



HISTORIC  
FRANKLIN  
TENNESSEE

ITEM #8  
WRKS 02/23/2010

## MEMORANDUM

February 3, 2010

**TO:** Board of Mayor and Aldermen

**FROM:** David Parker, City Engineer/CIP Executive  
Eric Stuckey, City Administrator *Ei*

**SUBJECT:** Goose Creek Bypass/I-65 Interchange  
SPUI vs TUDI – Additional Information

### Purpose

The purpose of this memorandum is to provide the Board of Mayor and Aldermen (BOMA) with additional information regarding options for the interchange design at the Goose Creek Bypass and I-65.

### Background

For initial background concerning this issue see attached memo from David Parker and Eric Stuckey to BOMA dated December 29, 2009. The additional information being provided is based on comparisons of the **Interchange Modification Study** prepared by Sain Associates, Inc for the Tennessee Department of Transportation (TDOT) and the traffic studies prepared by Fischbach Transportation Group, Inc. for the Boyle Developments located on three quadrant of the interchange. The traffic volumes reported in these studies are then compared to the results of a study, “**Tight Diamond Interchange versus Single Point Urban Interchange: Pedestrians Perspective**”, conducted by Ahmed Amer, M.S., Center for Sustainable Mobility, Virginia Tech Transportation Institute (see attached presentation by Mr. Amer at the 2<sup>nd</sup> International Symposium on Freeway and Tollway Operations in June 2009).

From comparing the Sain Associates volume Projections with the Fischbach projections for the design year 2028, we found that the Fischbach volumes averaged 25% higher overall combining the AM and PM peak hour periods (23% in the AM peak and 27% in the PM peak). The percentage differences of the Fischbach volumes on the east side of the interchange are double those on the west side of the interchange. With this difference in volumes we wondered if the two firms’ studies included the same developments in their projections.

Further comparison of the traffic studies seem to indicate that the Fischbach studies included additional approved developments from the Sain study. The Fischbach studies identify the Stream Valley and Ladd Park developments as components of the background traffic. After adding the Stream Valley and Ladd Park site traffic to the Sain interchange volumes, and comparing the resulting total to the Fischbach volumes, the Sain plus off-site volumes is overall about 6% below the Fischbach projections (4.5% in the AM peak and 8.0% in the PM peak). Since these differences are now within an acceptable statistical error range when comparing these type studies, we have concluded that the Sain Associates traffic volume projections have not accounted for the Stream Valley and Ladd Park predicted traffic. Therefore, it appears appropriate to use the Fischbach traffic volumes as the expected interchange traffic volumes for the design year 2028. The Fischbach studies indicate a 2028 AM design hour volume of 7,769 VPH and a 2028 PM design volume of 11,217 VPH.



The Amer study, Tight Diamond versus Single Point, used as part of the study design various levels of service (LOS) depending on the traffic loading volumes. These are, Light (4000 VPH), Medium (5500 VPH) and Heavy (7000 VPH) [VPH = vehicles per hour]. The conclusions from this study are that the single point urban interchange (SPUI) is more efficient over the tight diamond interchange (TDI) for Heavy and Medium Traffic and either type interchange can be used for Light Traffic. From the Fischbach traffic studies the Goose Creek/I-65 Interchange is expected to experience Heavy Traffic by the design year 2028.

From the Research Development and Technology report for the Missouri Department of Transportation (MoDOT) as related in the December 29<sup>th</sup> memo, when the crossroad volume is between 15,000 and 30,000 AADT (Average Annual Daily Traffic), SPUIs are a superior option to Diamond interchanges. The Fischbach traffic studies indicate an expected traffic volume reported as Average Daily Traffic (ADT) for design year 2028 from the Boyle Developments at the interchange of approximately 51,660 ADT. According to Carl Baughman, Traffic/Transportation Engineer for Franklin, adding background traffic from the area could increase this volume to around 90,000 ADT. Therefore, the design volumes on the crossroad point to the SPUI as the clearly superior option in terms of providing acceptable traffic service.

### **Financial Impact**

The City has already agreed to fund \$4.8 million towards the construction of a SPUI at Goose Creek/I-65. According to TDOT staff this funding is not expected to be needed until FY 2014. This funding and timing was incorporated into the Board-approved Capital Investment Funding Plan.

If the City decides to not fund the increased cost of the SPUI (rescind, or terminate, the Agreement), then TDOT will fund the entire cost of the Goose Creek Interchange and it will be constructed as a TUDI. The City would then be able to reprogram the \$4.8 million of approved capital investment funding. In accordance with Section IX of the Agreement, the City is obligated to reimburse TDOT for any expenditure(s) they have or have obligated towards the project as a SPUI. On February 2<sup>nd</sup>, Darrell Moore, Project Manager, indicated that the cost to date (December 2009 ledger) is approximately \$200,000.00.

### **Options**

1. Do nothing and continue with the approved Agreement (Pin No. 111070.00) with TDOT.
2. Rescind/terminate the Agreement (PIN No. 111070.00) with TDOT with the expectation to reimburse TDOT for costs to date. In an email dated February 2, 2010, Darrell Moore, Project Manager for TDOT stated, "To date, final ROW and utility plans are being developed and prepared to be turned in toward the middle of April 2010. Should the SPUI design be changed, the schedule would be adjusted enough in order for our Design and Structures Divisions to redevelop plans for the Diamond and would also require revised environmental and possible soils and geology work. This change could apply up to a nine-month delay to the current schedule."



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### **Recommendation**

From a technical traffic engineering standpoint, the review of literature concerning the differences between a SPUI and a TDI indicates that for future circumstance (traffic volumes) the SPUI will better serve the citizens of Franklin. The policy question for the Board then appears to be: "Is this the best use of \$4.8 million to benefit the City and its citizens?" Board direction related to this expenditure relative to our various capital needs will be needed.



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## MEMORANDUM

December 29, 2009

**TO:** Board of Mayor and Aldermen

**FROM:** David Parker, City Engineer/CIP Executive  
Eric Stuckey, City Administrator *ES*

**SUBJECT:** Goose Creek Bypass/I-65 Interchange  
Single Point Urban Interchange (SPUI)

### Purpose

The purpose of this memorandum is to provide the Board of Mayor and Aldermen (BOMA) with information regarding options for interchange design at the Goose Creek Bypass and I-65.

### Background

At the last (December 10, 2009) Capital Investment (CIP) Committee meeting there was a discussion concerning the City continuing with the Agreement (PIN No. 111070.00, dated October 24, 2008) with the Tennessee Department of Transportation (TDOT) for funding of the proposed single point urban interchange (SPUI). Through this memo we will provide some additional information to assist you in your discussions and consideration of continuing with the City's proposed funding of a portion of the construction cost of the Goose Creek Bypass/I-65 Interchange Modifications/Improvements.

The City of Franklin entered into the Agreement (PIN No. 111070.00) to fund \$4,800,000 of the construction cost of the proposed SPUI. The City did this because TDOT was planning to construct the interchange as an urban diamond (generally referred to as a Tight Urban Diamond Interchange, or TUDI) and the City wanted the interchange constructed as a SPUI. The \$4.8 million is the construction cost difference in the two types of interchanges. All design to this point for the interchange project has been done based on this Agreement, or for the construction to be a SPUI.

The main question being asked concerning Franklin's expenditure of \$4.8 million towards the construction of a SPUI verses a TUDI is; "What benefit does Franklin gain from this expenditure?" At the time the City entered into the Agreement with TDOT, the answer to this question was simply that a SPUI would provide greater traffic capacity in a safer manner. The analogy was that the City did not want to create another SR 96 (Murfreesboro Road) Interchange, typical TUDI, with its congestion and safety issues.

What we are attempting to do with this memo is provide answers to questions such as: "What is the percentage increase of capacity of a SPUI verses a TUDI?" and "What are the safety advantages that are talked about?" In order to answer these questions we have conducted a literature (reports and studies) review of the two types of interchanges and offer the following for your consideration.

### **Traffic Capacity**

The following are recommendations/comments from a Research Development and Technology report for the Missouri Department of Transportation (MoDOT) and a report from Applied Technology and

Traffic Analysis Program (ATTAP). The MoDOT report was formulated after reviewing questions sent out via the AASHTO Research Advisory Committee listserve with fourteen states responding.

1. When the crossroad volume is between 15,000 and 30,000 AADT (Average Annual Daily Traffic), SPUIs are a superior option to Diamond interchanges. SPUIs are considered to have more capacity than Diamond interchanges. So SPUIs are usually used in high volume conditions. When Volumes are between 20,000 and 35,000 AADT for major roads, a SPUI should be used instead of a Diamond Interchange.

Based on the traffic counts and projections for use in the Major Thoroughfare Plan Update using the Metropolitan Planning Organization's (MPO) traffic model, the 2008 AADT for the Goose Creek Bypass (crossroad) is 12,215 (count station is west of I-65) with the projected 2035 AADT at 18,602. This 2035 projected AADT exceeds the volume stated as when a SPUI is a superior option and we feel that this projection is low. The reason we feel the projection is low is because it doesn't appear that the Berry Farms Development approved concept plan(s) have been taken into account in predicting population and employment numbers for the various Traffic Analysis Zones (TAZs) that cover this development. For instance, the TAZ covering the Reams-Fleming Section of the Berry Farms Development lists a population of zero (0) and employment of zero (0) when the approved concept plan indicates 400 residential units and 2,212,700 SF of commercial/office. We have forwarded this information to our consultant doing the Major Thoroughfare Plan Update for correction in the model. Just as the TAZ for the Reams-Fleming area appears to need correction, the other two TAZs covering the remaining sections of the Berry Farms Development need to be corrected and these corrections will indicate an increase in the predicted traffic to use the Goose Creek Interchange.

The major road (I-65) has a 2008 AADT count of 56,638 and a projected 2035 AADT of 121,474. The 2008 AADT count already exceeds the volume of traffic for the major roads stated above when a SPUI "should" be used.

2. It is easier to coordinate the SPUI's one signal with other signalized intersections compared to the Diamond interchanges's two signals. Thus the SPUI is preferred when arterial coordination is required. A typical SPUI has a three-phase signal verses a four-phase controller.

Upon completion of development in the Goose Creek Interchange area, there must be signal coordination along the Goose Creek Bypass/Peytonsville Road corridor. This corridor is listed as a major arterial in Franklin's Major Thoroughfare Plan. Between Lewisburg Pike and I-65, the Berry Farms Development has three (3) major access points approved on Goose Creek Bypass. If a TUDI was constructed, there would be a potential to have six (6) signalized intersections from Lewisburg Pike to I-65 (signal at Lewisburg and two at I-65 included) within a distance of approximately 0.9 miles. This compares to seven (7) signalized intersections on SR 96 (Murfreesboro Road) from Mack Hatcher Parkway to I-65, a distance of approximately 1.25 Miles.



3. Left-turn paths are flatter for a SPUI and can be made at higher speeds, thus increasing saturation flow rates and intersection capacity.

### **Safety**

We have been unable to find any study indicating a major difference in the number of accidents with use of the two different types of interchanges (SPUI vs TUDI). From an ATTAP report we have found that SPUIs seem to have an increased number of side-swipe accidents compared to the TUDI, but a smaller number of angle accidents. Typically, angle accidents are more severe than side-swipe accidents, thus more injuries. In a SPUI design there is only one conflict point, as compared to the two for a TUDI.

From a study conducted through the Federal Highway Administration, Turner-Fairbank Highway Research Center, titled "Crash Comparison of Single Point and tight Diamond Interchanges" we have learned that, that the safety comparison did not reveal a significant difference between the two types of interchanges for total crash. However, the SPUIs were found to be safer than the comparable TUDI for injury and fatality frequencies.

The answer to the original question of what benefit does the City get from the construction of a SPUI, is reduced congestion, improved capacity and increased safety. It is impossible, however, to quantify the exact percentage of these benefits. Studies simply have not been accomplished that provides that data.

### **Financial Impact**

The City has already agreed to fund \$4.8 million towards the construction of a SPUI at Goose Creek/I-65. According to TDOT staff this funding is not expected to be needed until FY 2014. This funding and timing was incorporated into the Board-approved Capital Investment Funding Plan.

If the City decides to not fund the increased cost of the SPUI (rescind, or terminate, the Agreement), then TDOT will fund the entire cost of the Goose Creek Interchange and it will be constructed as a TUDI. It is our understanding that there will be some delay in the project being ready for construction if TDOT has to change the design of the interchange from a SPUI to a TUDI. Also, in accordance with Section IX of the Agreement, the City is obligated to reimburse TDOT for any expenditure(s) they have or have obligated towards the project as a SPUI. We do not know the magnitude of expense incurred by TDOT to date on this design.

### **Options**

1. Do nothing and continue with the approved Agreement (Pin No. 111070.00) with TDOT.
2. Rescind/terminate the Agreement (PIN No. 111070.00) with TDOT with the expectation to reimburse TDOT for costs to date. Reprogramming the \$4.8 million of approved capital investment funding.

### **Recommendation**

From a technical traffic engineering standpoint, the review of literature concerning the differences between a SPUI and a TDUI indicates that for future circumstance (traffic volumes) the SPUI will better



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serve the citizens of Franklin. The policy question for the Board then appears to be: "Is this the best use of \$4.8 million to benefit the City and its citizens?" Board direction related to this expenditure relative to our various capital needs will be needed.





# **Tight Diamond Interchange versus Single Point Urban Interchange: Pedestrians Perspective**

**Ahmed Amer, M.S.**

Ph.D. Candidate, CEE

Center for Sustainable Mobility

Virginia Tech Transportation Institute

Virginia Tech

**2<sup>nd</sup> International Symposium on Freeway  
and Tollway Operations**

June 2009

# Outline

- Introduction
- Problem Definition
- Study Design
  - Traffic Volumes
  - Signals Phasing
- Analysis Results
  - Light Traffic Scenarios
  - Medium Traffic Scenarios
  - Heavy Traffic Scenarios
- Summary and Conclusions

# Introduction

**TDI**

Tight Diamond  
Interchange

vs.

**SPUI**

Single Point Urban  
Interchange

## Control Operation

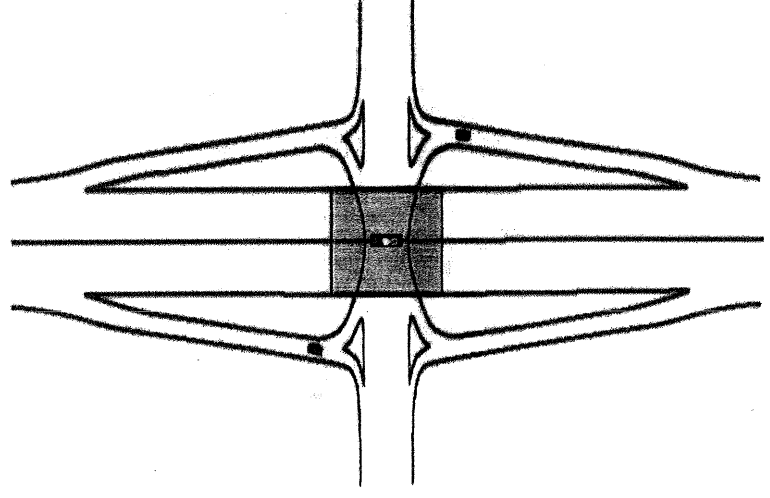
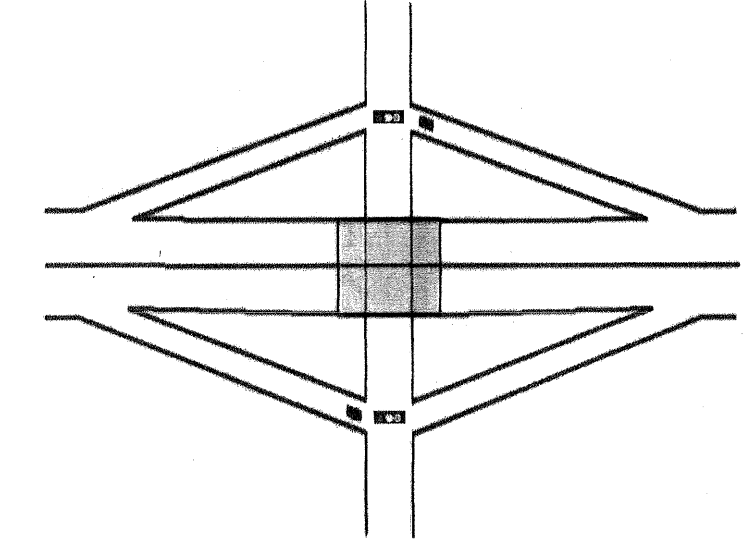
- Operates as two closely spaced signalized intersections, managed together as one signal
- Compresses the two intersections into one signalized intersection

# Introduction

**TDI**

**SPUI**

**General Layout**

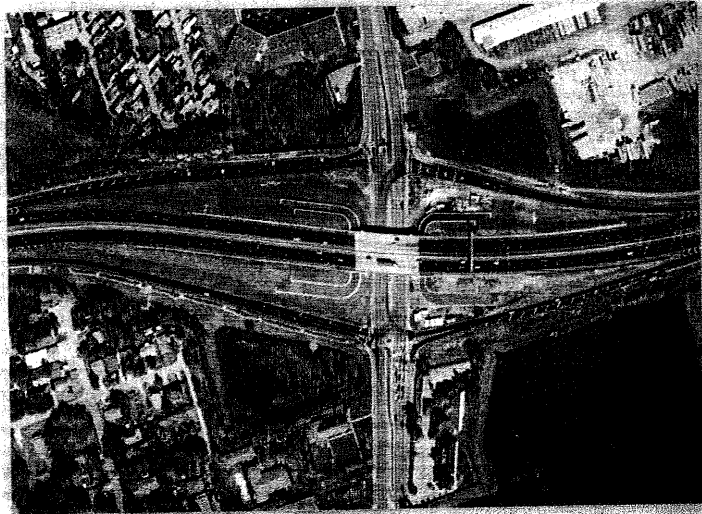


# Introduction

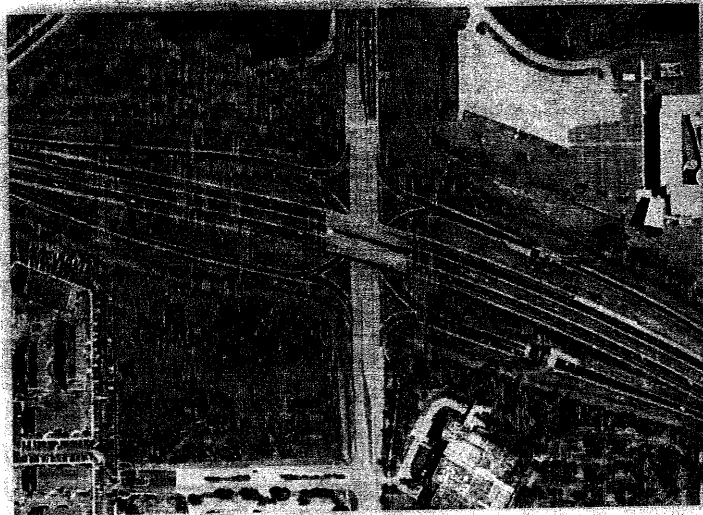
**TDI**

**SPUI**

## Example Application



SR-408 at Kirkman Road, FL



SR-408 at Valencia Collage Lane, FL

Ahmed Amer

# Introduction

**TDI**

**SPUI**

## Operation Features

- Easier for the user to understand and get familiar with
- Shorter clearance times
- Left turns proceed simultaneously
- Less delay with heavier traffic volumes

# Problem Definition

- Many arguments over the use of the TDI or the SPUI:
  - Apparently, SPUI is more preferred over TDI
  - Considering pedestrians, SPUI may have longer delays than TDI
- Pedestrian control requires sufficient clearance time based on the walking speed:
  - MUTCD = 4.0 ft/sec (Traditionally)
  - ADAAG = 3.5 ft/sec (Considering disabilities)

# Problem Definition

## Study Objectives:

- to compare the performance of the TDI vs. the SPUI from a pedestrians-operation perspective
- to investigate the impact of reducing walking speed from 4.0 ft/s (MUTCD) to 3.5 ft/s (ADAAG)



# Problem Definition

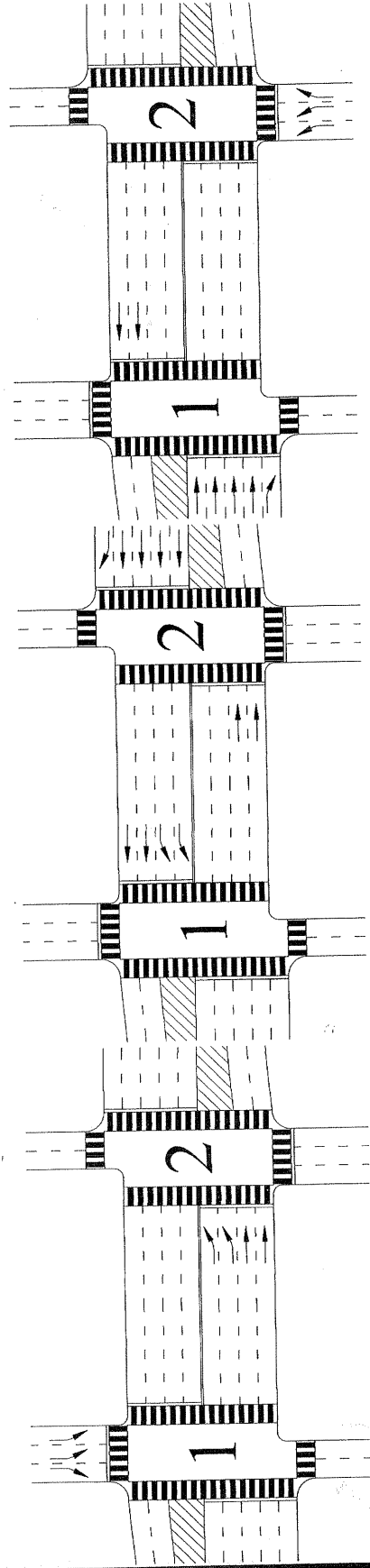
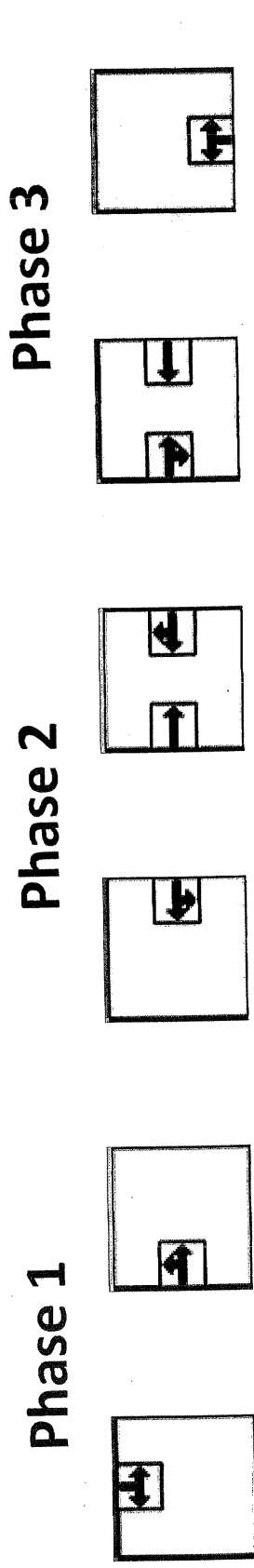
- Control delay is the main measure of performance for the signalized intersection
- Control delay: delay experienced by a driver due to congestion at an intersection due to:
  - deceleration while approaching the intersection,
  - stopping in a queue at the intersection, and
  - acceleration after the queue is released
- Hence, control delay is used to compare the operation of the TDI vs. the SPU

# Study Design

- Three traffic loading volumes: (various LOS)
  - Light (4000 vph)
  - Medium (5500 vph)
  - Heavy (7000 vph)
- Two traffic balance distributions:
  - Balanced (70% arterial / 30% ramps)
  - Heavy ramps (60% arterial / 40% ramps)
- Two pedestrian speeds:
  - MUTCD (4.0 ft/sec)
  - ADAAG (3.5 ft/sec)
- Total: 12 TDI + 12 SPUI = 24 loading scenarios

# Study Design

## TDI Signal Phasing:

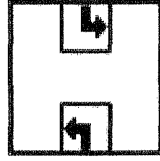


$$Y+AR = 3 + 1 = 4 \text{ sec}$$

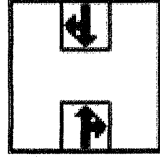
# Study Design

## SPUI Signal Phasing:

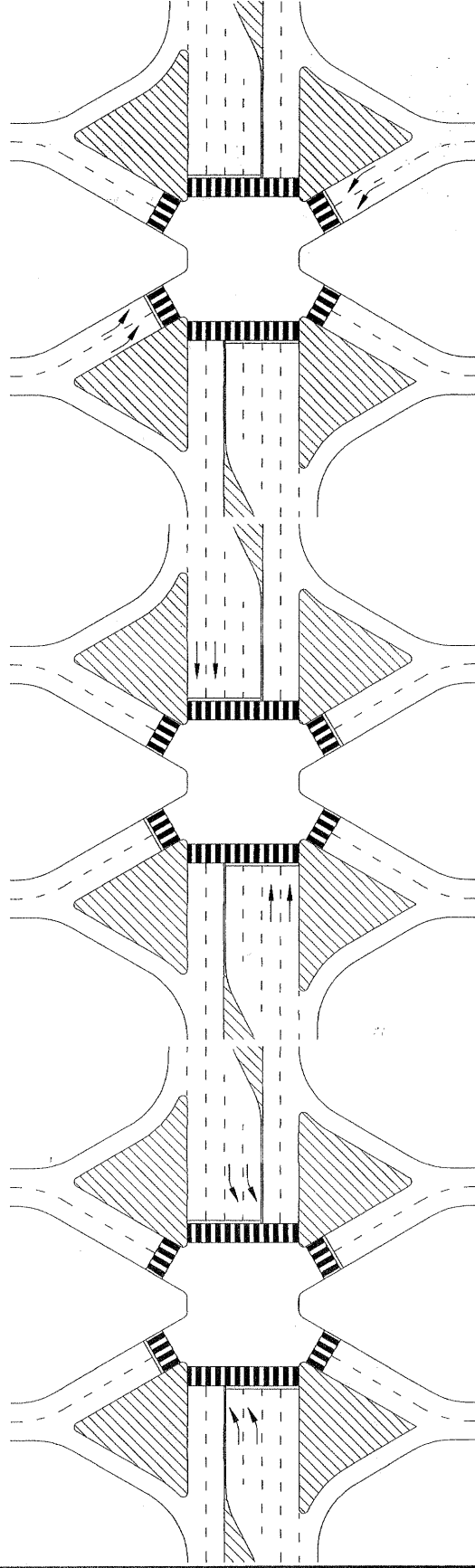
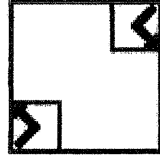
Phase 1



Phase 2



Phase 3



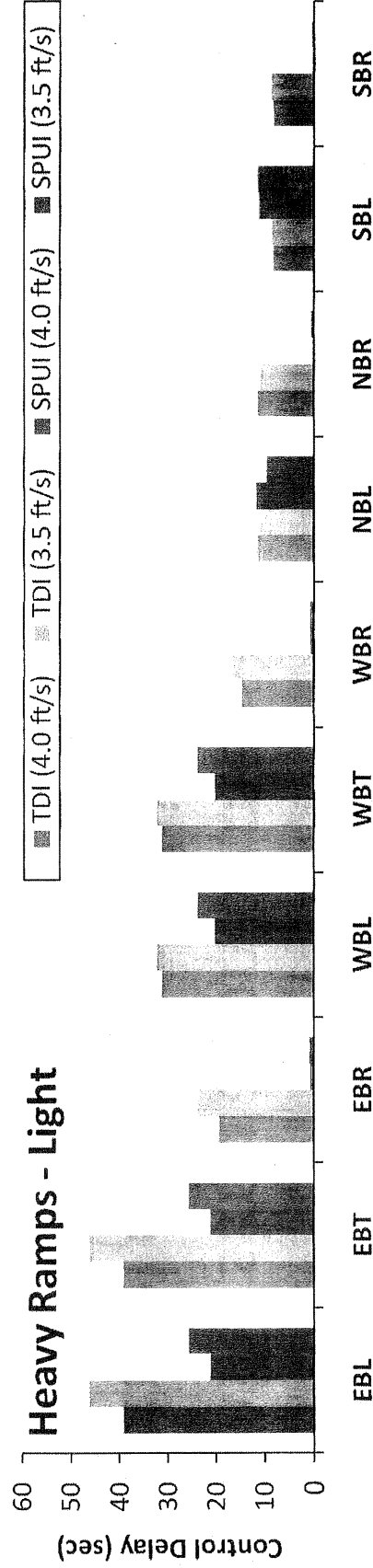
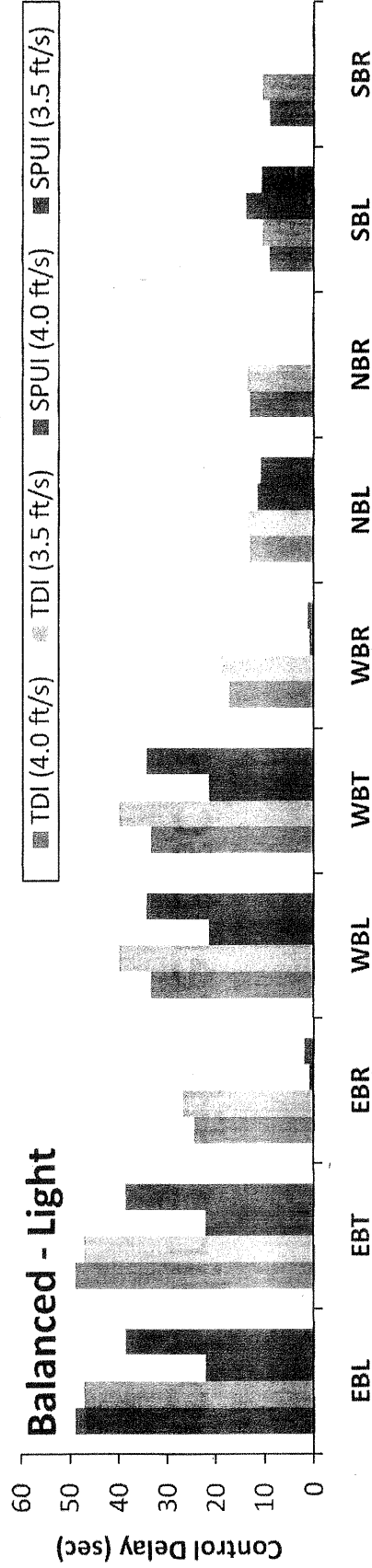
$$Y+AR = 4 + 2 = 6 \text{ sec}$$

# Study Design

- Traffic simulation to measure the average control delay per vehicle
- Synchro to optimize the signal timings
- Modeling different scenarios using CORSIM
- Control delay comparisons for different scenarios

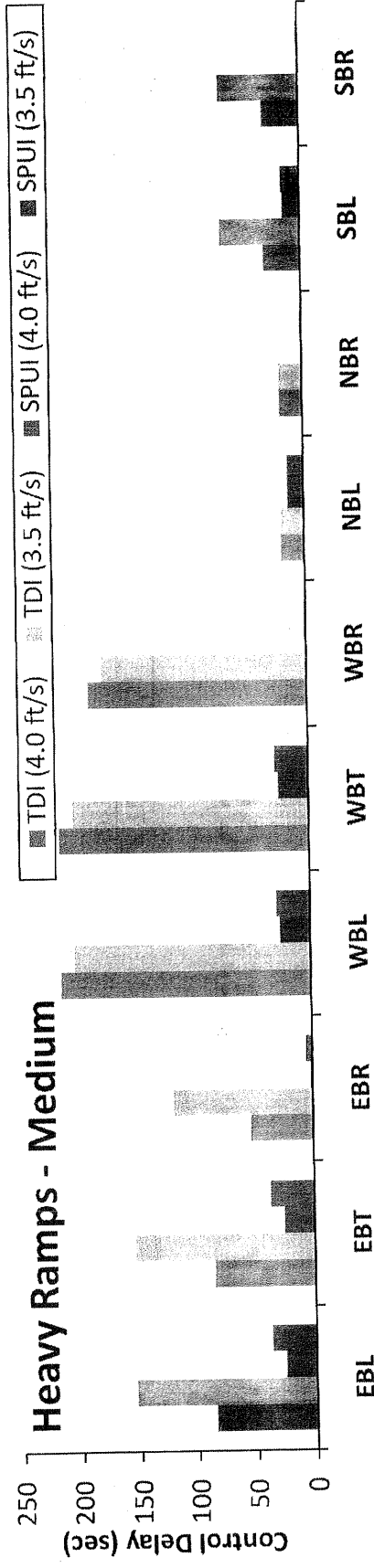
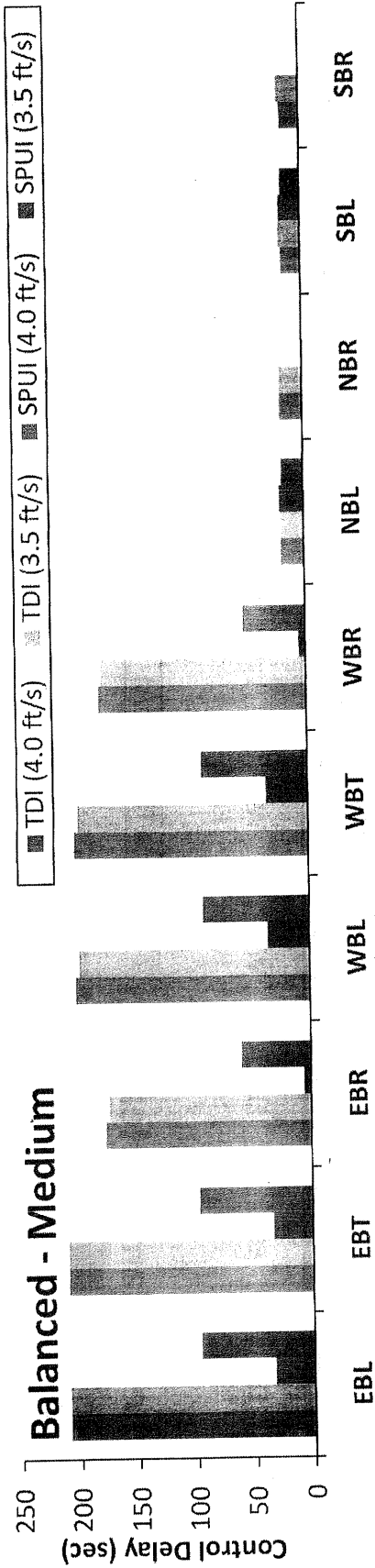
# Analysis Results

## Light Traffic Scenarios:



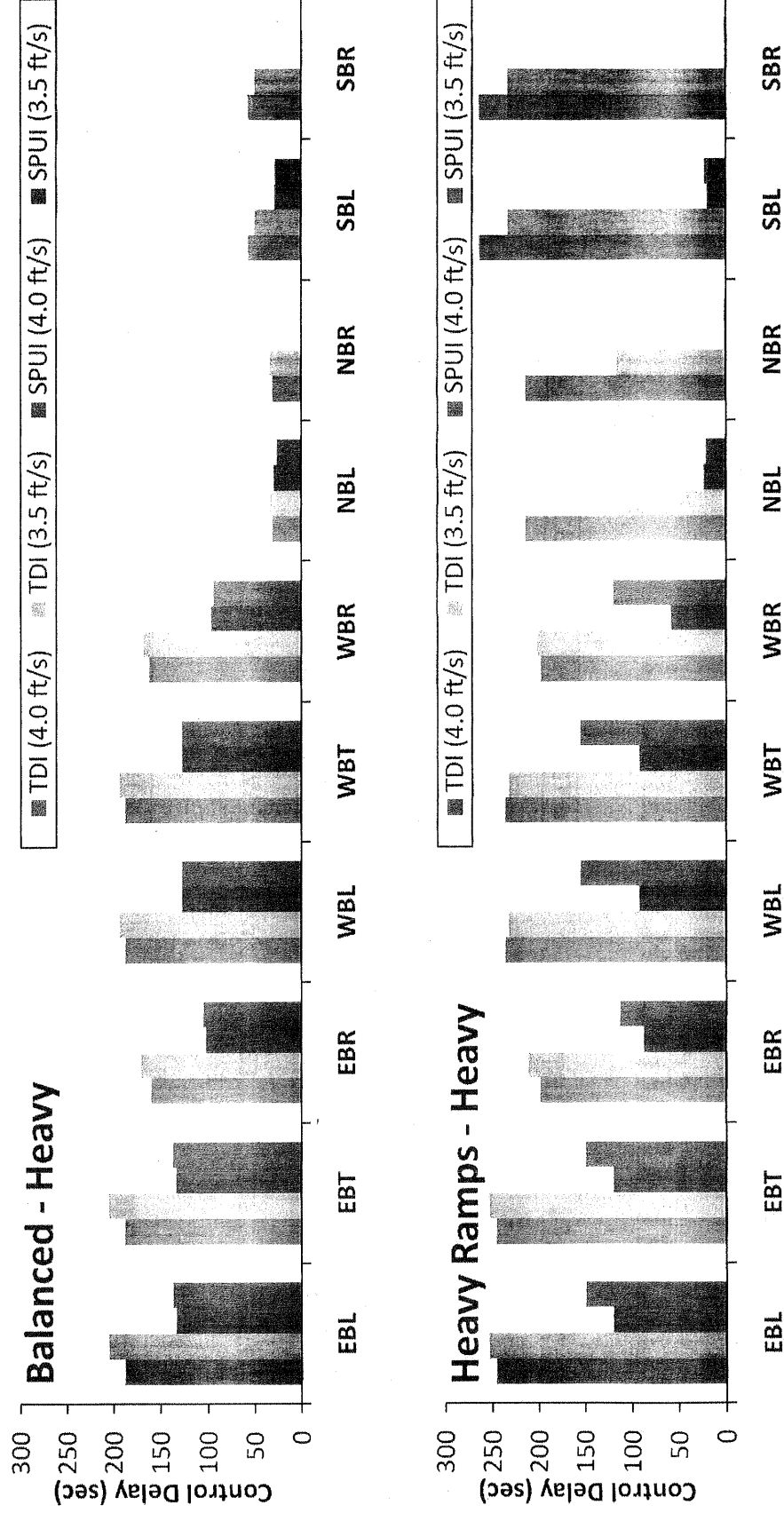
# Analysis Results

## Medium Traffic Scenarios:



# Analysis Results

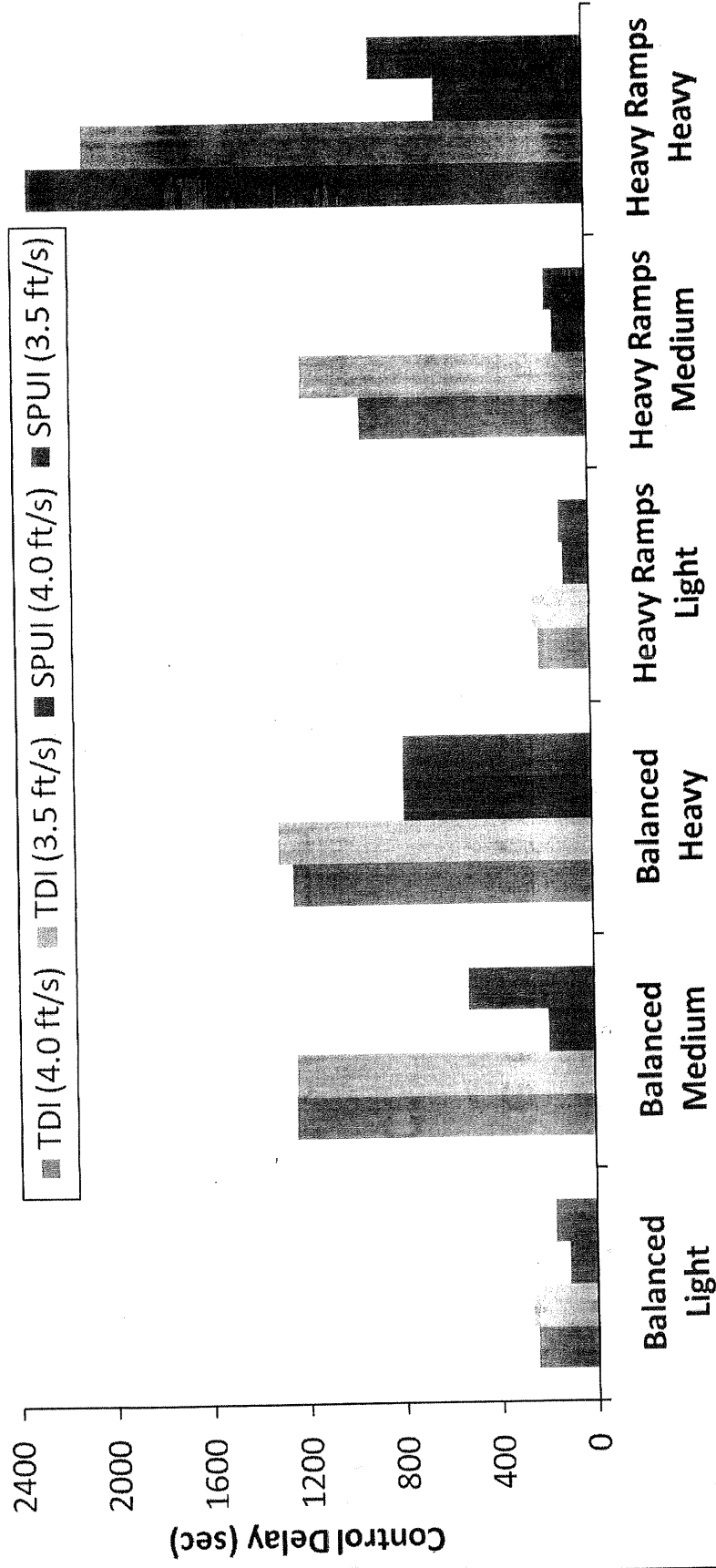
## Heavy Traffic Scenarios:





# Summary & Conclusions

## Total Control Delay – All Scenarios:



# Summary & Conclusions

- Heavy and Medium Traffic:
  - **SPUI** is more efficient over **TDI**
- Light Traffic:
  - Either **SPUI** or **TDI** can be used
- Traffic Distribution:
  - Small impact on control delay
- Walking Speed:
  - Minor effect with light and medium traffic
  - Not recommended with heavy traffic