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Peak-Period One-Way Operation of an Urban Expressway

JOHN F. TEMPLE

The evaluation of an experimental urban traffic control strategy designed to reduce recurring congestion on the Arlington Expressway in Jacksonville, Florida, is described. The 60-day experimental project involved the daily conversion of a 2.8-mile section of the expressway to one-way operation toward the downtown area during the morning peak period and one-way operation out of the downtown area during the evening peak. The one-way operational plan, which provided temporary additional capacity for the peak direction, was developed by the Jacksonville Traffic Engineering Department and approved for implementation by the Florida Department of Transportation (FDOT). The effectiveness of the one-way strategy was measured by using before and after studies. The primary objectives of the evaluation were to identify existing points of congestion and quantify the delay incurred, to measure travel-time savings realized by motorists who used the one-way operation, and to compare user benefits with the negative effects experienced by motorists forced to divert to alternative routes. The results of the before study identified a four-lane bridge (Mathews Bridge) as the primary capacity constraint for peak-period traffic entering and leaving the downtown Jacksonville area. The one-way operation, in effect, doubled the capacity of this bridge to serve the peak directional flow and eliminated the recurring congestion that had developed on its approaches. During the morning westbound one-way operation, stopped delay at the Mathews Bridge toll plaza was reduced 78 percent in the peak half-hour. During the evening eastbound operation, average running speed on the expressway improved by 56 percent. Motorists entering and leaving the downtown area opposite to the peak directional flow experienced increased trip length and travel time as a result of the requirement to use alternative routes, but these increases were not unreasonable. Analysis of the systemwide impacts on fuel consumption showed a marginal net benefit. After the evaluation, FDOT approved indefinite continuation of the one-way strategy.

In July 1981, the Jacksonville Transportation Authority (JTA) and the Jacksonville Traffic Engineering Department approached the Florida Department of Transportation (FDOT) with a plan for easing morning and evening traffic congestion on the Arlington Expressway, a four-lane, limited-access facility that links downtown Jacksonville with residential areas located to the east across the St. Johns River. The plan involved daily conversion of a 2.8-mile section of the expressway to one-way operation toward downtown during the morning peak period and one-way operation out of the downtown area during the evening peak.

The FDOT acknowledged the need to improve peak-period conditions on the expressway and recognized the potential for a low-cost, high-benefit freeway management strategy that would be of widespread interest should the concept prove to be successful. Accordingly, FDOT approved an experimental demonstration period of 60 days, during which an evaluation of the one-way operation would be conducted. The Research and Studies Section of the FDOT Bureau of Traffic Operations was assigned the responsibility for developing and implementing the evaluation. This paper documents the results of that study.

The material presented here primarily addresses the impact on those traffic operational characteristics that could be satisfactorily measured through comparative studies conducted in the weeks just before and during the 60-day experimental period.

ONE-WAY OPERATION

Project Location

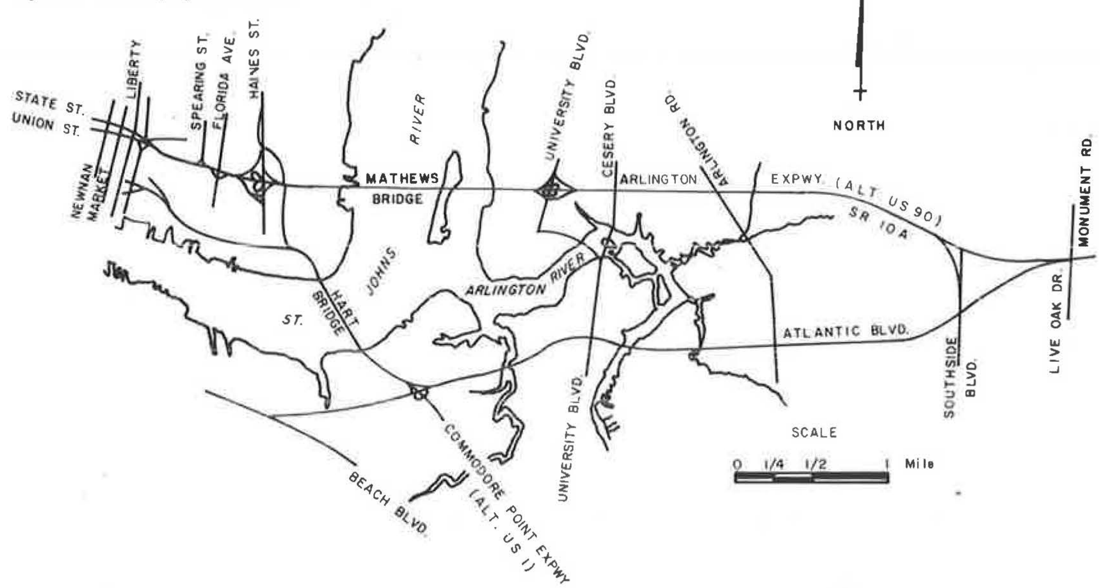
Downtown Jacksonville is located in the central portion of Duval County and is situated on the St. Johns River, which separates the downtown area from numerous suburbs to the east and southeast. A total of five bridges span the river within a distance of 4 miles (see Figure 1).

The Arlington Expressway is an easterly extension of State and Union Streets, which are prominent one-way arterials that accommodate downtown travel in the westbound and eastbound directions, respectively. The expressway is designated as Alternate US-90 and FL-10A. Full control of access on the expressway begins at Liberty Street and extends eastward over the river by way of the Mathews Bridge to Southside Boulevard, a total length of 5.7 miles. Located at the eastern terminus of the Mathews Bridge is a toll plaza at which motorists crossing the bridge in either direction must pay the required toll.

On the west side of the river between Liberty Street and the Mathews Bridge are three interchanges. Two serve low-volume surface collectors in residential areas on the fringes of the central business district (CBD), and the third provides a connection to Alternate US-1 and Haines Street. Haines Street provides access to Jacksonville's Gator Bowl and the surrounding riverfront industrial area. Alternate US-1 south of the Haines Street interchange becomes the Commodore Point Expressway and crosses the St. Johns River via the Isaiah Hart Bridge, located approximately 1 mile south of the Mathews Bridge. Like the Mathews Bridge, the Hart Bridge is a toll facility and has a similar toll schedule.

On the east side of the Mathews Bridge, there is a major interchange at University Boulevard, approximately 1100 ft east of the toll plaza. Between University Boulevard and Southside Boulevard, the Arlington Expressway is flanked by frontage roads with slip ramps that provide ingress and egress. Only two additional north-south streets, Cesery Boulevard and Arlington Road, provide connections between areas separated by the expressway on the east side of the river.

Figure 1. General project location.



Strategy

The objective of the one-way operation was to relieve the congestion on the expressway for inbound traffic (westbound) during the weekday morning peak period and for outbound traffic (eastbound) during the evening peak. Congestion developed in the morning in the vicinity of the toll plaza due to heavy approach volumes from the two expressway lanes to the east and from the University Boulevard entrance ramps, which continue as added expressway lanes from the interchange to the toll plaza. The capacity of the immediate approach to the toll plaza, therefore, exceeded the two-lane capacity of the Mathews Bridge, which is inherently constricted by limited lateral clearances and steep grades. The two westbound lanes of the expressway on the west side of the river have no difficulty in accommodating traffic flowing over the bridge, and from the west end of the bridge to Liberty Street the expressway operated without congestion.

During the evening peak a similar situation occurred, except in the eastbound direction. High approach volumes on the two eastbound lanes combined with a high entering volume on the Haines Street interchange ramps at the west end of the bridge resulted in congestion that backed up traffic on the expressway at the beginning of the bridge. During both peak periods, the Mathews Bridge was incapable of accommodating the traffic flow rate accommodated on its approaches.

To relieve this recurring congestion, authorities felt it necessary to increase the capacity of the Mathews Bridge in the peak direction. Various alternatives, including the contraflow operation of a single additional lane in the peak direction, were dismissed due to safety considerations. The preferred strategy called for a total conversion of all expressway lanes to the peak direction between Liberty Street on the west and the Mathews Bridge toll plaza on the east.

During periods of one-way operation, toll collectors in booths that normally serve traffic traveling opposite the peak direction collected tolls from motorists who were diverted across the toll plaza through these booths and onto the Mathews Bridge in the converted lanes. All entrance and exit ramps connecting to the converted side of the expressway were barricaded to prevent conflicting traffic movements. Additional traffic control and minor detouring were required downtown in the immediate vicinity of Liberty Street in order to allow one-way traffic to enter and exit the freeway. Signs, barricades, and uniformed police officers were used for this purpose. Morning and evening one-way operations are shown in Figures 2 and 3.

In consideration of unfamiliar motorists who might be following designated U.S. routes, Alternate US-90 was rerouted for the experiment to other facilities not affected by the one-way operation. Realizing that a complete conversion of even a short section of the expressway that included the Mathews Bridge would require motorists traveling opposite the peak direction to use an alternate route to cross the St. Johns River, authorities wished to limit the duration of the one-way operation as much as possible so that the desired additional peak-direction capacity would be provided only when needed and inconvenience to opposing traffic would be minimized.

Investigation of traffic data led authorities to determine that 45 min of one-way operation was required in both the morning and the evening. It was estimated that the time required to terminate opposing traffic, to set up the necessary traffic barricades on access ramps, and to clear the section of expressway to be converted would total 15 min. A similar time was allowed to reverse the process and return the expressway to normal operation at the end of each one-way period. The total time for conversion, operation, and reversion was therefore estimated to be 1.25 h. The anticipated schedules for morning and evening operation are given in Table 1.

Before initiation of the one-way experiment, Jacksonville newspapers printed a significant amount of information on how and when the expressway would be converted and what alternative routes were available.

EVALUATION PLAN

Objectives

The purpose of the Arlington Expressway experiment was to increase temporarily the capacity of the facility to accommodate peak traffic flows and thereby

Figure 2. One-way operation of Arlington Expressway: morning peak.

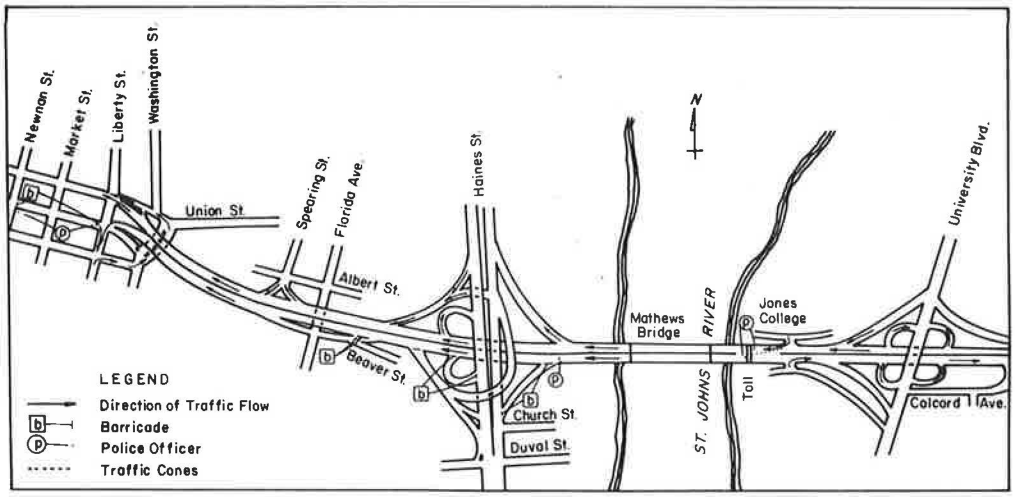


Figure 3. One-way operation of Arlington Expressway: evening peak.

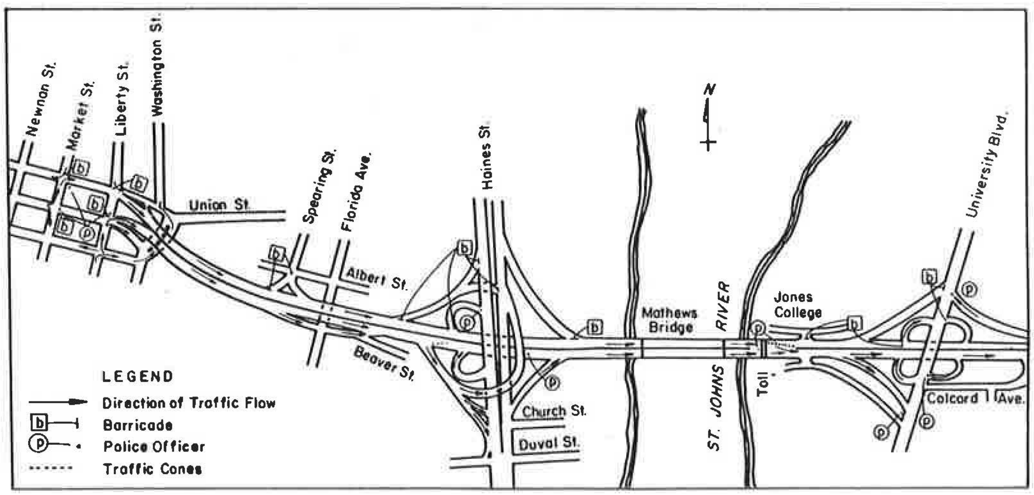


Table 1. Anticipated schedule of one-way operation.

Item	Morning Period (a.m.)	Evening Period (p.m.)
Ramp closures and expressway clearance	7:15-7:30	4:45-5:00
One-way operation	7:30-8:15	5:00-5:45
Expressway clearance and barricade removal	8:15-8:30	5:45-6:00

reduce the recurring congestion and delay experienced by motorists. To evaluate the effectiveness of the strategy, a series of before and after studies was conducted to measure the impacts on traffic flow. Three primary objectives were established for the evaluation:

1. Identify points of congestion and measure the delay incurred,
2. Measure the travel-time savings realized as a result of the one-way operation, and
3. Compare the benefits derived by motorists using one-way operation with the negative effects incurred by motorists forced to divert to alternative routes.

Data Collection Techniques

Study of Toll Plaza Operations

Because congestion developed during the morning peak period in the area of the toll plaza at the east end of the Mathews Bridge, there was some speculation that the toll booths were the constraining factor and that additional toll collectors would help alleviate the long queues on the approach to the plaza. Other concerned parties suggested that the Mathews Bridge, with only two westbound lanes, was the ultimate capacity constraint. To study the problem, time-lapse photography from a 12-story building near the toll plaza was used.

Films were taken continuously from 6:30 to 8:00 a.m. on two weekdays before initiation of the experimental one-way operation. Similar films were taken on the same weekdays two weeks after the one-way operation had been in effect. From these films (8 mm at 2 frames/s), changes in lane volume distribution, toll booth processing rate, and delay in queues waiting to pay tolls were determined.

Speed and Delay Studies

To measure travel-time savings experienced by motorists using the Arlington Expressway, moving-vehicle speed and delay studies were conducted. Terminal nodes for the study section were established in downtown Jacksonville on the west and at Monument Road on the east. The resulting route length was 6.6 miles. These locations were selected because they represented logical diversion points for traffic forced to travel an alternative route during the periods of one-way operation.

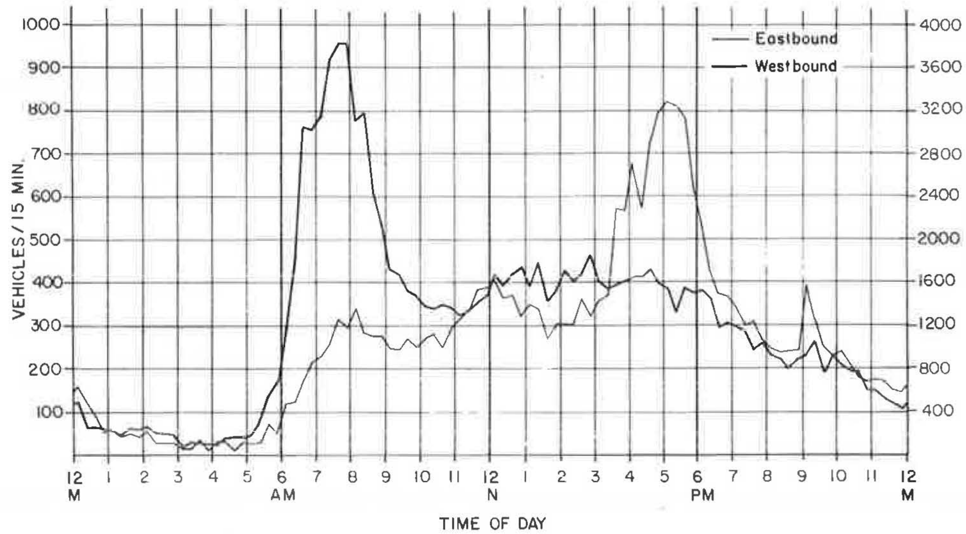


Figure 4. Traffic volume on Mathews Bridge over 24-h period.

Table 2. Directional traffic flow during periods of one-way operation.

Peak Period	Eastbound Volume	Eastbound Percent	Westbound Volume	Westbound Percent	Total Volume
7:15-8:15 a.m.	1215	25	3605	75	4820
4:45-5:45 p.m.	3207	76	1017	24	4224

Intermediate nodes were established at all interchanges and signalized intersections on the Arlington Expressway route and on the Atlantic Boulevard-Hart Bridge route, which was the most direct diversion corridor. Speed and delay studies were made on the diversion route as well to determine any negative impacts on those facilities and to quantify the increased travel time incurred by diverted motorists.

Study of Expressway Volume Throughput

To monitor the effectiveness of the one-way operation in allowing greater volumes of traffic to move to and from the downtown area during peak periods, traffic counts were made at all ingress and egress points on the Arlington Expressway from Liberty Street to University Boulevard. Observers with synchronized watches were stationed at various vantage points along the corridor, and they monitored entering and exiting traffic volumes traveling in the peak direction. Volumes were recorded at the end of each 3-min interval.

Traffic Counts Along Alternative Route

To estimate the volume of traffic that was forced to travel the alternative route to and from Jacksonville opposite the peak direction, 15-min traffic counts were taken during the periods of one-way operation at major intersections along Atlantic Boulevard. These counts were taken on individual days before and after the one-way operation began. They were used, along with toll collection data at the Hart Bridge, to estimate not only the volume of traffic that was diverted but also where along the route this volume entered or departed. By analyzing these volumes and speed and delay data, estimates could be made of the total additional travel time and delay experienced by diverted motorists.

EXISTING OPERATIONAL CHARACTERISTICS

Traffic volume counts obtained on the Mathews Bridge portion of the Arlington Expressway showed a daily use of approximately 55 000 vehicles. Flow profiles for eastbound and westbound directions are shown in Figure 4, and from this figure the distinct morning and evening peak directional flows can be seen.

With the one-way operation in effect, motorists traveling opposite the peak direction would be forced to adjust their departure time or to use an alternative route. Directional traffic flow during morning and evening peak periods of one-way operation is given in Table 2. During both peaks, the potential exists for diversion of about 25 percent of the total traffic crossing the St. Johns River.

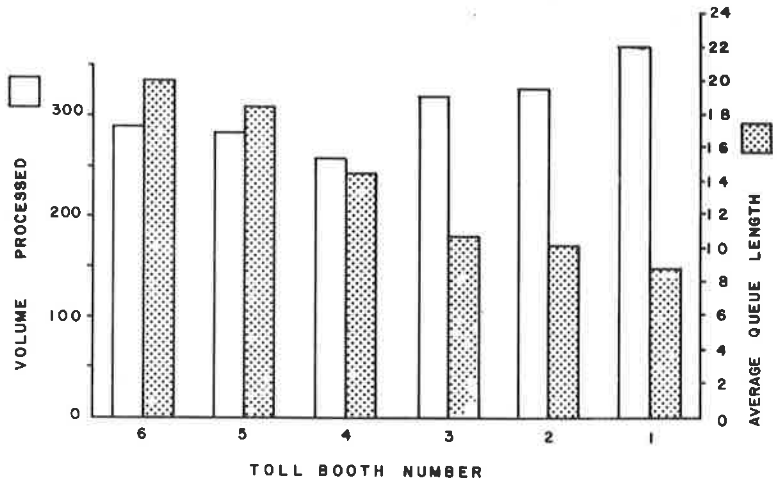
Morning Peak Period

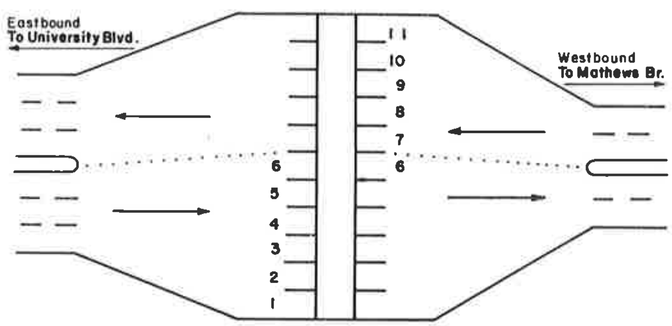
During the morning peak, 6 of the 11 tollbooths at the Mathews Bridge toll plaza serve the eastbound traffic (booths 1-6). Figure 5 shows for each of these booths the volume of traffic served between 7:30 and 8:00 a.m. and the average number of vehicles in the queue waiting to pay the toll. The histograms reveal that, whereas use of the booths is approximately uniform, the queue for each is not.

Motorists approaching the plaza from the expressway to the east were reluctant to use tollbooths 1-3 unless the queues there were very short. This is due to the fact that they would then have to merge back into the main traffic stream processed by booths 4-6. As the queues for booths 4-6 became longer and began approaching University Boulevard, westbound traffic entering the expressway at that interchange had no choice other than booths 1-3 because queues at other booths extended beyond their entry point. As a result, all available tollbooths were continuously used during the peak half-hour. Therefore, although approaching traffic could be redistributed to result in more uniform queue lengths, the total vehicle delay would remain unaffected.

Analysis of film footage of the toll plaza operation revealed that, on the average, each tollbooth processes a vehicle every 6.0 s. With six booths operating, this produces a throughput rate of 3600 vehicles/h. The Mathews Bridge, with its limited lateral clearances and steep grade, is marginally capable of accommodating this volume. The area between the toll plaza and the bridge became intermittently jammed during the peak, such as when the

Figure 5. Tollbooth use before one-way operation use: 7:30-8:00 a.m., westbound.





momentary throughput rate at the plaza exceeded the average or when a truck or bus labored up the bridge incline. Therefore, providing additional tollbooths to serve peak morning traffic without increasing the capacity of the Mathews Bridge would only cause greater congestion on the approach to the bridge and further restrict flow.

Vehicle delay at the toll plaza was quantified through analysis of the time-lapse films. Several hundred randomly selected vehicles were tracked through the toll plaza, and their time in a queue was recorded. The upper portion of Figure 6 shows average stopping delay in a queue during the morning peak half-hour (7:30-8:00 a.m.) and the lower portion shows 3-min approach volumes arriving between 7:00 and 8:30 a.m. In comparing the two graphs, it can be seen that delay in a queue continues to increase as long as the 3-min approach volume steadily exceeds 180 vehicles, which equals the mean processing rate of the six tollbooths combined (6.0 s/vehicle/booth). At about 7:52 a.m., when the approach volume drops below the 200 mark, delay begins to decrease dramatically as the six tollbooths can process more vehicles than are approaching. During the peak half-hour, the average stopped delay for all six booths was 91 s. Individual delays were measured as high as 3 min, 27 s.

Once a motorist had passed the toll plaza and entered the bridge, flow over the bridge and into the downtown area was uninterrupted unless there was an incident on the bridge.

Evening Peak Period

Evening traffic crossing the Mathews Bridge in the eastbound direction enters the expressway at two major points. Approximately 50 percent enters from Union Street, and about 40 percent enters at the Haines Street interchange. Figure 7 shows a comparison of input volume at these major ingress points during the evening peak.

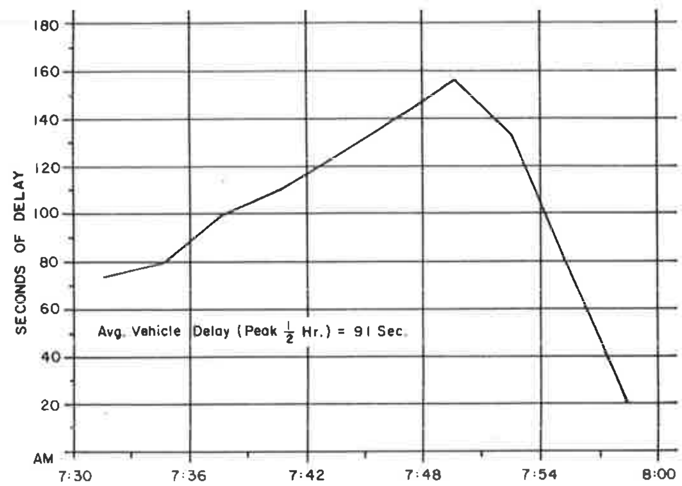
Entrance to the expressway from Union Street is controlled by a traffic signal at Liberty Street. Entrance at the Haines Street interchange is accomplished on one of two free-flow ramps, one from northbound Haines Street and one from southbound Haines Street. As the flow rate on the expressway approaches the capacity of the bridge (at approximately 4:35 p.m.), congestion develops at the west end of the bridge and extends westward through the Haines Street interchange area. The bumper-to-bumper flow along the expressway makes merging maneuvers at the two Haines Street ramps very difficult. As a result, motorists entering at this interchange experience delays as long as 6 min around 5:00 p.m. Once a vehicle is on the bridge, speed increases again and travel is uninterrupted except for stops at the toll plaza.

Travel-time data for speed and delay runs made in the eastbound direction are shown in Figure 8. The average of eastbound runs made with the peak flow between 4:00 and 6:00 p.m. (nine runs) is plotted against the average of eastbound runs made between 7:00 and 8:30 a.m. (eight runs), which represents an off-peak period for this direction. Figure 8 reveals that virtually all of the excess travel time experienced with the peak flow in the evening occurs between Liberty Street and the beginning of the bridge. Average running speed in the evening was only 22 mph between these points; in the morning it was 45 mph. The remainder of the trip shows no appreciable difference, including the delay at the toll plaza. The similarity in toll plaza delay for eastbound morning and evening traffic is due to the previously discussed relation between the capacity of the Mathews Bridge and the mean processing rate of the tollbooths. As in the morning period, 6 of the 11 tollbooths are servicing the major traffic flow in the evening.

RESULTS OF ONE-WAY OPERATION

The peak-period one-way operation of the Arlington Expressway began as scheduled on the morning of Tuesday, August 18, 1981. Reversal of the eastbound lanes to the westbound direction commenced with the radio-coordinated unveiling of temporary guide signs and placement of barricades at all eastbound entrance ramps in the downtown area. After a brief period, a police officer on a motorcycle would drive from Liberty Street to the toll plaza to ensure that the last vehicles allowed on the eastbound lanes had successfully cleared the section of the expressway

Figure 6. Average stopped delay at toll plaza before one way-operation: 7:30-8:00 a.m.



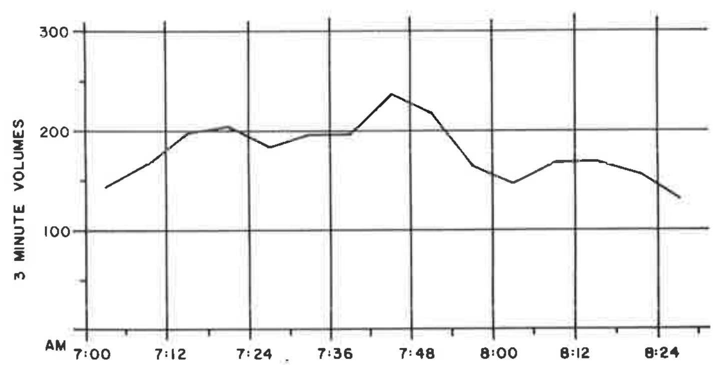


Figure 7. Arlington Expressway input volumes before one-way operation: eastbound, evening.

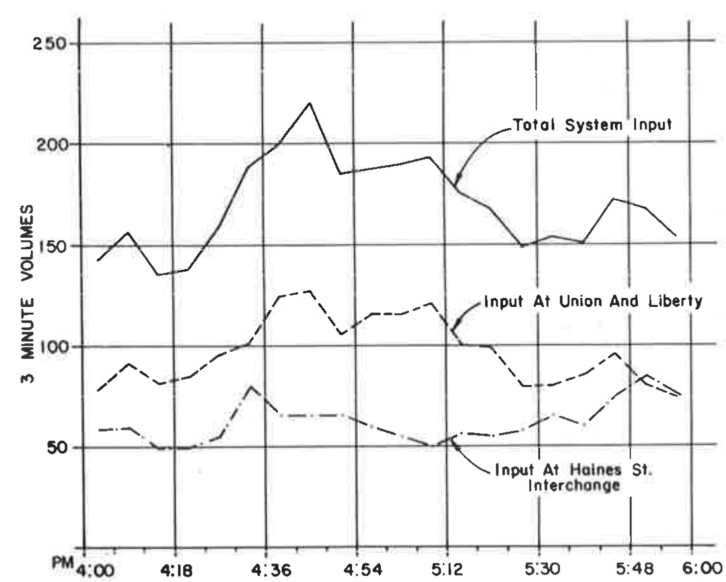
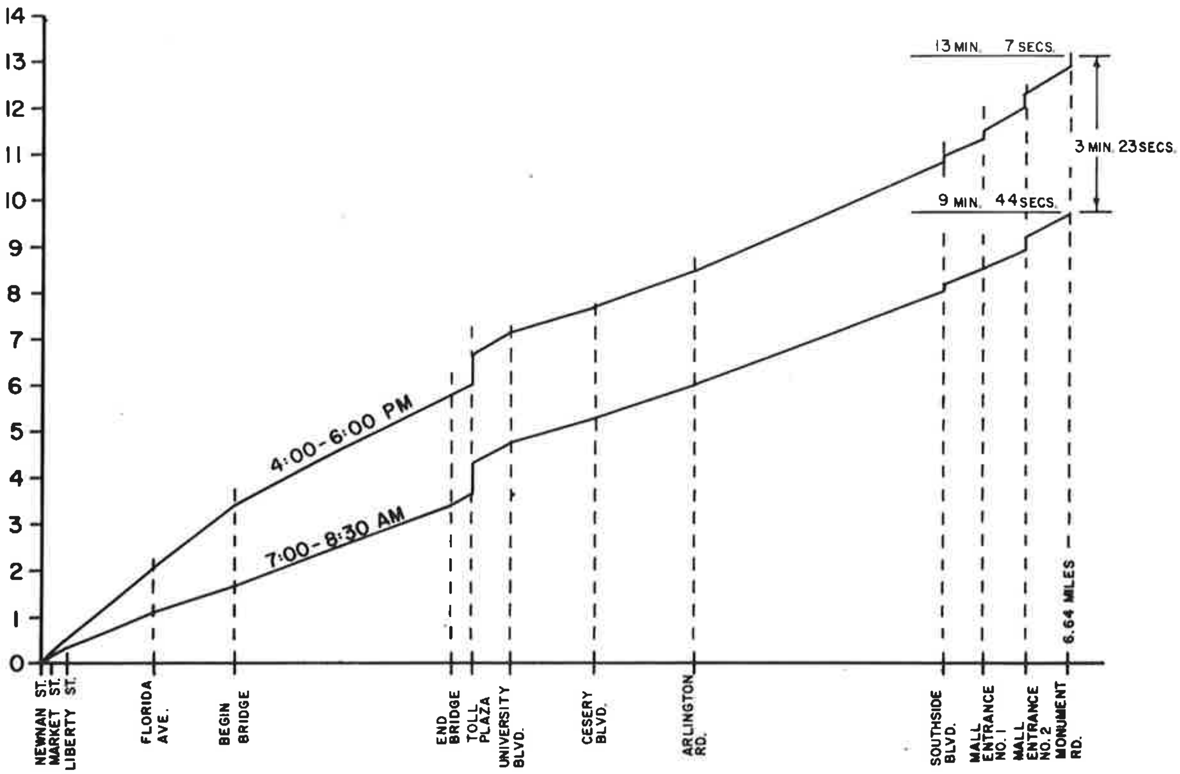


Figure 8. Travel time and delay before one-way operation: eastbound, evening versus morning.



to be reversed. Once this was accomplished, westbound traffic approaching the toll plaza in the median lane of the expressway was channelized with traffic cones through tollbooths 6-9 and onto the Mathews Bridge. Because of the median barrier that extends from the eastern end of the bridge to downtown, traffic in the contraflow lanes was unable to exit before reaching Union Street at Liberty Street. Here, contraflow traffic was forced to turn north or south onto Liberty since Union Street remained one-way eastbound beyond that point.

Conversion of the expressway to one-way operation in the evening was accomplished in a similar manner, and temporary guide signs and barricades were used as rapidly as possible. After a police officer drove the facility westbound and verified clearance, other uniformed officers downtown diverted traffic from Union Street one block north to State Street and eastward onto the contraflow lanes. This traffic was also required to travel the 2.8 miles to the toll plaza without exiting. At the plaza, booths 3-11 served eastbound traffic, which was channelized back to the normal lanes just beyond the plaza.

Promotional literature and press releases issued by Jacksonville authorities had stated that one-way operations would be in effect from 7:30 to 8:15 a.m. and from 5:00 to 5:45 p.m., with 15-min transition periods before and after each reversal. Under normal, incident-free conditions, authorities were able to routinely accomplish the transitions in about 5 or 6 min, which resulted in actual one-way periods from 7:20 to 8:20 a.m. and from 4:50 to 5:50 p.m.

Effect of Morning One-Way Operation

Allowing the eastbound lanes of the Arlington Expressway to operate in the westbound direction in effect doubles the capacity of this facility to carry vehicles from Arlington to downtown Jacksonville. With nine booths open to approaching traffic instead of six, the change in the length of queues was quite dramatic. Figure 9 shows histograms of tollbooth use and average queue length for the peak half-hour when one-way operation was in effect. In comparing Figure 9 with Figure 5, it can be seen that the average queue lengths before ranged from 9 to 20 vehicles and the maximum average queue length after was fewer than 3 vehicles.

As Figure 10 shows, shorter queues at the toll plaza mean less delay. Superimposed on the delay curve for the "before" condition is the average vehicle delay during the peak half-hour of one-way operation. The average stopped delay at the toll plaza was reduced from 91 to 20 s, a reduction of 78 percent. The volume of approaching traffic for which these delays were measured was actually greater during one-way operation, as shown in the lower portion of Figure 10.

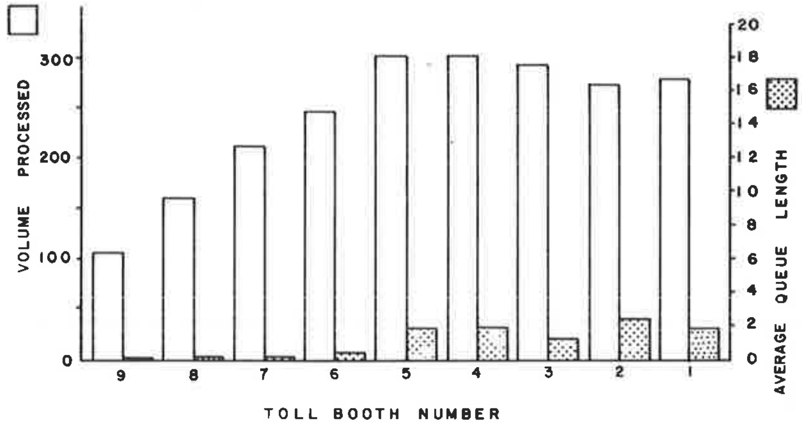
During the one-way operation from 7:20 to 8:20 a.m., an average of 4273 westbound vehicles crossed the Mathews Bridge. Of these, 31 percent traveled in the contraflow lanes and 69 percent in the normal manner.

Travel time and delay data for moving-vehicle studies made between 7:20 and 8:20 a.m. both before and after initiation of the one-way operation are shown in Figure 11. Only data for the portion of the route between University Boulevard and Liberty Street are depicted because travel time on expressway segments east and west of these points was unaffected. A total of five runs in the "before" condition were compared with four runs in the "after" condition. As expected, the only appreciable difference brought about by the one-way operation is a reduction in delay at the toll plaza.

Effect of Evening One-Way Operation

Analysis of the eastbound evening flow in the "before" condition revealed that the majority of the

Figure 9. Tollbooth use after one-way operation: 7:30-8:00 a.m., westbound.



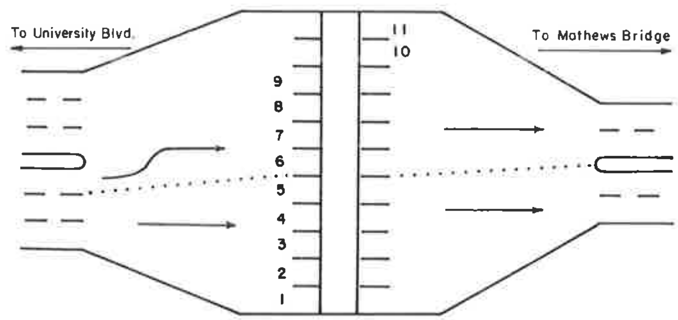
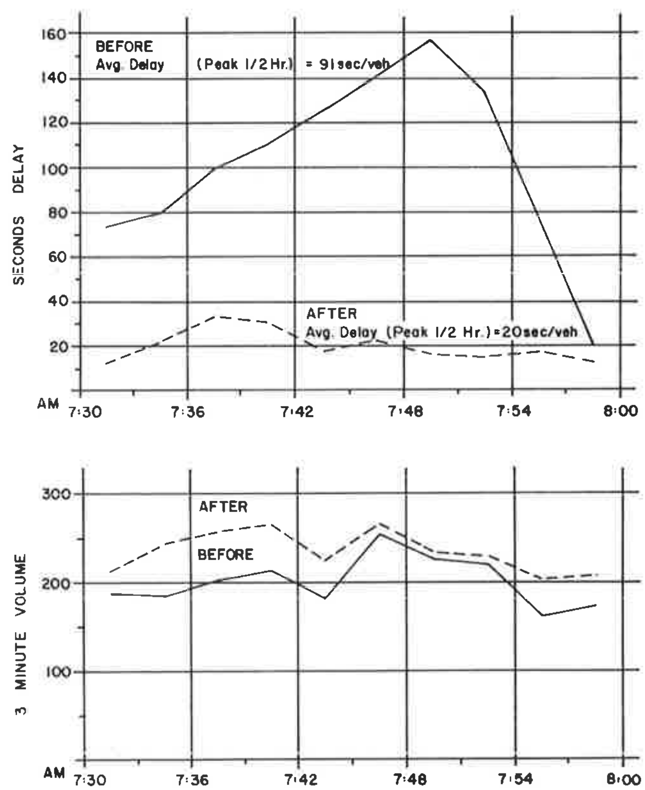


Figure 10. Approach volumes and stopped delay at toll plaza during one-way operation: 7:30-8:00 a.m.



delay occurred between Liberty Street and the beginning of the bridge and also on the Haines Street ramps for those vehicles that attempt to enter the expressway at that interchange. With the one-way operation in effect, all of the traffic approaching the expressway on Union Street was diverted to State Street and forced to cross the bridge on the contraflow side. This is a significant percentage of the total traffic using the Mathews Bridge during this period. In contrast to the morning period, when 31 percent of the vehicles traveled in the contraflow lanes, during the evening one-way operation 42 percent of the 3683 vehicles using the bridge traveled in the contraflow lanes. As a result, traffic passing the Haines Street interchange entrance ramps was greatly reduced, and motorists entering the expressway at this location experienced no delay.

As Figure 12 shows, the elimination of delay on the southbound Haines Street ramp had a profound effect on the traffic using this expressway entrance. Between 4:50 and 5:50 p.m., ramp volume averaged 544 vehicles in the "before" study. During this period in the "after" study, volume increased to 892 vehicles. Although verification studies were not made, it is believed by those familiar with the experiment that the increased traffic using this ramp during the period of one-way operation was traffic that, on perceiving the congestion that prevailed before the experiment, had opted to continue southbound on Haines Street, crossing the St. Johns via the Hart Bridge, which was operating quite freely.

Effects of the one-way operation on travel time eastbound in the evening are shown in Figure 13. A total of four runs made during the "before" condi-

Figure 11. Travel time and delay: before and after one-way operation, westbound, 7:20-8:20 a.m.

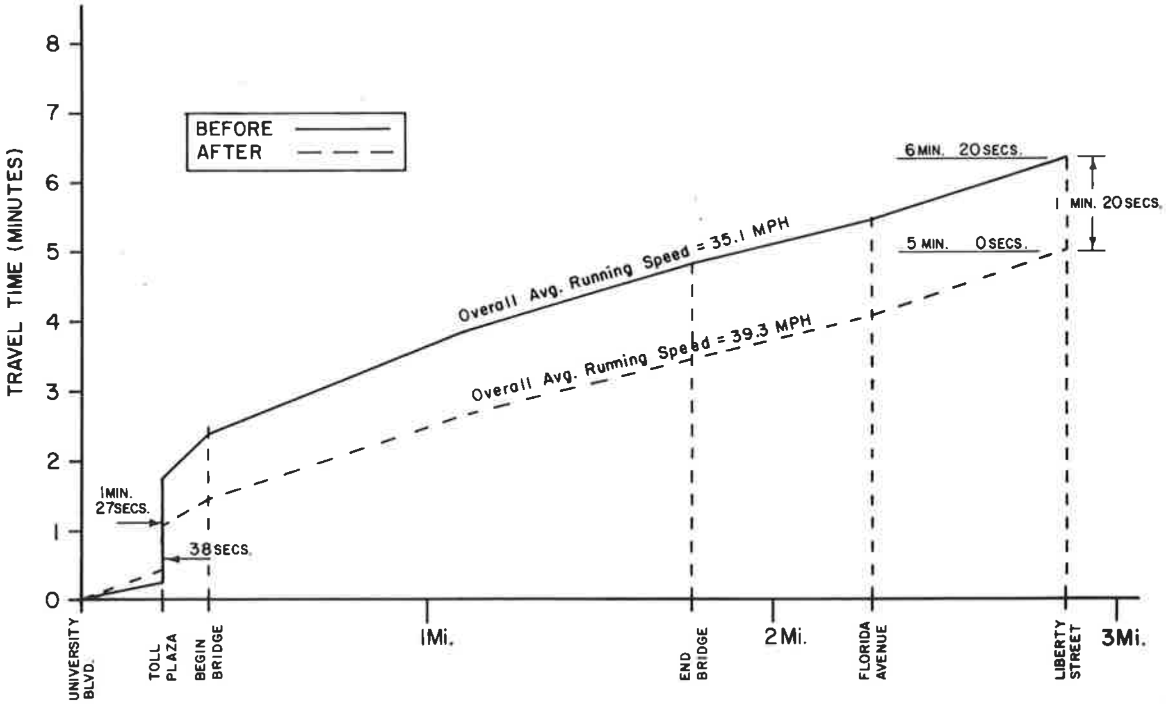
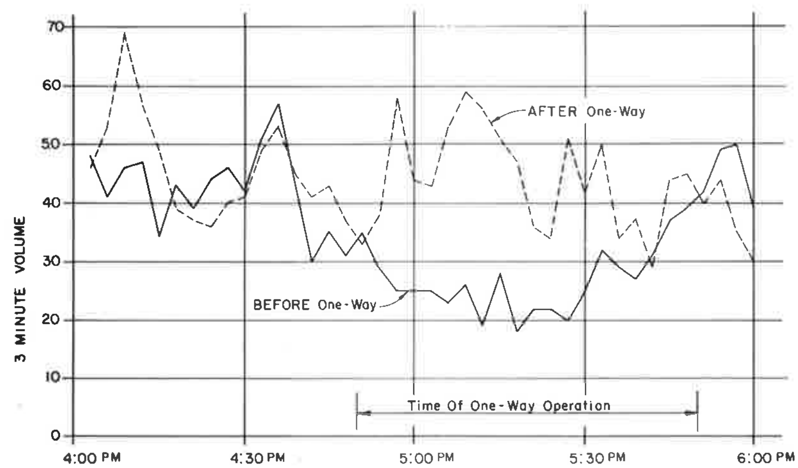


Figure 12. Input volume from southbound Haines Street to eastbound Arlington Expressway.



tion were compared with six runs made during the one-way operation. The average travel time for runs made between 4:50 and 5:50 p.m. was 3 min and 5 s shorter during the one-way operation. As expected, the most significant reductions occurred between Liberty Street and the beginning of the Mathews Bridge. Average running speed, which in this case is the travel distance divided by total travel time minus stopped delay at the toll plaza, increased from 23 to 35 mph.

It must be noted that, because a true evaluation of the improvements in travel time and delay resulting from the one-way operation required a comparison of only those "before" and "after" runs conducted during the very brief time frames of 7:20-8:20 a.m. and 4:50-5:50 p.m., the limited number of such runs did not provide statistically significant differences in average travel times. However, continued observation of the one-way operations led the evaluation team to conclude that the differences indicated by the analysis are an accurate measure of the improvements derived under incident-free conditions.

Figure 14 shows a histogram of tollbooth use for the evening peak half-hour. Because of the traffic cone configuration used at the toll plaza, booths 4 and 5 service higher volumes than the seven others. Later in the experiment, after city traffic engineering staff and toll plaza management had perceived a continual underuse of booth 6, traffic cones were realigned to channelize contraflow traffic through that booth. This made tollbooth use more uniform.

Net Effect on Fuel Consumption

To estimate the systemwide net effect on fuel consumed by motorists crossing the St. Johns River, the estimated fuel savings of motorists who benefited from the one-way operation were compared with the excess consumption experienced by diverted motorists forced to use the alternative routes. Average travel times, stopped delays, and speeds served as inputs to fuel consumption equations (1). Traffic volume data, collected along the Arlington Expressway and Atlantic Boulevard-Hart Bridge corridors, were analyzed to establish the volume of diverted motorists and the points from which they diverted. For Arlington Expressway users, savings were derived from comparison of "before" and "after" data collected on the expressway within the one-way operational time periods. For diverted motorists, excess fuel consumption was derived from a comparison of travel time data obtained from runs made on the Arlington Expressway before implementation and runs made on the diversion route after one-way operation began.

As demonstrated earlier, total travel time on the Arlington Expressway in the morning was essentially unchanged by the one-way operation except for the reduction in stopped delay at the toll plaza. The

Figure 13. Travel time and delay: before and after one-way operation, eastbound, 4:50-5:50 p.m.

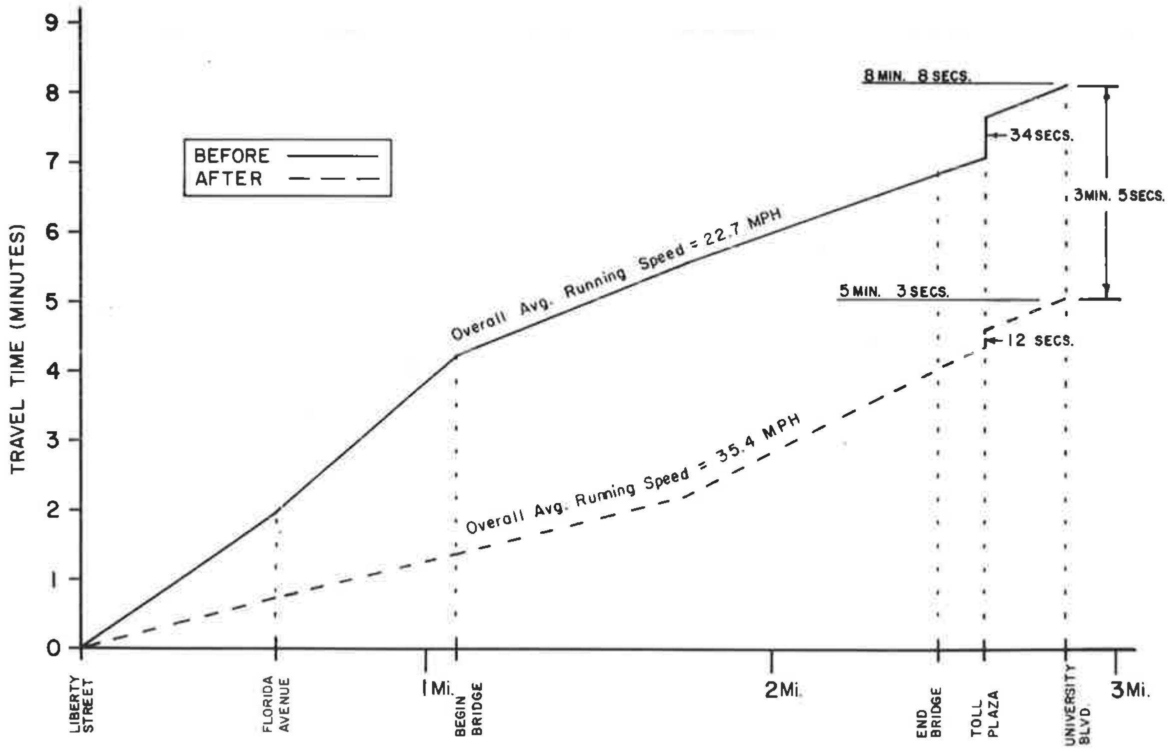
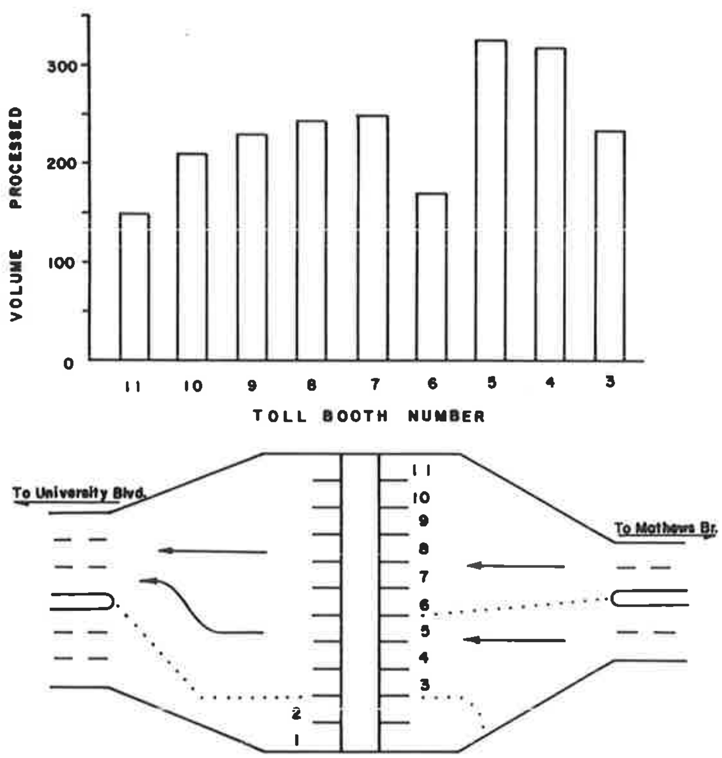


Figure 14. Tollbooth use during one-way operation: 4:30-5:00 p.m.



fuel savings brought about by this reduction in delay westbound were not sufficient to offset the excess fuel consumed by the volume of eastbound traffic that followed the identified diversion routes from downtown to areas east of the river. When calculated per-vehicle fuel consumption values for the various routes were multiplied by the measured volumes of traffic using those routes, it was estimated that the net effect was a 13-gal increase in fuel consumed during a single morning period.

During an evening period, when expressway motorists experienced greater reductions in delay and also improvements in average speed, the analysis of fuel consumption indicated a net savings of 25 gal. The estimated overall net effect from a single day's operation of the one-way strategy was therefore a savings of some 12 gal of fuel.

It is important to note that the above figures do not consider the significant reduction in delay realized by evening motorists entering the Arlington Expressway at the Haines Street interchange. No data were available to estimate their savings. In addition, the volume of traffic that had originally traveled the Arlington Expressway opposite the peak directions could not be totally accounted for from intersection counts made during the experiment. It is suspected that many drivers in this category altered their departure times to arrive immediately before or after the one-way periods so as to cross the river without diverting.

The fuel consumption analysis was not intended to accurately quantify the actual net effects of the one-way strategy. It served, rather, as a general indicator of the degree to which the strategy was influencing systemwide fuel consumption. From the analysis, the evaluation team concluded that overall fuel consumption was not grossly affected either positively or negatively.

CONCLUSIONS

The conclusions expressed in this section are based on the comparative analyses and on observations made by the evaluation team. Time constraints did not allow a comprehensive evaluation of such scope that all operational impacts could be analyzed, quantified, and compared to determine the absolute net effects of the one-way operation. Much of the impetus for initiating the one-way operation developed in response to those occasions when an incident on the Mathews Bridge resulted in lengthy delays and severe driver frustration. It was not intended, within the scope of this evaluation, to prepare for and monitor operations under these conditions, although they occur frequently. Certainly, because of the added capacity provided for the peak direction, the congestive effects of incidents would be greatly reduced under the one-way operational strategy.

Toll Plaza Operations

Analysis of the 8-mm time-lapse films revealed that before the experiment the toll plaza operation was conducted quite efficiently and that, particularly in the morning, the optimal number of tollbooths were open to serve peak directional flows. This finding is contrary to opinions expressed by some that additional available tollbooths would, in and of themselves, reduce queue lengths and stopped delay. Without the one-way operation, additional booths to serve the inbound morning traffic would have resulted in greater congestion between the toll plaza and the bridge. However, with the one-way operation in effect, additional available tollbooths for the peak direction were of significant benefit.

Morning One-Way Operation

Delays experienced by westbound morning traffic occurred between University Boulevard and the beginning of the Mathews Bridge. The one-way operation was effective in reducing this delay by 78 percent during the peak half-hour. Motorists who opted to use the converted lanes of the expressway could do so with ease. As a consequence, they were prevented from exiting the expressway before its termination downtown. This restriction posed no problem, however, because the vast majority of the traffic is commuter traffic and drivers soon familiarized themselves with the operation and the options available. Aside from the reduction in delay on the approach to the Mathews Bridge, no additional improvements in travel time could be identified.

Evening One-Way Operation

Greater benefits were derived from the one-way operation during the evening peak period. Average running speed increased from 23 to 35 mph between Liberty Street and University Boulevard. Congestion on the expressway in the vicinity of the Haines Street interchange was virtually eliminated, and vehicles entering the expressway here were unimpeded in doing so.

Impact on Diverted Motorists

Preliminary traffic counts showed a potential for diversion of 25 percent of the total traffic crossing the Mathews Bridge during the scheduled periods of one-way operation. This volume of traffic could not be totally accounted for in the analysis of the Atlantic Boulevard-Hart Bridge alternative route. It is unlikely, though, that any appreciable diversion to other alternative routes took place. Therefore, it is concluded that the majority of motorists have modified their departure times in response to the expressway closure schedule. This is substantiated by data that show increased approach volumes at the toll plaza immediately before and after conversion of the expressway.

Those motorists who did divert from the Arlington Expressway to the Atlantic Boulevard-Hart Bridge route at the common termini of the two study corridors did not experience unreasonable increases in travel time and delay to and from downtown Jacksonville, nor did the additional volumes on the alternative route result in any noticeable changes in congestion in that corridor.

Attainment of Objectives

When the effects of both the morning and evening operations are combined, the excess fuel consumed is approximately equal to that saved. No monetary value was assigned to either the fuel measures or the travel time and delay measures. These values would be speculative, and a comparison would be incomplete without consideration of implementation costs and long-term impacts on toll revenues.

The objective of the one-way operation implemented in this experiment was to eliminate the recurring congestion and resulting delay experienced by peak commuter traffic entering and leaving downtown Jacksonville via the Arlington Expressway. It was understood that some inconvenience and additional expense would be realized by those motorists who were required to use alternative routes. In view of the data presented in this paper, it must be concluded that the stated objective was accomplished by the one-way strategy.

The Jacksonville Police and Traffic Engineering Departments have demonstrated their ability to routinely implement the one-way operation well within the publicized time limits for conversion. Other than the diversion necessitated by the one-way operation, no additional adverse effects were identified either on the expressway or on the surface streets that provide access.

Perhaps the most significant aspect of the one-way operation is the newfound ability to maintain peak traffic flow across the St. Johns River during an incident on the Mathews Bridge. Previously, a stalled vehicle or accident on the bridge would have brought traffic to a standstill until the involved vehicles could be removed. The flexibility of the one-way plan, particularly in the morning, allows assignment of a large percentage of the traffic to either side of the barrier wall in response to an incident. This maintains traffic flow and allows authorities to reach and clear the incident more easily, thereby reducing its overall congestive effects.

Viewing the peak-period one-way operation in the broader sense of urban freeway management, it is significant to note the degree of cooperation and commitment exhibited by the various agencies involved. The city of Jacksonville must be recognized for developing a systematic strategy directed at reducing the recurring congestion experienced by a sizeable portion of its population. The plan could only be implemented successfully with the concerted efforts of the Jacksonville Police Department, which provided on-the-street traffic control, and the Toll Facilities Office of FDOT, which altered toll collection methods to accommodate contraflow traffic.

Following a review of the evaluation by state and local authorities, FDOT approved indefinite continuation of the one-way strategy. Accordingly, city officials appropriated the necessary funds for law enforcement personnel through FY 1982/83.

ACKNOWLEDGMENT

I wish to express my gratitude to R. Henry Mock of the city of Jacksonville, who was instrumental in developing the one-way operational strategy, and to FDOT District II Traffic Operations personnel who participated in data collection activities. A special expression of gratitude is extended to Anton Huber, formerly of the FDOT Bureau of Traffic Operations, who coauthored the original evaluation report from which this paper was developed.

REFERENCE

1. Procedures for Estimating Highway User Costs, Fuel Consumption, and Air Pollution. FHWA, May 1980.

Publication of this paper sponsored by Committee on Freeway Operations.

Abridgment

Diary of a Traffic Management Team: The Houston Experience

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The traffic management team approach to solving transportation operational problems in a rapidly growing urban area—Houston, Texas—is discussed. The Houston Traffic Management Team, as it is referred to, is an interagency group that is composed of representatives from Harris County law enforcement agencies; city, state, and county transportation departments; and the Metropolitan Transit Authority. The team meets monthly to discuss such topics as the review of traffic control strategies for major urban rehabilitation projects, review and approval of proposed operational changes to existing facilities, and operational problems encountered by law enforcement officials. The most important result of the team's activities since its inaugural meeting in January 1981 is the communication links that have been established between all transportation-related agencies in Harris County. It is recommended that the traffic management team approach be applied when the successful operation of existing transportation facilities crosses jurisdictional boundaries, as in Harris County.

Urban traffic management solutions to freeway and city-street operational problems encountered in large metropolitan areas require the cooperation of all transportation-related agencies. Toward this goal, the District Office of the Texas State Department of Highways and Public Transportation (TSDHPT) in San Antonio formed the first corridor management team in October 1975 (1). Representatives from the San Antonio Department of Traffic and Transportation, the District Office of TSDHPT, the San Antonio Transit System, and the San Antonio Police Department were present at the inaugural meeting. It is important to note that no specific operational funds were allocated for team activities. The cost of the operational improvements discussed are borne by the member agencies as part of their normal responsibilities. Finally, the personnel involved in these meetings were people in authority at an operational level, not administrative heads who made major policy decisions. In subsequent meetings, items such as the following were discussed: traffic handling during special events, the effects of inclement weather conditions on arterial and freeway systems, high-accident-rate locations, traffic control plans, and coordination of research efforts. The success of these meetings led to the creation of traffic management teams in other Texas cities, including Beaumont, Corpus Christi, El Paso, Fort Worth, Houston, Lubbock, Midland-Odessa, and Wichita Falls.

Houston, Texas, is the principal city in Harris County. However, high population concentrations exist in other areas that are not within the Houston city limits. These areas are either self-governing municipalities, such as Baytown, Bellaire, and Pasadena, or areas that are within one of the four county precincts. Consequently, several municipal agencies are responsible for such public services as roadway maintenance, law enforcement, and traffic signal operations. For example, frontage road sig-