# TRAFFIC MODELS AS PROACTIVE TRAFFIC SIGNAL MANAGEMENT TOOLS: A CASE STUDY IN HILLSBOROUGH COUNTY, FLORIDA

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## Abstract

This paper focuses on the methodologies used to create and validate a countywide Synchro traffic model for Hillsborough County, Florida. The validated traffic model is used to conduct traffic signal retiming and capacity analysis on a continuous basis. Procedures used to conduct the project are documented and where appropriate, recommended best practices are offered.


## Introduction

The Traffic Signal Operation Self Assessment[1] recently conducted by the National Transportation Operations Coalition brought to light the current state of managing our traffic signals and signal systems. Although the self assessment painted a poor picture of traffic signal management, many jurisdictions were well aware of their shortcomings and are actively working to improve the situation. This article discusses the recently completed Phase 1 of Hillsborough County's proactive Signalized Intersection Timing Update Program (SITUP), which included creation and validation of the countywide Synchro traffic model. The goals of the SITUP project are to reduce vehicular, pedestrian and bicycle crashes, travel time, and emissions. In addition, these improvements can be used to benchmark the performance at signalized intersections and calculate the benefit-cost ratio of updating signal timing plans. Building a countywide traffic model is a starting point and a tool to be used in the effort to reach the goals of SITUP. The reasons the model was built, the methodologies used to validate the model, and how the model is used now and in the future are documented. The procedures and methodologies presented in this paper can provide scalable solutions for jurisdictions of all sizes.

## Background

Hillsborough County is a rapidly growing jurisdiction encompassing Tampa, Florida. The County currently operates nearly 500 traffic signals, over 60 percent coordinated, under central system control. Three traffic signal timing technicians perform tasks ranging from annual operations reviews to citizen concerns, as well as maintaining and updating signal timing. As with most agencies, staff is over tasked with daily activities. Several years ago, staff set out to transform from a reactive to a proactive approach as related to traffic signal timing. Early steps to achieve that goal included training of personnel, implementation of management procedures, tracking citizen and interagency contacts, and procurement of hardware and software tools.

Initial staff training included a traffic engineering seminar on traffic flow theory and well as hardware and software vendor training seminars. Synchro was chosen as the traffic model to provide capacity analysis and signal timing development. Synchro's Universal Traffic Data Format (UTDF) database features provided the ability to electronically transfer large data sets, which provided data migration capacity[2]. Time-Space/Platoon-Progression Diagram Generator (TS/PP-Draft) was chosen as the travel time and delay study tool. TS/PP-Draft easily connects to a commercially available GPS receiver to provide real time position and speed for signal timing fine tuning with reporting capabilities of before and after studies.

Finally, a consultant was selected that had advanced knowledge of Synchro and traffic signal timing implementation experience. The consultant provided software specific training, validated the county Synchro model, and performed signal system retiming services.

## Model Development Process

The following methodology was used to develop the Hillsborough County Synchro model.

1. **Establish base map and coordinate system:** The first step was to establish the coordinate system by which the signal system will be modeled. A base map or back ground image in dxf, bmp, or jpg formats must be used. At this stage of the model development the dxf format was used and is recommended due to its ease of use, small file size and accuracy. It is crucial that the image, in any of the allowable formats, be accurately scaled so that the intersection's *x* and *y* coordinates are correct. A coordinate-correct dxf image was used by Hillsborough County. This establishes a base map that reflects actual coordinates from the field, and can be cross-indexed with a Global Positioning System (GPS) (which is used regularly for travel time runs) and the county Geographic Information System (GIS).

2. **Develop roadway and intersection network:** Once the base map was established, the roadway network was developed using high quality aerial mapping. The aerials were used to determine approach and departure geometry, and well as measure storage lengths and crosswalk lengths. In the absence of aerial photography, personnel would have to conduct field studies to obtain this information. A method that worked well was to display the aerial image on one computer (an LCD projector works even better) and have another set up to code the geometry in Synchro.

3. **Apply intersection attributes:** Appropriate intersection attributes, such as intersection node number (identification number) and zone or system number, were coded in the model. Matching an existing physical numbering system, such as the central control software system in the case of Hillsborough County, creates relational database features which pay immediate dividends when transferring data via UTDF features.

4. **Code intersection timing data:** The existing timing sheet database was used to input the current traffic signal timing data. It was important that the data entry personnel understand not only Synchro but the controller parameters and the timing sheet in detail. There were minor translation issues that occurred between the controller timing sheet and Synchro input. Some front end work was required to ensure the accuracy of the timing parameter translations. Figure 1 illustrates a typical signal timing sheet.

5. **Enter traffic data:** A separate program within Hillsborough County Traffic Services is the traffic data collection program. The project manager established an elaborate spreadsheet that incorporates all intersection turning movement counts, approach counts and adjustments for neighborhood growth and seasonal factors. Utilizing Synchro's UTDF feature, intersection turning movement counts, heavy vehicle percentages, and peak hour factors were transferred electronically. The front end effort to establish the volume spreadsheet and the UTDF transfer was more than warranted due to the capabilities it offers.

This process is not absolute, and traffic engineers interested in developing a jurisdiction-wide model have many options. Jurisdictions may have access to many Synchro files that were developed for past timing projects or traffic studies by either staff or consultants. Synchro has the option to merge existing files together based on a coordinate-correct layout. The desired network can then be completed by adding the additional network areas using the methods identified in this paper. By starting with available network sections, the task of creating a jurisdiction wide model is greatly reduced.

## Model Validation Process

To ensure that the model was built with accurate data and that the data entry was performed correctly, model validation steps and quality review procedures were implemented. The following items highlight the model validation and quality review procedures:

1. **Verify traffic data collection procedures:** A common issue with congested systems is that traffic turning movement counts are collected based on served traffic (vehicles measured passing the stop bar), while ignoring the demand traffic (represented by the queue backup at the end of data collection period). A review of current practice revealed that new procedures needed to be implemented that accounted for demand traffic.

2. **Establish reasonable saturated flow rate defaults:** Saturated flow rate studies were conducted at random intersections throughout the county to ensure an adequate sampling of conditions. The findings of the saturated flow rate studies confirmed that the default values of the Highway Capacity Manual were accurate. This does not discount the need or value of future saturated flow rate analysis; it did however provide reasonable confidence in current practice.

3. **Conduct appropriate field reviews:** When conflicts arose between data sets, field visits were required to resolve conflicts and ensure model accuracy. Field reviews were conducted at approximately 25 percent of all intersections.

4. **Develop quality review checklists:** To ensure the data entry was accurate, quality review checklists were developed that required engineers to initial for each completed task. This included intersection location, numbering, naming, geometry, volume, and operations data. A final review was established in which the engineer is stating the model inputs are correct for each intersection. A sample of the Quality Control sheet is illustrated in Figure 2.

The model validation process outlined above does not imply that the model is completely calibrated. The intent is to use the validated model as the starting point for all signal timing efforts, which may include a step to properly calibrate the model prior to stating the existing conditions analysis. Figure 3 illustrates the completed model in Synchro.

## Model Value/Uses

The process to validate the countywide Synchro model required significant time, effort and funding. Was it worth it? Will it make us more efficient? Does it support the goals of SITUP? To each of those questions the answer is a resounding yes. The following represent some of the benefits have been realized since completing the validated model:

1. **Error checking:** A byproduct of working through all of the time sheets was the inherent error checking that occurred. Issues with existing controller timings and the timing sheet database were addressed and corrected.

2. **Analysis of Congested Systems:** Once the model was complete, groups of coordinated intersections, or systems (referred to as “zones” in Synchro), were evaluated to determine a congestion index. The congestion index analyzed delay/vehicle and normalized it for the number of intersections in the zone. Intersection Capacity Utilization per intersection in the zone was also reviewed. The final ranking of most congested systems (zones) provides a starting point for the prioritized list of signal retiming projects. Figure 4 illustrates the congestion index ranking.

3. **Signal Timing:** An obvious benefit of the validated model is to have the starting point of a signal retiming project already completed. As new retiming projects are started, the appropriate sections of the countywide model are “cropped” out. Once the retiming project is completed, the changes are merged back into the countywide model, thus preserving the integrity of the database. Signal timing tool interoperability is also supported by the model. TS/PP-Draft files can be quickly created by transferring UTDF network files, reducing the preparation time to conduct travel time and delay studies and improving the accuracy of those studies.

4. **Rapid Analysis and Decision Making:** By establishing the countywide model, a benchmark intersection capacity analysis tool is available that can assist in performing rapid analysis of traffic operations. As public works professionals, the ability to accurately respond to citizen concerns or political pressure is vital to our credibility.

## Future Directions

Building on the success of Phase 1 of this project, the morning and midday peak periods will be modeled in Synchro similar to the afternoon peak. This effort will not be nearly as tasking since generally only the timing parameters and traffic volumes have changed (geometry and phasing parameters generally do not). Like a GIS, a jurisdiction-wide Synchro model is only as good as the data within it.

A key assumption in taking on these efforts will be that the model integrity will be maintained. This means that any signal timing change performed will need to be replicated in the base models. Although this may sound tedious, simple procedures will ensure this is completed accurately.

As Hillsborough County transitions to new traffic signal controllers and central control software, increased use of electronic signal timing databases will be implemented. Synchro’s UTDF features greatly enhance that future direction and our capability to meet unknown future opportunities.

It has been the intent since the beginning of the project to share the countywide model to adjacent jurisdictions and local developer consultants. The hope is that by sharing the model, increased jurisdictional cooperation as well as improved consultant deliverables will occur (resulting in reduced project evaluation time required and time delay in commenting period).

Finally, now that the model is completed it needs to be used in support of SITUP defined goals such as reducing traffic congestion and improving route travel times through improved signal timing and appropriate capacity improvement projects.

## Conclusions

Recent national attention has attempted to focus efforts on the need for improved traffic signal operations. This paper discussed recent activities in Hillsborough County for a proactive management program and one of its components – a validated countywide traffic operations model. Some of the benefits of this tool include: prioritization of signal timing projects, benchmarking of current capacity, and foremost streamlined signal timing deployment in an effort to reduce traffic congestion. The methodologies utilized in the project are scalable for jurisdictions of all sizes and has proven to be a useful tool in our efforts to improve traffic signal operations.

## References:

1. http://www.ntoctalks.com/, 4/14/2006
2. FHWA Signal Timing Process Final Report, Sabra, Wang and Associates, 12/2003
3. Hillsborough County SITUP work products and project reports, Albeck Gerken, Inc., 2005

## Jeff Gerken

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## Robert Wood

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# HILLSBOROUGH COUNTY TRAFFIC ENGINEERING

## PHASE(Ø) TIMING SHEET

| | |
|---|---|
| Flash | See Dayplan Schedules |
| Max II | ON WITH COORDINATION |

Location : Sheldon Rd @ Linebaugh Ave

Intersection # Mist # 260 System: Sheldon Rd

Node # 1260 File Name: Linebaugh Ave

| MOVEMENT | Ø | MIN | EXT | CLR | RED | MAX I | MAX II | WLK | FDW | RECALL | Mem. On/Off/CNA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EBLT (Lead-Protected) | 1 | 7 | 5.0 | 4.5 | 1.0 | 15 | 50 | | | | LOCK |
| WB | 2 | 10 | 4.0 | 4.5 | 1.0 | 40 | 65 | 7 | 33 | | |
| SBLT Protected- | 3 | 7 | 3.0 | 4.5 | 1.0 | 18 | 40 | | | | LOCK |
| NB Coord Ø | 4 | 10 | 4.0 | 4.5 | 1.0 | 45 | 70 | 7 | 39 | MIN | NON-CNA |
| WBLT (Lag-Protected) | 5 | 5 | 3.0 | 4.5 | 1.0 | 15 | 35 | | | | LOCK |
| EB | 6 | 10 | 6.0 | 4.5 | 1.0 | 40 | 75 | 7 | 32 | | |
| NBLT Protected- | 7 | 5 | 3.0 | 4.5 | 1.0 | 18 | 30 | | | | LOCK |
| SB Coord Ø | 8 | 10 | 4.0 | 4.5 | 1.0 | 45 | 70 | 7 | 36 | MIN | NON-CNA |

Comments:

| Comments | Initials | Date |
|---|---|---|
| * Set all Perms to 0-5 Seconds/ * * * Enable CKT 56 - WRM / Recall Ø4 & Ø8 WRM | | |
| * * Adjusted CSO 111 gave 5 sec to EBTH | REW | 11/08/05 |
| *** Operational Analysis / Site Survey / Adjusted Pedestrian Timings | REW | 01/30/06 |

Overlap

OLA = WBRT

OLB = Ø N/A

OLC = Ø N/A

OLD = Ø N/A

Prepared By: Robert Wood Date: 01/30/06 Approved By: Date:

Reviewed By: Date: Implemented By: Date:

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# HILLSBOROUGH COUNTY TRAFFIC ENGINEERING

## COORDINATION TIME SHEET

Location : Sheldon Rd @ Linebaugh Ave

Intersection # Mist # 260

Ø # Movement

Ø1= EBLT (Lead-Protected)

Ø2= WB

Ø3= SBLT

Ø4= NB

Ø5= WBLT (Lag-Protected)

Ø6= EB

Ø7= NBLT

Ø8= SB

OLA= WBRT

OLB= Ø N/A

OLC= Ø N/A

OLD= Ø N/A

Day Plan # 1

| Day | Time | Cycle | Split | Offset |
|---|---|---|---|---|
| M-F | 00:00 | CKT | 13 | OFF |
| M-F | 05:30 | CKT | 13 | ON |
| M-F | 05:30 | 1 | 1 | 1 |
| M-F | 08:45 | 2 | 1 | 1 |
| M-F | 14:30 | 3 | 1 | 1 |
| M-F | 19:00 | 2 | 1 | 1 |
| M-F | 23:00 | CKT | 13 | OFF |

Day Plan # 2

| Day | Time | Cycle | Split | Offset |
|---|---|---|---|---|
| S-S | 00:00 | CKT | 13 | OFF |
| S-S | 07:00 | CKT | 13 | ON |
| S-S | 07:00 | 2 | 1 | 1 |
| S-S | 23:00 | CKT | 13 | OFF |

Cycle Lengths

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 150 | 120 | 150 | | |

Offsets

| SECS | Cycle 1 | Cycle 2 | Cycle 3 | Cycle 4 | Cycle 5 |
|---|---|---|---|---|---|
| Off 1 | 77 | 29 | 78 | | |
| Off 2 | | | | | |
| Off 3 | | | | | |
| **%** | **Cycle 1** | **Cycle 2** | **Cycle 3** | **Cycle 4** | **Cycle 5** |
| Off 1 | 51% | 24% | 52% | | |
| Off 2 | | | | | |
| Off 3 | | | | | |

Phase Splits

| | | CYCLE 1= | 150 | | | CYCLE 2= | 120 | | | CYCLE 3= | 150 | | | CYCLE 4= | | | | CYCLE 5= | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ø | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | |
| | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec |
| 1 | 25% | 38.0 | | | 20% | 24.0 | | | 20% | 30.0 | | | | | | | | | | |
| 2 | 30% | 45.0 | | | 36% | 43.2 | | | 34% | 51.0 | | | | | | | | | | |
| 3 | 19% | 29.0 | | | 18% | 21.0 | | | 12% | 18.7 | | | | | | | | | | |
| 4 | 25% | 38.0 | | | 27% | 31.8 | | | 34% | 50.3 | | | | | | | | | | |
| 5 | 7% | 11.0 | | | 16% | 18.6 | | | 17% | 26.2 | | | | | | | | | | |
| 6 | 48% | 72.0 | | | 41% | 48.6 | | | 37% | 54.8 | | | | | | | | | | |
| 7 | 11% | 16.0 | | | 16% | 18.6 | | | 15% | 22.5 | | | | | | | | | | |
| 8 | 34% | 51.0 | | | 29% | 34.2 | | | 31% | 46.6 | | | | | | | | | | |

Force Offs

| | CYCLE 1 | | | | CYCLE 2 | | | | CYCLE 3 | | | | CYCLE 4 | | | | CYCLE 5 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ø | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | | SPLIT 1 | | SPLIT 2 | |
| | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec | % | sec |
| 1 | 25% | 38 | | | 20% | 24 | | | 20% | 30 | | | | | | | | | | |
| 2 | 55% | 83 | | | 56% | 67 | | | 54% | 81 | | | | | | | | | | |
| 3 | 75% | 112 | | | 74% | 88 | | | 66% | 100 | | | | | | | | | | |
| 4 | 0% | 0 | | | 0% | 0 | | | 0% | 0 | | | | | | | | | | |
| 5 | 55% | 83 | | | 56% | 67 | | | 54% | 81 | | | | | | | | | | |
| 6 | 48% | 72 | | | 41% | 49 | | | 37% | 55 | | | | | | | | | | |
| 7 | 66% | 99 | | | 72% | 86 | | | 69% | 103 | | | | | | | | | | |
| 8 | 0% | 0 | | | 0% | 0 | | | 0% | 0 | | | | | | | | | | |

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**Figure 1, Hillsborough County Timing Sheets**

**Signalized Intersection Timing Update Program (SITUP)**
**PM Model Validation**

Intersection Name: Hillsborough Ave(US 92) & Williams Rd
Main Street/Direction: ____________________
Intersection Node Number: 1002 Revised:_______
Assigned Intersection Zone (System Number): __________

Quality Assurance Measures:

| Task Item | Initial when completed | Comments |
|---|---|---|
| 1. Verify Intersection Name, Node Number and Zone | □ ____ | |
| 2. Verify proper node location on county DXF map. | □ ____ | |
| 3. Verify data in Lanes Window: Using the county mosaic file with ER Viewer, verify the following items:<br>▪ Approach/departure/segment geometry<br>▪ Turn pocket lengths (stop bar to middle of the taper)<br>▪ Detector settings: Side Streets and Aux lanes 22'lead/2' trail, Main Streets: 56' lead/50'trail | □ ____ | |
| 4. Verify data in Volume Window: Update Turning Movement Counts, peak hour factor and truck percentage from County TMC spreadsheet (data provided by Hillsborough County). Annotate any calibration settings in Comments. | □ ____ | |
| 5. Verify data in Phasing Window: Using the Signalized Timing Sheets (provided by Hillsborough County) verify phasing data entered correctly. Specific items include:<br>▪ Initial times: see timing sheet<br>▪ Yellow time: see timing sheet<br>▪ All Red time: see timing sheet<br>▪ Vehicle Extension (match Minimum Gap to Extension): see timing sheet<br>▪ Proper Pedestrian times (ped phase, Walk, FDW): see timing sheet<br>▪ Minimum Split: use F12 to calc, round up<br>▪ Allow Lead/Lag Optimize: set to FIXED<br>▪ Recall Mode: see timing sheet (generally C-MAX for 2/6, others NONE), listed as Min on sheet<br>▪ Dual Entry/Inhibit Max: use default | □ ____ | |
| 6. Verify data in Timing Window: Using the Signalized Timing Sheets (provided by Hillsborough County) verify timing data entered correctly. Specific CSO 311 items include:<br>▪ Standard Ring and Barrier<br>▪ Intersection operation: controller type<br>▪ Verify all phases entered properly<br>▪ Cycle length: see timing sheet<br>▪ Splits: see timing sheet<br>▪ Offset: see timing sheet (if in CNA operation, add FDW time to timing sheet offset for Synchro input)<br>▪ Offset Reference (Main Street - Beginning of Yellow) | □ ____ | □ Minimum Error reviewed and is correct |

General Comments:________________________________________________________________

Final QC Approval: ________________
Jeff Gerken, PE, PTOE
Florida PE # 61111

**Figure 2, Quality Review Checklist**

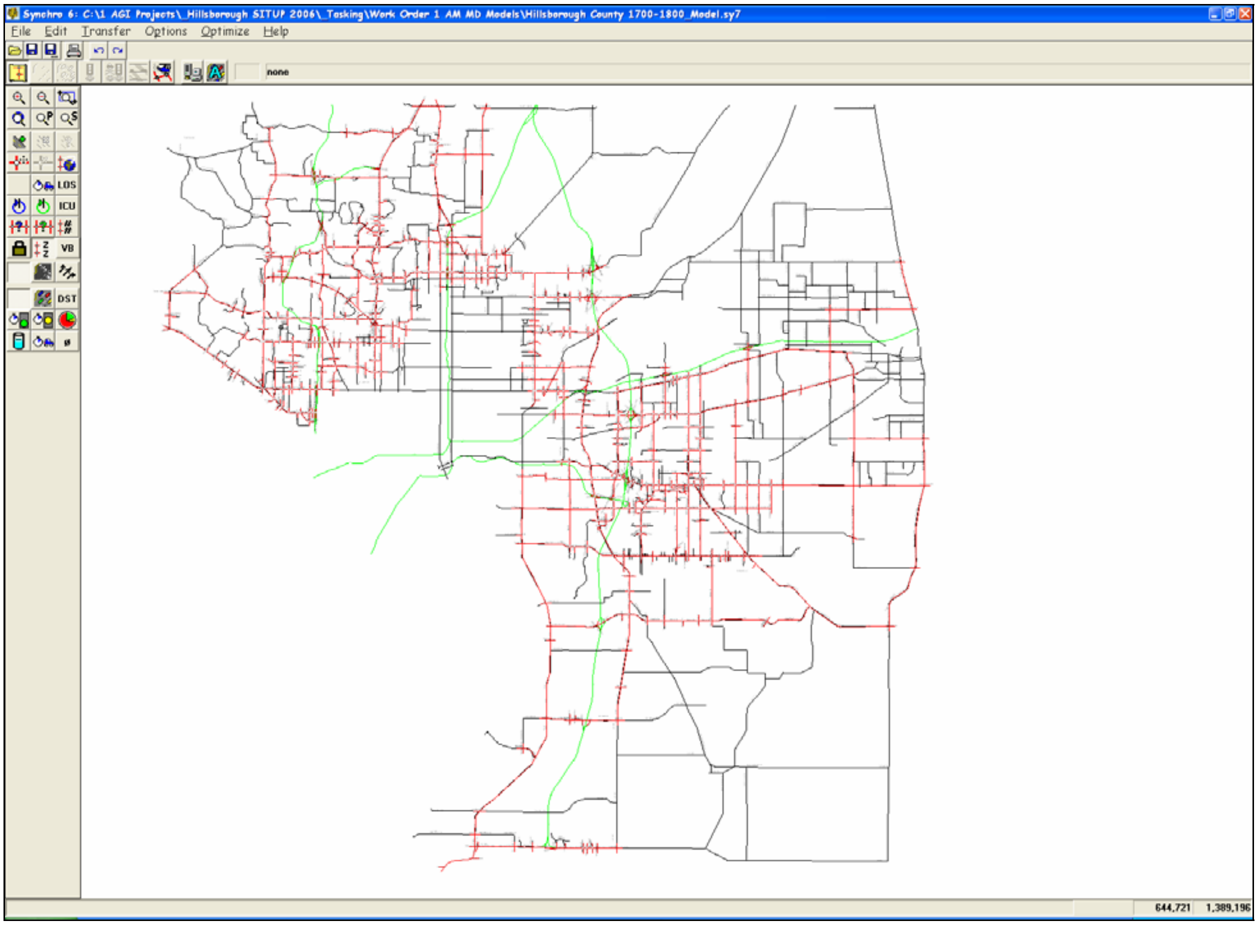


**Figure 3, Countywide Synchro Model**

| Ranking Based on Seconds of Delay/Vehicle | | | | |
|---|---|---|---|---|
| Congestion Rankings | Zone # | Total Delay / Veh (s/v) | # of Intersections in Zone | Zone Names |
| 1 | Zone 6 | 198 | 4 | BLOOMINGDALE AVE WEST |
| 2 | Zone 41 | 178 | 1 | LAMBRIGHT ST / SLIGH AV |
| 3 | Zone 15 | 174 | 19 | FLETCHER AV EAST |
| 4 | Zone 11 | 161 | 15 | DALE MABRY HWY SOUTH |
| 5 | Zone 3 | 159 | 3 | ANDERSON RD |
| 6 | Zone 4 | 123 | 4 | BENJAMIN RD |
| 7 | Zone 17 | 114 | 4 | FOWLER AVE |
| 8 | Zone 13 | 102 | 12 | EHRLICH RD |
| 9 | Zone 35 | 101 | 11 | US 301 CENTRAL |
| 10 | Zone 16 | 94 | 4 | FLETCHER AVE WEST |
| 11 | Zone 5 | 77 | 10 | BEARSS AV |
| 12 | Zone 26 | 74 | 9 | LUMSDEN RD |
| 13 | Zone 27 | 74 | 9 | MEMORIAL HWY WEST |
| 14 | Zone 34 | 70 | 17 | SR 60 WEST |
| 15 | Zone 19 | 67 | 4 | MEMORIAL HWY EAST |
| 16 | Zone 38 | 64 | 2 | WATERS AV CENTRAL |
| 17 | Zone 37 | 62 | 2 | WATERS AV EAST |
| 18 | Zone 31 | 60 | 5 | SR 60 EAST |
| 19 | Zone 46 | 55 | 3 | US 301 SOUTH |
| 20 | Zone 7 | 54 | 5 | BOYETTE RD |
| 21 | Zone 8 | 52 | 15 | BUSCH BLVD |
| 22 | Zone 9 | 51 | 10 | BLOOMINGDALE AVE EAST |
| 23 | Zone 12 | 51 | 4 | DALE MABRY HWY NORTH |
| 24 | Zone 36 | 45 | 7 | HILLSBOROUGH AV (US 92) |
| 25 | Zone 24 | 44 | 2 | SHELDON RD NORTH |
| 26 | Zone 25 | 43 | 3 | LINEBAUGH AV WEST |
| 27 | Zone 21 | 40 | 5 | HILLSBOROUGH AVE (US 92) |
| 28 | Zone 14 | 39 | 7 | FALKENBURG RD |
| 29 | Zone 32 | 37 | 8 | DR M.L.KING BLVD (SR 574) |
| 30 | Zone 22 | 35 | 10 | HILLSBOROUGH AVE (SR 580) EAST |
| 31 | Zone 39 | 34 | 8 | WATERS AV WEST |
| 32 | Zone 45 | 32 | 2 | US 301 NORTH |
| 33 | Zone 1 | 31 | 2 | 131ST AV |
| 34 | Zone 2 | 28 | 9 | 56TH ST |
| 35 | Zone 28 | 28 | 5 | PARSONS AV |
| 36 | Zone 44 | 26 | 4 | VAN DYKE RD |
| 37 | Zone 43 | 26 | 3 | PROVIDENCE RD SOUTH |
| 38 | Zone 33 | 23 | 3 | SUN CITY CENTER BLVD (SR 674) |
| 39 | Zone 23 | 22 | 6 | KINGSWAY AVE |
| 40 | Zone 40 | 22 | 4 | HILLSBOROUGH AV (SR 580) WEST |
| 41 | Zone 42 | 19 | 4 | PROVIDENCE RD NORTH |
| 42 | Zone 29 | 19 | 3 | PROGRESS BLVD |
| 43 | Zone 20 | 15 | 5 | HANLEY RD |
| 44 | Zone 47 | 14 | 4 | US 41 |
| 45 | Zone 18 | 14 | 3 | LINEBAUGH AV EAST |
| 46 | Zone 10 | 13 | 5 | BULLARD PARKWAY |
| 47 | Zone 30 | 5 | 1 | SHELDON RD SOUTH |

**Figure 4, Zone Congestion Ranking**