: lim Δ area per person = 0 and $X \rightarrow \infty$. This problem is particularly apparent at the critical peak volumes. Therefore, a logarithmic scale is used along the Y-axis to improve the visual perception of the condition. The Fruin levels of service are listed on the right side of the chart. The chart summarizes the data given in USS reports 1, 3, and 9 through 20.

A variation of part B, which would also be derived from part A or USS report 9—link occupancy—would be a nomograph that showed the required area for a platform as a function of passenger population over time for the various levels of service.

CONCLUSION

Interactive computer graphics has the potential to make the USS computer program an effective part of transit station designers' creative process. A review of the USS output reports showed that, although they can aid in answering basic design questions, the information in the reports often is not in a form that designers can readily perceive and use. Four types of graphics can improve the ability of USS to aid designers:

1. Station animation allows designers to visualize intricate spatial and temporal station-vehicle activities.
2. Histograms show the distribution of particular simulation data.
3. Station diagrams allow the designer to relate the performance of individual elements to the entire station network.

4. Two types of performance charts graphically summarize a great deal of information on (a) individual paths through the station and (b) the population and area per person in a particular space.

The last two types of graphics were developed by the authors from data already present in one form or another in USS reports.

Although the use of these graphics was described in the specific context of the USS computer program, their use is open to application in many other types of design problems that involve movement of people and vehicles. The use of computer graphics, and especially the development of the innovative display techniques demonstrated in this application, serve to highlight problem areas and focus attention on specific aspects of simulation modeling. Graphic tools provide a superior format for computer output that enables the designer and the analyst to interpret the simulation results more quickly and apply them to the design problem.

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Use of Interactive Computer Model STREAK for Transportation Planning

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STREAK, an interactive set of computer programs for transportation planning, is described in both nontechnical and technical terms, and some experience in its use is discussed. The program uses portable desk-top terminals and conventional telephone lines. Outputs on the portable terminal include responsive dialogue (questions and answers), tabular arrays, and data plotted by coordinates for use with overlaid maps. Capabilities of the model include multimodal network development, pathfinding in multimodal networks, travel demand estimation for all modes, travel assignment, and outputs in map coordinates or tabular form under direct user control. The primary advantage of STREAK in planning studies is its ability to evaluate and report findings on an alternative in a matter of seconds. A secondary advantage is the ease with which the model performs data corrections and network modifications directly via the terminal. The model has proved its value in several studies.

An interactive set of computer programs has been developed to assist planners with problems that require the testing of many candidate solutions. Although primarily designed for sketch-planning studies, the programs have proved to be useful for a variety of planning problems including many that involve only a few alternative solutions. The programs, called Strategic Transportation Evaluation and Analysis Kit (STREAK), are actuated by means of a portable desk-top terminal and a conventional telephone line. The purpose of this paper is to describe the role of STREAK in the planning process, provide a brief technical description of the models, and discuss experience to date with their use.

STREAK AND THE PLANNING PROCESS

STREAK is well suited for network evaluation, travel demand forecasting, locational analysis, and accessibility calculations. Though primarily intended for sketch planning, it can also be used for detailed studies of small to medium-sized areas.

The major capabilities of the model include the following: