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EVALUATION OF TRAFFIC INFORMATION AND PREDICTION SYSTEM (TIPS) AS WORK ZONE TRAFFIC CONTROL

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EVALUATION OF TRAFFIC INFORMATION AND PREDICTION SYSTEM (TIPS) AS WORK ZONE TRAFFIC CONTROL

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EXECUTIVE SUMMARY

As part of a pavement rehabilitation project on I-64, the Traffic Information and Prediction System (TIPS) was installed as a means of providing real-time data for motorists in advance and through the work zone. This system collects real-time data using roadside non-contact (microwave) sensors, processes the data in a personal computer, calculates travel time between different points on the roadway, and displays the travel time information on several portable changeable message signs positioned at pre-determined locations along the roadway. The system displays information in the form of travel time and distance through the work zone. The objective of this report was to document the performance of TIPS as a method to provide accurate and current information to drivers as they travel through a work zone.

The primary components of the evaluation included the following: 1) the performance and reliability of TIPS, 2) the accuracy of travel time estimates, 3) diversion of traffic from I-64 to an adjacent route, 4) crash data during construction and 5) opinions of drivers who had just traveled through the work zone.

Although problems with reliability and accuracy were encountered, TIPS was shown to have the potential to provide current information to drivers traveling through work zones. However, for the system to be effective, several changes from the methodology used in this project should be made. Suggestions include:

- Installation and maintenance of TIPS should be assigned to the prime contractor or an on-site subcontractor with the responsibility to monitor and make any changes in a timely manner.
- The TIPS logic and software should provide for automatic detection and notification of problems.
- Provisions for variable message signs should be the responsibility of the TIPS contractor.
- Use of this type of system would be more effective at construction sites that did not involve numerous changes in lane closure locations as occurred at this project.
- Providing real-time information would be more effective if delay time and a potential alternative route could be offered to motorists.

There was a slight increase in crashes in the construction zone compared to previous years. This increase was due to rear-end crashes related to congestion. There was an increase in traffic volume on the parallel route (US 60) that appeared to be related to local drivers not using the interstate. Interviews with drivers found that they observed and understood the signs but questioned the usefulness of the information provided. Although the average difference between the actual and displayed travel times was not high, there were instances where this difference was substantial. The correlation between the actual and predicted times became worse at the signs closest to the work zone.

A general specification was included for future applications of real-time traveler information systems in work zones.

1.0 INTRODUCTION AND BACKGROUND

Work zone activity on four-lane high-speed roadways continues to be one of the areas with the highest potential of compromised safety for workers and road users. Recent statistics indicate that more than 1,000 fatalities occur annually in highway work zones in the United States. With continued reconstruction and maintenance of many highways in Kentucky and elsewhere, the issues of safety and efficiency of travel in work zones are being addressed through the use of new types of traffic control devices. Various methods are being tested to provide motorists with real-time information relating to the work activity in order for them to make decisions about their travel alternatives. Past reports have documented the results of evaluations of various types of these systems in Kentucky (1, 2, 3).

As part of a pavement rehabilitation project on Interstate 64 (I-64) in Franklin and Shelby Counties, the Traffic Information and Prediction System (TIPS) was installed as a means of providing real-time data to motorists in advance of the work zone. The cost to implement and manage TIPS during the project was approximately $275,000. The construction project involved milling and resurfacing the section of interstate between KY 395 in Shelby County and US 127 in Franklin County. The length of the resurfacing project was 9.8 miles. At this location, I-64 is a rural, four-lane road with a speed limit of 65 mph. The weighted annual daily traffic (ADT) along this section of I-64 is about 36,400. Work activity on the project extended from July 22, 2003 to December 8, 2003.

The TIPS technology has previously been installed and operated in Ohio and Wisconsin (4,5). The TIPS project in Ohio was located on I-75 in the Dayton area and the project in Wisconsin was on I-94 in Racine County. It was concluded from the Ohio study that actual times were within plus or minus four minutes of the predicted times for 88 percent of the observations. A focus of the Wisconsin study was traffic diversion and it was found that between 7 and 10 percent of the freeway traffic was diverted to the alternative route.

TIPS collects real-time data using roadside non-contact (microwave) sensors, processes the data in a personal computer, calculates travel time between different points on the roadway, and displays the travel time information on several portable changeable message signs positioned at pre-determined locations along the roadway prior to the start of the work zone. The system at this location displayed information in the form of the travel time and distance from each sign to travel through the work zone. It is an automated system that uses a base station with a computer and radio for wireless control of the system from a central location. The software calculates current travel times or delays at 30-second intervals. The system then displays messages on portable message signs to drivers as they approach the work zone. Sensors were placed on the advance warning signs as well on two sensor trailers (one at the taper and one in the work area).

On this project four signs were placed in advance of the work zone with the messages providing information about the time and distance from that sign to the end of the work zone. Other messages relating to such events as a crash in the work zone could be input manually. It has been suggested by the TIPS developer that other potential media for dissemination of the information include the internet, rest areas with kiosk-type stations, truck stops, offices, and other work places such as factories. Potential benefits of the system include more informed and less frustrated motorists, information to provide motorists the ability to choose alternate routes, and improvements in the safety associated with work zones. The system is designed to be portable from one work zone to another and to function with minimal human intervention.

The objective of this report was to document the performance of the Traffic and Information and Prediction System as a method to provide accurate and current information to drivers as they travel through a work zone.

2.0 EVALUATION PROCEDURE

An evaluation of the TIPS system was conducted for the pavement rehabilitation project on I-64 in Franklin and Shelby Counties during the summer and fall of 2003. The project involved eastbound and westbound traffic on I-64 from US 127 in Franklin County to KY 395 in Shelby County for both directions of travel on I-64. The TIPS system collected data and provided information to travelers in both directions on I-64. Work alternated between each direction so it was not necessary to provide data for both directions on the same day. In addition, work did not occur in both directions on the same day. As work progressed, the work location changed which required the signs to be moved periodically. Contract requirements restricted the hours of work in an attempt to avoid times with the highest traffic volumes. The work hours were from about 7 pm to 6 am westbound and about 11 am to 7 pm eastbound. Work was not conducted on Fridays or any holidays or days where there was a special event in a surrounding area. Components of the evaluation included the following:

1) Performance and Reliability: The overall performance of the system was documented to determine if the system could be maintained consistently and was responsive to the appropriate messages.
2) Travel Time Estimates: The travel time estimated by the system logic and displayed on the message signs was compared to actual travel time measured by driving through the work zone. The time to travel from each of the four signs to the end of the work zone was recorded and compared to the message displayed on each sign. The distance displayed on the message board was also compared to the actual distance.
3) Diversion: US 60 is a parallel route to I-64. The impact of traffic on US 60 as an alternate route was evaluated by driving the alternate route during periods of heavy congestion on I-64 when maximum diversions would be expected. Observations were made concerning whether traffic was diverting when there was a backup on I-64. Volume counts on US 60 during days of work were compared to days with no construction and data from previous years.
4) Crash Data: Traffic crash data were collected during the time period of resurfacing work on I-64 and compared to the same dates during the previous

several years. The dates of the crashes were compared to days when work was being conducted. Crash reports were reviewed on those days to determine if the crash was related to the work zone.

5) Driver Opinion: The desired procedure was to interview drivers stopping in a rest area after they had just driven through the work zone. A rest area is located about eight miles east of the work zone. Surveys were taken in that rest area when work was in progress. There is no rest area close to the end of the work zone for westbound traffic. Eastbound drivers were asked if they observed the messages on the signs, if they understood the messages, and if the messages provided useful information.

3.0 RESULTS

3.1 Performance and Reliability

Several problems occurred related to the maintenance of the system and the ability to display the appropriate message on the variable message signs (VMS). Part of this problem related to the numerous changes in the location of the work zone that included changes in the direction of the construction activity. These movements required the signs to be moved frequently. Four signs were to be placed prior to the start of the taper. However, all four signs were in place for only about 60 percent of the data collection time. The major reason for the absence of signs was the presence of an adjacent construction project that would have caused confusion if all four signs were placed.

Another problem related to the capability of the signs. There was a requirement that VMS owned by the Kentucky Transportation Cabinet must be used in the project. These signs were not part of the contract and several problems occurred when attempting to integrate the signs with TIPS. The specifications for the VMS would have been different if they had been part of the contract with the knowledge that they had to be compatible with TIPS.

In a few instances there was a problem in communicating the proper message to the appropriate sign. This occurred when the sign message indicated on the computer in the office did not agree with the message displayed on the VMS. The TIPS contractor indicated the sensor was not operating properly due to the terrain and the RF signal transmitted. A possible explanation offered was the gradient changes in the area of the work that rendered the system non-functional at times.

The various problems were eventually corrected. However, they did result in the system either being inaccurate or not operating for substantial periods of time. The time required to correct problems was increased since responsibility was not assigned directly to the prime contractor and the subcontractor was not on-site on a daily basis.

3.2 Travel Time and Distance Estimates

The route was driven during construction with the time recorded to travel from each VMS to the end of the work zone and compared to the time given on the sign. These travel times were recorded on various dates between July 23 and November 10, 2003. A total of 73 travel time runs were conducted with all four signs operating for 42 of these runs. It should be noted that even though TIPS calculates travel time at 30-second intervals, the displayed travel times were in 4-minute increments. Following is a summary describing the comparison of actual and displayed times from each sign to the end of the work zone. Sign 1 is the first sign a motorist would encounter with Sign 4 being the last sign before reaching the actual work zone.

Actual vs. Displayed Times	Sign 1	Sign 2	Sign 3	Sign 4
Average difference (minutes)	3:54	4:25	4:47	3:23
Maximum difference (minutes)	20:07	21:37	16:01	18:10
Minimum difference (minutes)	0:06	0:34	0:01	0:19
Average percent difference	28	31	45	41
Standard deviation (minutes)	3:40	3:59	4:37	3:48

Graphs showing the comparison between displayed/predicted and actual times from each sign to the end of the work zone are shown in Figures 1 through 4. The predicted times are presented in 4-minute intervals. The middle line on the graphs represents a linear fit of actual and predicted times. The lines above and below represent a variance of one standard deviation from the linear fit line. The correlation between the actual and predicted times decreased at the signs closest to the work zone. It should be noted that the low estimated times for Sign 1 to the end of the work zone occurred when all four signs were not operating and the first sign observed was close to the work zone. In addition, there were infrequent major delays with few travel times over 30 minutes. The difference ranges between predicted and actual travel times are shown below.

Difference (minutes)	Percent
Under 4	64
4 to 8	24
8 to 12	5
Over 12	7

To further clarify the magnitude of the differences between predicted and actual travel times, an additional breakdown of the data is shown below.

Range of Percent Difference	Percent
Under 10	23
10-20	23
21-30	20
31-40	8
41-50	4
Over 50	22

As noted, the distance from each sign to the end of the work zone was also compared to that given on the sign. Following is a summary of those results. The differences typically occurred as a result of the location of the work zone being moved without a corresponding change of the distance shown on the sign.

Difference in Distance (Actual vs. Displayed)	Sign 1	Sign 2	Sign 3	Sign 4
Average distance (miles)	1.20	1.58	1.11	0.65
Maximum distance (miles)	3.50	4.00	3.50	3.50
Minimum distance (miles)	0	0	0.25	0
Average percent difference	18	16	23	17

3.3 Diversion

The signs did not provide a message informing drivers to divert to the parallel route. There is one interchange (Exit 48) between the construction limits at Exits 43 and 53. Drivers could divert to US 60 and bypass the construction. Observations showed a few drivers would exit I-64 and divert to US 60 during the times when a large delay occurred. This occurred infrequently and the small number of diverted vehicles would not have affected congestion on US 60.

However, volume data on US 60 showed there was a substantial increase in traffic volumes in 2003 compared to 2002. The increase was higher on days when construction was occurring on I-64. The data apparently indicate that some local drivers, who were aware of the work activity on I-64, were using US 60 rather than I-64 in 2003. The ADT on US 60 in 2003 during construction work days increased about 35 percent with an increase of up to about 20 percent on days during the construction time period when no work was being conducted. The large percent increase on US 60 was primarily due to the relatively low volumes on US 60 compared to I-64. There was an increase in ADT of about 1,000 on US 60 on days with work on I-64 that represents only about 3 percent of the ADT on I-64. There was no indication that the increase in volume in US 60 caused any problem.

3.4 Crash Data

Crash data on I-64 were summarized between the KY 395 and US 127 interchanges in 2003 during the construction-related time period (July 22, 2003 through December 8, 2003). These data were compared to the number of crashes in the work zone area for the same dates for the previous five years. Crashes on the 63 days in which there was some type of construction related activity were reviewed. There were 18 crashes on days with construction activity in 2003. This was an increase from an average of 13 crashes on these same dates for the past five years. The number of crashes in the previous years on the same 63 days varied from 8 in 1999 to 18 in 2000.

A review of the crash reports showed that only 8 of the 18 crashes during the 2003 dates with construction could be directly related to construction activity. Seven of these eight crashes were rear end crashes. Five of the seven rear end crashes were attributed to construction related congestion and two involved a construction vehicle. The remaining crash involved a single vehicle where a combination truck hit a guardrail. One of the rear-end crashes involved a fatality when a combination truck hit the rear of a stopped van with two of the other rear end crashes involving an injury.

The small increase in the number of crashes on I-64 during the dates of construction in 2003 when compared to previous years is consistent with the number of crashes that could be directly related to the construction activity. A review of crashes on the parallel route (US 60) showed no increase in crashes during the dates of construction on I-64.

3.5 Driver Opinion

A sample of drivers stopping at the rest area just east of the work zone were asked questions concerning their observations of the messages on the VMS leading to the work zone and lane closure. The surveys were conducted during times of construction in the eastbound lanes.

Interviews were conducted with 58 drivers who indicated they had traveled through the work zone between Shelbyville and Frankfort. Almost all of those interviewed (95 percent) indicated they had observed a message on the VMS. The travel time message was observed by 50 of the drivers while 52 drivers stated they observed the distance message.

The drivers were asked to rate, using a scale of 1 to 5, if they understood the messages and if the messages were useful (with a rating of 5 being very understandable or very useful). Of those responding, 96 percent thought the messages were very understandable. However, only 19 percent rated the signs as being very useful. The average rating was 3.3 for the usefulness of the signs.

Drivers were asked if they had any comments or suggestions. While there were several comments that good information was provided, there were questions about how useful the information was since no specific alternative route was suggested. There were several comments that the times given on the signs were not accurate.

4.0 SUMMARY AND CONCLUSIONS

Although problems with reliability and accuracy were encountered, the Traffic Information and Prediction System (TIPS) was shown to have the potential to provide current information to drivers traveling through work zones. Problems related to maintenance of the system and the ability to display the appropriate message on the variable message signs (VMS) were noted. Frequent changes in the location of the work zone and the direction of the construction activity diminished the applicability and resulting benefits from the system. Compatibility of the VMS provided by the Kentucky

Transportation Cabinet resulted in several problems when attempts were made to integrate the signs with TIPS. A more compatible system would likely have resulted if the signs had been specified as part of the TIPS contract.

Discrepancies were noted in the displayed messages as compared to the actual time and distance measured at the work site. The difference between predicted travel times and actual travel times was less than 4 minutes in 64 percent of the comparisons and greater than 12 minutes in 7 percent. However, further analysis showed that there was more than a 50 percent difference between predicted and actual times in 22 percent of the observations. Terrain conditions with substantial gradient changes contributed to the problem of communicating the proper message to the appropriate sign. Inattention to the positions of the signs relative to the work zone was apparently the reason for the differences in actual versus displayed distances on the message signs.

The number of crashes increased slightly during the days of construction compared to previous years. The construction-related crashes were typically rear end crashes related to congestion. During construction, there was an increase in traffic on US 60, which is a parallel route to I-64. Observations indicate the increase in traffic on the parallel route was related to local drivers not using the interstate because they were aware of the construction as opposed to drivers diverting from the interstate due to observed congestion. The increase in traffic volume on US 60 represented only about three percent of the ADT on I-64. There was no increase in crashes on US 60 during the construction activity on I-64.

Drivers interviewed after they traveled through the construction area indicated they saw and understood the signs but they questioned the usefulness of the signs since no alternative route was offered and the accuracy of the times displayed was questioned. Although the average difference between the actual and displayed travel times was not high, there were instances where this difference was substantial. The correlation between the actual and predicted times became worse at the signs closest to the work zone.

5.0 GENERAL SPECIFICATIONS FOR FUTURE APPLICATIONS

For future applications of a traffic-responsive driver information system in work zones, the following general specification should be considered for incorporation into the contract requirements.

- The system should include an accurate means of detecting vehicles and determining their speeds as they approach and travel through the work zone.
- The system should collect the real-time traffic information and transmit that data from remote locations in advance of the work zone to a base station.
- The system should process the real-time information and use that data to estimate travel times to pass through the work zone.
- The system should display on electronic message boards the estimated travel times and distances to pass through the work zone.

- The system should calculate and display expected delay time to travel through the work zone.
- A minimum of three message boards should be placed in advance of the work zone to display the travel time, distance, and delay information.
- Installation and maintenance of TIPS should be assigned to the prime contractor or an on-site subcontractor with the responsibility to monitor and make changes in a timely manner.
- Provisions should be made to require that the system be operational before the contractor can begin work each day.
- The TIPS system logic and software should provide for automatic detection and notification of problems.
- Provisions for variable message signs should be the responsibility of the TIPS contractor.
- Construction sites should be selected that do not involve numerous changes in lane closure locations.
- To provide maximum usefulness, sites should have a traffic volume where significant delays would be expected and have an alternate route available.
- For sites that have severe terrain changes, provisions should be made to ensure that the RF signal is transmitted properly between sign locations and the base computer.

6.0 REFERENCES

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4. Zwahlen, H.T.; “Evaluation of a Real-Time Travel Time Prediction System in a Freeway Construction Work Zone,” Ohio University, 2001.

5. Horowitz, A.J.; Weisser, I; and Notbohm, T.; “Diversion from a Rural Work Zone Owing to a Traffic-Responsive Variable Message Signage System,” Center for Urban Transportation Studies, University of Wisconsin, 2003.

Figure 1: Comparison Between Predicted and Actual Times (Sign 1)

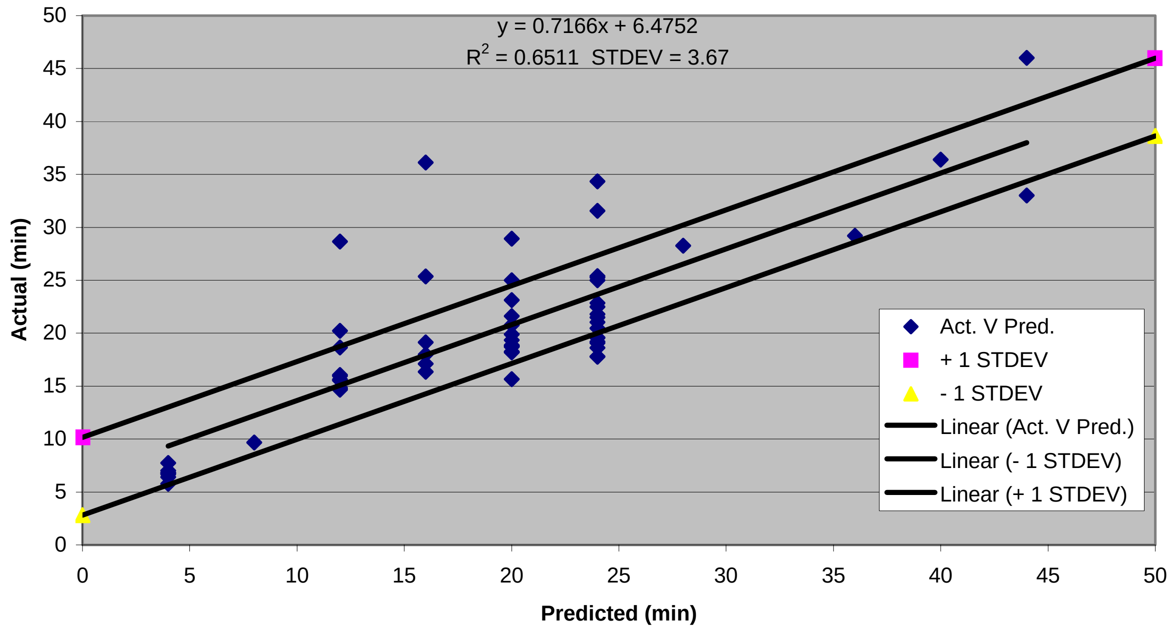

Figure 2: Comparison Between Predicted and Actual Times (Sign 2)

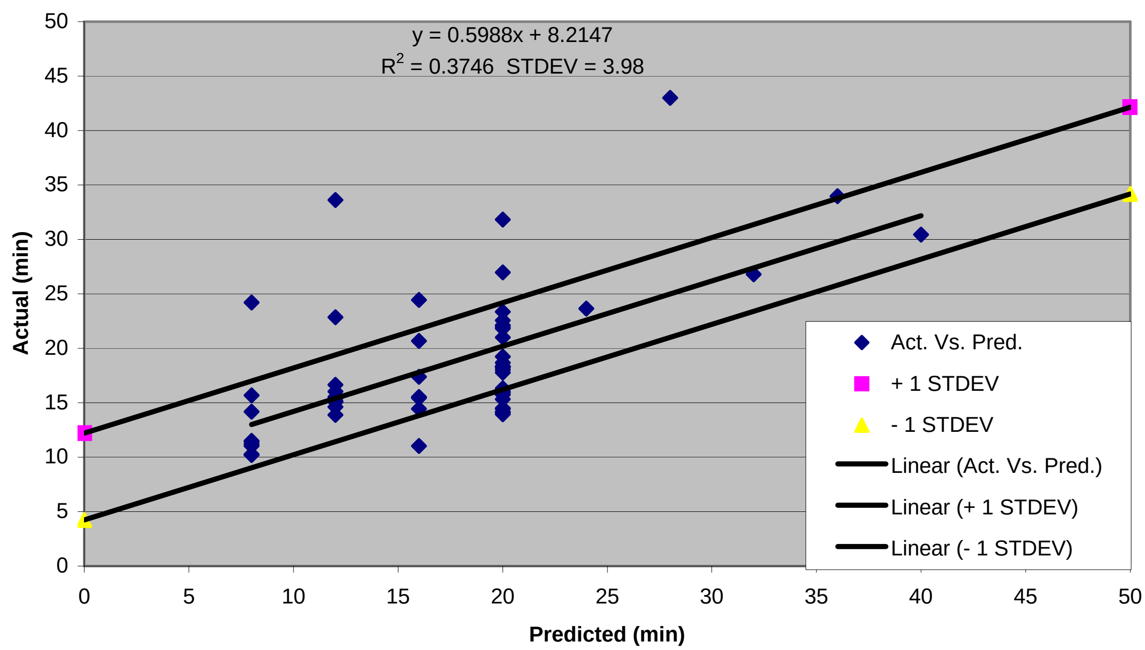

Figure 3: Comparison Between Predicted and Actual Times (Sign 3)

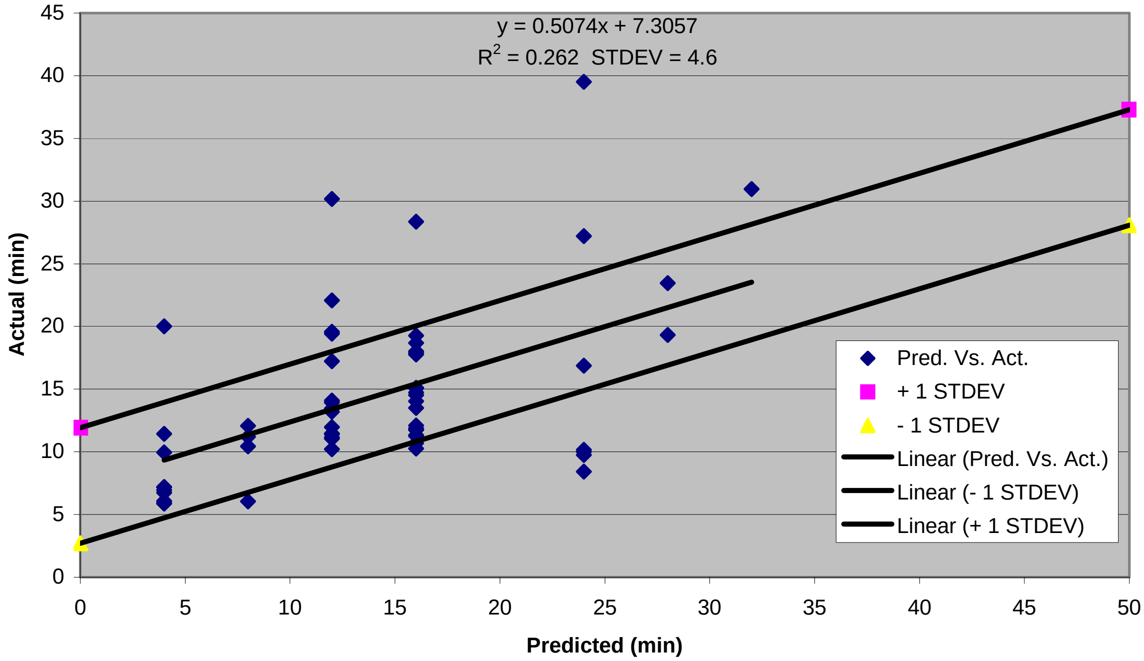

Figure 4: Comparison Between Predicted and Actual Times (Sign4)