# TECHNICAL REPORT

## AIRPORT CIRCLE
## SAFETY & OPERATIONAL
## ANALYSIS

IN ASSOCIATION WITH:

**MBO ENGINEERING, LLC**
**BORTON-LAWSON**
**SIGNAL CONTROL PRODUCTS, INC.**


*Taylor Wiseman & Taylor*
*ENGINEERS / SURVEYORS / SCIENTISTS*

*Submitted to:*

Jennifer Marandino, PE
Team Leader, Capital Programming & Safety
**South Jersey Transportation Planning Organization**
782 Brewster Road, Unit B6
Vineland, NJ 08361

*June 30, 2013*


05463.7000.00

# TABLE OF CONTENTS:

TABLE OF FIGURES/PHOTOGRAPHS/TABLES ........ 3
INTRODUCTION: ........ 5
EXISTING TRANSPORTATION FACILITIES: ........ 6
DELILAH ROAD (ATLANTIC COUNTY ROUTE 646): ........ 6
Delilah Road and Atlantic City Expressway Interchange 9, eastbound on/off-ramps: ........ 6
Delilah Road and Atlantic City Expressway Interchange 9, westbound off ramp: ........ 6
Delilah Road, Fourth Street and Next Generation Boulevard: ........ 6
TILTON ROAD (ATLANTIC COUNTY ROUTE 563): ........ 8
AMELIA EARHART BOULEVARD ........ 8
AIRPORT CIRCLE, PRIOR TO THE 2011 CONSTRUCTION PROJECT: ........ 8
AIRPORT CIRCLE SIGNAL IMPROVEMENT PROJECT (NOVEMBER, 2011): ........ 9
AIRPORT CIRCLE CRASH HISTORY ........ 10
2003-2011 PRE-CONSTRUCTION CRASH REVIEW (Rotary Intersection, No Signal Control): ........ 11
2012 CRASH ANALYSIS (Immediate Post Construction Period): ........ 13
Crash Types—2012: ........ 13
2012 Crash Breakdown—Day of Week: ........ 15
2012 Crash Analysis: Time of Day: ........ 16
2012 Crash Analysis—Weather Conditions: ........ 17
2012 Crash Analysis—Personal Injury/Fatality Analysis ........ 18
2012 Crash Analysis--Location ........ 19
2012 Crash Analysis—Likely Causation Factors: ........ 21
2012 CRASH RATE PER MILLION ENTERING VEHICLES: ........ 22
SAFETY ANALYSIS CONCLUSIONS: ........ 23
EXISTING TRAFFIC CONDITIONS: ........ 25
TRAFFIC DATA COLLECTION: ........ 25
Manual Turning Movement Counts: ........ 26
Automatic Traffic Recorder Counts: ........ 26
Autoscope Count Detectors: ........ 27
Origin-Destination Studies: ........ 29

Saturation Flow Checks: 30
OPERATIONAL ANALYSIS (2013 AM AND PM COMMUTER PEAK HOURS): 31
EXISTING CONDITIONS: 31
TIMING MODIFICATIONS: 32
TIMING AND PHASING MODIFICATIONS: 32
AMELIA EARHART BOULEVARD RELOCATION: 33
ANALYSIS SOFTWARE: 33
MODELING NOTES: 34
LANE UTILIZATION: 37
CALIBRATION: 39
RESULTS: 39
ADDITIONAL SCENARIOS: 42
CONCLUSIONS/RECOMMENDATIONS: 43
USE OF HIGHWAY SAFETY MANUAL (HSM): 44
Crash Modification Factors: 44
SIGNING IMPROVEMENTS: 45
MINOR GEOMETRIC IMPROVEMENTS: 48
ACCESS MANAGEMENT AT SUNOCO/WAWA DRIVEWAYS: 49
PEDESTRIAN/CYCLE OPERATIONS: 49
SIGNAL OPERATIONS: 50
SOURCES/BIBLIOGRAPHY: 52

# TABLE OF FIGURES/PHOTOGRAPHS/TABLES

Figure 1: Project Location Map ........................................ 7
Photo 1: 2006 Aerial Photo of "Airport Circle" in Egg Harbor Township, Atlantic County. (Fogletto, 2010) ........................................ 8
Photo 2: Looking northwest at newly constructed "Airport Circle", November, 2011 (McKelvey, 2011) ........................................ 9
Photo 3: Looking EB on Delilah Road west of Airport Circle ........................................ 10
Table 1: Airport Circle Crash Summary, 2003-2011, Crash Type by Year ........................................ 11
Table 2: Airport Circle Crash Summary, 2003-2011—Crash Types as a % of Total Crashes ........ 12
Table 3: Crash Types Atlantic County-Wide as a Percentage of Total Crashes, 2003-2011 ........ 13
Figure 2: 2012 Airport Circle Crash Type ........................................ 14
Figure 3: Average Atlantic County Crash Types, 2003-2012 ........................................ 14
Figure 4: 2012 Crash Breakdown by Day of Week ........................................ 15
Figure 5: Average Day of Week Crashes, Atlantic County 2003-2012 ........................................ 15
Figure 6: Airport Circle Time of Day Analysis-2012 Crashes ........................................ 16
Figure 7: Average Crash Time (Time of Day), Atlantic County, 2003-2012 ........................................ 16
Figure 8: Airport Circle Crash Weather Conditions, 2012 ........................................ 17
Figure 9: Atlantic County Crash Weather Conditions Average, 2003-2012 ........................................ 17
Figure 10: Airport Circle--2012 Personal Injury/Fatality Analysis ........................................ 18
Figure 11: Atlantic County Injury Severity Average: 2003-2012 ........................................ 18
Figure 12: 2012 Airport Circle Crash Locations (bar graph) ........................................ 19
Figure 13: 2012 Crash Diagram, Airport Circle ........................................ 20
Figure 14: 2012 Crash Analysis--Likely Causation Factors, Airport Circle ........................................ 21
Figure 15: Atlantic County Average, 2003-2012, Likely Causation Factors ........................................ 21
Table 4: Crash Type by Year, Airport Circle, 2003-2012 ........................................ 23
Table 5: Crash Types as a Percentage of Total Crashes, Airport Circle, 2003-2012 ........................................ 24
Table 6: Crashes Atlantic County-Wide as a Percentage of Total Crashes, 2003-2012 ........................................ 25
Table 7: Average Daily Traffic in vicinity of Airport Circle ........................................ 27
Figure 16: Existing (2013) Volumes ........................................ 28
Table 8: AM Peak Origin/Destination Results--Airport Circle ........................................ 29
Table 9: PM Peak Origin/Destination Results--Airport Circle ........................................ 30
Table 10: Modeling Assumptions, Existing Conditions Scenario ........................................ 31
Table 11: Modeling Assumption for Timing Modifications Scenario ........................................ 32
Table 12: Lane Utilization Adjustments, Airport Circle ........................................ 38
Figure 17: Calibrated Driver Parameters, Airport Circle ........................................ 39
Table 13: Morning Peak Hour Results, Airport Circle, SimTraffic™ ........................................ 40
Table 14: Evening Peak Hour Results, Airport Circle, SimTraffic™ ........................................ 40

Table 15: Morning Peak Hour Total Zone Performance, Airport Circle, SimTraffic™ .................. 41
Table 16: Evening Peak Hour Total Zone Performance, Airport Circle, SimTraffic™ ................... 41
Table 17: Observed Destinations on Airport Circle Approaches, 2013 ....................................... 45
Photos 4, 5, 6, 7: Representative Destination Signing, Airport Circle, Atlantic County. ............. 46
Figure 18: Diagrammatic Sign Panels, Airport Circle, Atlantic County ........................................ 48
Figure 19: Proposed Geometric Improvements, Amelia Earhart Boulevard at Airport Circle. ... 48
Photo 8: Sunoco Driveway, located on south leg of Tilton Road. ............................................... 49
Table 18: Optimized Signal Timing, Airport Circle AM Peak Hour ............................................... 51
Table 19: Optimized Signal Timing, Airport Circle PM Peak Hour ............................................... 51

## INTRODUCTION:

The intersection of Delilah Road (Atlantic County Route 646), Tilton Road (Atlantic County Route 563) and Amelia Earhart Boulevard, locally known as "Airport Circle" in Egg Harbor Township, Atlantic County, New Jersey was reconstructed and opened in November, 2011. The improved intersection can be described as a hybrid circle, with Delilah Road bisecting the circle, and the Tilton Road/Amelia Earhart movements accommodated in the circle. The intersection is now controlled by a sophisticated traffic signal system, providing full actuation and four distinct phases. All approaches except Amelia Earhart Boulevard are under signalized control. Amelia Earhart Boulevard is yield sign controlled.

The rotary intersection provided significant operational challenges due to traffic growth. Traffic growth was significant within the project influence area, largely attributed to the expansion of the Atlantic City International Airport and the William J. Hughes FAA Technical Center. Improvements at the circle evolved since project inception in 1989, and several prominent civil engineering firms have been involved including Urbitran, Greenhorne & O'Mara and most recently, Dewberry.

The 2011 operational improvement was subject to public scrutiny in late 2012 due to a series of articles published in the Press of Atlantic City indicating that crash rates had increased post construction within the project area. This safety and operational analysis was commissioned by the South Jersey Transportation Planning Organization, on behalf of Atlantic County. The purpose of this analysis is to review existing crash records, review the existing traffic signal operation and make recommendations to improve both intersection safety and operations. The project team includes Taylor Wiseman & Taylor, MBO Engineering, LLC, Borton-Lawson, and Signal Control Products, Inc.

## EXISTING TRANSPORTATION FACILITIES:

The intersection of Delilah Road (Atlantic County Route 646), Tilton Road (Atlantic County Route 563) and Amelia Earhart Boulevard is located in Egg Harbor Township, Atlantic County, New Jersey. The location of the project area is depicted by Figure 1. The project area of influence extends on Delilah Road to its signalized intersections with the Atlantic City Expressway Interchange 9 Eastbound and Westbound off-ramps to the west and Next Generation Boulevard/Fourth Street to the east.

### DELILAH ROAD (ATLANTIC COUNTY ROUTE 646):

Delilah Road is a major county highway in Atlantic County. Its western terminus is the Black Horse Pike (US Route 40/US 322) in Hamilton Township. Its eastern terminus is the White Horse Pike (US Route 30) in Absecon, New Jersey. The intersection with US Route 30 is grade separated. To the west, the roadway provides access to the Atlantic City Expressway (Interchange 9). Land use along the roadway is a mix of residential and commercial. Major intersections are controlled by traffic signals, minor intersections are STOP-sign controlled. Three signalized intersections impact traffic operations at Airport Circle, including:

#### Delilah Road and Atlantic City Expressway Interchange 9, eastbound on/off-ramps:

The intersection of Delilah Road and the Atlantic City Expressway Interchange 9 eastbound on/off ramps is controlled by a three-phase semi-actuated traffic signal. Actuated phases are provided for the westbound left-turn (traffic heading eastbound on the Atlantic City Expressway) and for southbound traffic (traffic exiting the eastbound expressway proceeding eastbound or westbound on Delilah Road). Vehicle detection is provided by video-based detection. The existing controller is not coordinated with the adjacent signal at Delilah Road and Atlantic City Expressway westbound off-ramp.

#### Delilah Road and Atlantic City Expressway Interchange 9, westbound off ramp:

The intersection of Delilah Road and the Atlantic City Expressway Interchange 9 westbound off ramp is controlled by a two phase semi actuated traffic signal. The intersection is directly west of Airport Circle. Actuated phases are provided for northbound traffic (traffic exiting the westbound expressway proceeding eastbound or westbound on Delilah Road). Vehicle detection is provided by inductive loops. The existing controller is not coordinated with the adjacent signals on Delilah Road (Airport Circle to the east, AC Expressway Interchange 9 eastbound on/off ramps to the west).

#### Delilah Road, Fourth Street and Next Generation Boulevard:

The intersection of Delilah Road, Fourth Street and Next Generation Boulevard is controlled by a five-phase semi-actuated traffic signal. The intersection is directly east of Airport Circle. Individual phases are provided for eastbound/westbound left turning Delilah Road traffic, Delilah Road through traffic and for the side streets (Fourth Street and Next Generation Boulevard).


FIGURE 1

LOCATION MAP

AIRPORT CIRCLE SAFETY AND OPERATIONAL ANALYSIS

EGG HARBOR TOWNSHIP, ATLANTIC COUNTY, N.J.

Taylor Wiseman Taylor

ENGINEERS /SURVEYORS /SCIENTISTS

JUNE 2013

Fourth Street provides access to Delilah Terrace, a 102-unit manufactured housing community. Vehicle detection is provided by video based detection. The existing controller is not coordinated with the adjacent controller to the west at Airport Circle.

## TILTON ROAD (ATLANTIC COUNTY ROUTE 563):

Tilton Road is also a major county highway in Atlantic County. The southern terminus in Atlantic County is the intersection of Shore Road, Mill Road and Tilton Road in the City of Northfield, NJ, and its northern terminus is US Route 30 in Galloway Township. Route 563 actually connects Route 72 in Burlington/Ocean County with CR 629/Ocean Drive in Margate City. Similar to Delilah Road, major intersections are controlled by traffic signals, minor intersections are STOP-sign controlled. The speed limit within the project area is 50 miles per hour.

## AMELIA EARHART BOULEVARD

Amelia Earhart Boulevard provides direct access to the FAA William J. Hughes Technical Center and the Atlantic City International Airport from Airport Circle. The roadway is oriented north/south and features two lanes in each direction with turning lanes provided for left turn movements. The speed limit on Amelia Earhart Boulevard is 40 miles per hour.

## AIRPORT CIRCLE, PRIOR TO THE 2011 CONSTRUCTION PROJECT:

*Photo 1: 2006 Aerial Photo of "Airport Circle" in Egg Harbor Township, Atlantic County. (Fogletto, 2010)*

Airport Circle, prior to November, 2012, was a rotary intersection which provided direct access to the northern/southern legs of Tilton Road (CR 563), as well as the eastern/western legs of Delilah Road (CR 646), and Amelia Earhart Boulevard. Amelia Earhart Boulevard was a four-lane roadway with two lanes provided towards Atlantic City Airport, and two lanes provided for exiting traffic. Single lane approaches were provided for the Delilah Road and Tilton Road intersection approaches. The intersection's prior geometrics are illustrated by Photo 1.

The rotary intersection was known as a capacity chokepoint and a high crash area, particularly in the summer months. Despite being located in a highly sensitive environmental area in the jurisdiction of the NJ Pinelands Commission, Atlantic County began the process to improve the intersection as early as 1989. The 2011 signalized improvement project was a culmination of 15 years of planning and design, with the design consultants, Atlantic County and other stakeholders navigating both environmental and fiscal constraints on the project.

## AIRPORT CIRCLE SIGNAL IMPROVEMENT PROJECT (NOVEMBER, 2011):

In late November, 2011, Atlantic County and the South Jersey Transportation Authority opened the improved Airport Circle, concluding a thirteen month, $4.4 million construction project.


*Photo 2: Looking northwest at newly constructed "Airport Circle", November, 2011 (McKelvey, 2011)*

Elements of the intersection improvement project included:

- Delilah Road now bisects Airport Circle, allowing through traffic on Delilah Road to pass without negotiating the rotary intersection
- Installation of a state-of-the art traffic signal system providing wireless communication, video detection on all approaches, and battery back-up. Separate phases are provided for:
  - Delilah Road right-of-way
  - Southbound Tilton Road
  - Northern half of the traffic circle overlap (used to facilitate access by Amelia Earhart Boulevard, which is yield sign controlled) This overlap phase is on minimum recall.
  - Northbound Tilton Road
- Widening of Delilah Road to provide two lanes in both the east and westbound directions in the immediate vicinity of Airport Circle.
- Provision of new guide signing to assist motorists in navigating the signal-controlled rotary intersection.
- Provision of drainage improvements to support the roadway widening.

*Photo 3: Looking EB on Delilah Road west of Airport Circle*

## AIRPORT CIRCLE CRASH HISTORY

Traffic circles have been around for over a century, with one of the earliest documented being built in 1905 on the southwest corner of Central Park in New York City and named after Christopher Columbus. From the start, traffic circles provided the ability for a municipality to tie a number of intersecting roadways together and to regulate vehicular and non-vehicular traffic. Their effectiveness has been observed in both their efficiency and ability to manage relatively large volumes of traffic.

Traffic circles throughout New Jersey and the US have varied in the design and convention. The Airport Circle is no different and its post-construction improvements have made it a “hybrid” circle with the Delilah Road cut-through the middle of the Circle.

A review of literature on traffic circle safety provided very little information. A 2008 study “Operational Improvements at Traffic Circles: Safety Analysis” by Rutgers University on three circles in New Jersey indicated the same type of crash problem, same direction (rear-end) and side swipe that was found at Airport Circle. It should be noted though that all three circles were of different geometries than one another, and none were similar to the current Circle configuration. The FHWA's "Roundabouts: An informational Guide" provides a brief history and overview of traffic circles but does not provide any discussion on safety.

## 2003-2011 PRE-CONSTRUCTION CRASH REVIEW (Rotary Intersection, No Signal Control):

Although the roadway infrastructure and traffic control were changed significantly by the 2010-2011 construction at Airport Circle, the project team reviewed available crash data for Airport Circle prior to the improvements. The team has received crash reports for 2006-2008 (2008 partial year); 5 crash reports for 2005 (all in December) and one crash report for 2011 (December). In an effort to obtain crash data for 2003-2005 and 2011, the team accessed the Plan4Safety (P4S) web application. This application was developed by Rutgers University's Center for Advanced Infrastructure and Transportation's (CAIT) Transportation Safety Resource Center (TSRC). It should be noted that no crashes were reported in P4S from January 1, 2011 through April 27, 2011.

*Table 1: Airport Circle Crash Summary, 2003-2011, Crash Type by Year*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing | Other | No Crash Type Coded |
|---|---|---|---|---|---|---|---|---|---|
| **2003** | **28** | 17 | 3 | 1 | | | | 2 | 5 |
| **2004** | **31** | 12 | | 1 | | | | | 18 |
| **2005** | **29** | 16 | 1 | 5 | | | 1 | | 6 |
| **2006** | **47** | 31 | 5 | 9 | | 1 | | 1 | |
| **2007** | **54** | 35 | 3 | 14 | 1 | | | 1 | |
| **2008** | **24**** | 13 | 2 | 6 | 1 | | 1 | 1 | |
| **2009** | **30** | 24 | 3 | 2 | 1 | | | | |
| **2010** | **23** | 21 | 1 | 1 | | 1 | 1 | | |
| **2011*** | **22** | 17 | 2 | | | 2 | | | |

* No crashes reported 1/1/11 through 4/27/11
**Crashes 1/1/08 through 5/14/08 only
(projected over an entire year = 52 total crashes)

Actual crash reports
P4S

*Table 2: Airport Circle Crash Summary, 2003-2011—Crash Types as a % of Total Crashes*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing | Other | No Crash Type Coded |
|---|---|---|---|---|---|---|---|---|---|
| **2003** | **28** | 61% | 11% | 4% | | | | 7% | 18% |
| **2004** | **31** | 39% | 0% | 3% | | | | | 58% |
| **2005** | **29** | 55% | 3% | 17% | | | 3% | | 21% |
| **2006** | **47** | 66% | 11% | 19% | | 2% | | 2% | |
| **2007** | **54** | 65% | 6% | 26% | 2% | | | 2% | |
| **2008** | **24**** | 54% | 8% | 25% | 4% | | 4% | 4% | |
| **2009** | **30** | 80% | 10% | 7% | 3% | | | | |
| **2010** | **25** | 84% | 4% | 4% | | 4% | 4% | | |
| **2011*** | **22** | 77% | 9% | 0% | | 9% | | | |

* No crashes reported 1/1/11 through 4/27/11
**Crashes 1/1/08 through 5/14/08 only
(projected over an entire year = 52 total crashes)

Actual crash reports
P4S

It should be noted here that there is a discrepancy between the crash information that is reported from P4S versus the actual crash information provided by the Egg Harbor Township Police Department. P4S utilizes the NJDOT Accident Records Database which is comprised of all the crash reports that are sent to the NJDOT for inclusion. This database relies on each police department to send hard copies of every reportable crash (NJTR-1) to the NJDOT. It is assumed from the differences in total crashes that not all of the reportable crashes are in the NJDOT and P4S databases.

Using the years 2006-2008 (with a yearly projection for 2008), it can be seen from the above two tables the predominant crash type for the entire study period is same direction rear-end crashes, followed by same direction sideswipe and right angle crashes. This would be consistent with what would be expected for this type of intersection geometry.

A comparison of this particular intersection with the entire county is presented below. It should be cautioned here that the Airport Circle is a unique intersection configuration, unlike most of what is found within the county, therefore this is provided as informational only. P4S was used to produce the table below. The county roadways experience a significantly less amount of rear-end crashes overall than the Airport Circle and this is not unexpected. Crash types within the county have remained mostly consistent over the 2003 through 2011 period with the exception of fixed object and backing crashes. Changes to the crash form (NJTR-1) in 2006 may have contributed to how these crash types were reported in the past and could be a reason for the differences.

*Table 3: Crash Types Atlantic County-Wide as a Percentage of Total Crashes, 2003-2011*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing |
|---|---|---|---|---|---|---|---|
| **2003** | **10304** | 25% | 16% | 11% | 3% | 1% | 3% |
| **2004** | **10850** | 25% | 17% | 11% | 3% | 1% | 3% |
| **2005** | **10508** | 25% | 16% | 11% | 4% | 1% | 2% |
| **2006** | **10405** | 25% | 16% | 11% | 4% | 17% | 2% |
| **2007** | **10596** | 25% | 14% | 11% | 4% | 16% | 5% |
| **2008** | **10464** | 25% | 13% | 11% | 3% | 17% | 8% |
| **2009** | **10685** | 26% | 12% | 10% | 3% | 18% | 9% |
| **2010** | **9906** | 25% | 13% | 11% | 3% | 16% | 9% |
| **2011** | **9188** | 26% | 13% | 11% | 3% | 24% | 8% |

P4S

## 2012 CRASH ANALYSIS (Immediate Post Construction Period):

A review of the provided crash reports for 2012, post construction, revealed 60 crashes, 50 of which were reportable; 3 crashes were found to be outside the Circle limits, leaving 47 crashes that were analyzed for this report.

It should be noted here that caution should be exercised when using only one year's worth of crash data to draw any significant conclusions. Typically 3 years of data is desired for analysis to ascertain any trends or crash patterns.

### Crash Types—2012:

As can be seen from Figure 2 below, 53% of the crashes that occurred were same direction or rear-end crash types. These crashes tend to be property damage only (PDO), "fender-benders", with little or no injuries reported.

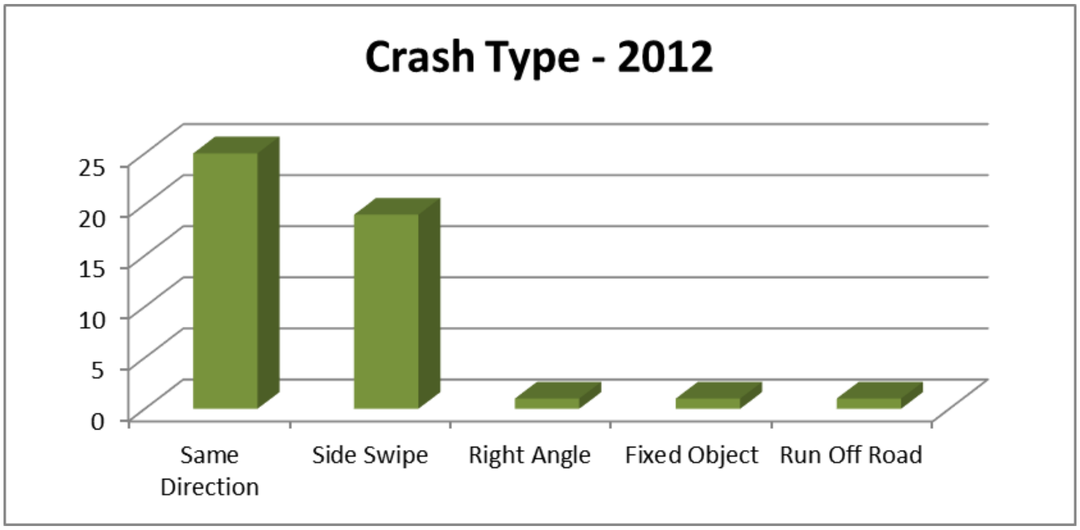



*Figure 2: 2012 Airport Circle Crash Type*

Figure 3, below summarizes the average crash types throughout Atlantic County for the years 2003-2012. The graph shows that 25% of county-wide crashes were rear-end, less than half of that occurring in the Airport Circle. Right angle crashes (county-wide) accounted for 14% of the crashes, with fixed object at 13% and side swipe at 11%.

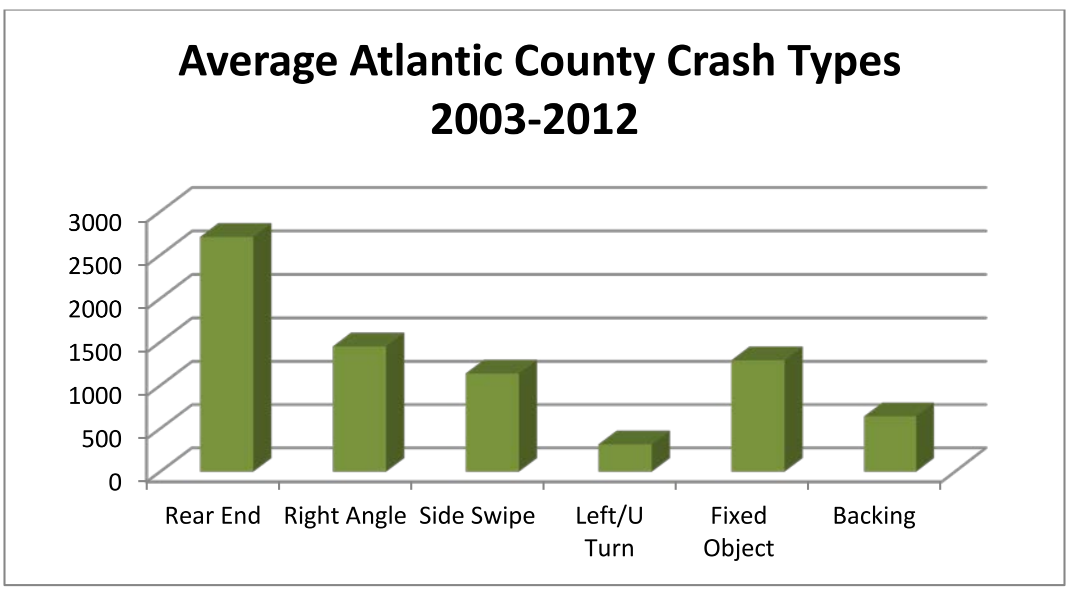



*Figure 3: Average Atlantic County Crash Types, 2003-2012*

## 2012 Crash Breakdown—Day of Week:

Figure 4 presents the breakdown of crashes by day of the week. 26% of the crashes occurred on a Tuesday, with Wednesday and Thursday, both at 17%, as the next highest days of the week for crash occurrence. This directly ties into the weekday commuting traffic patterns.

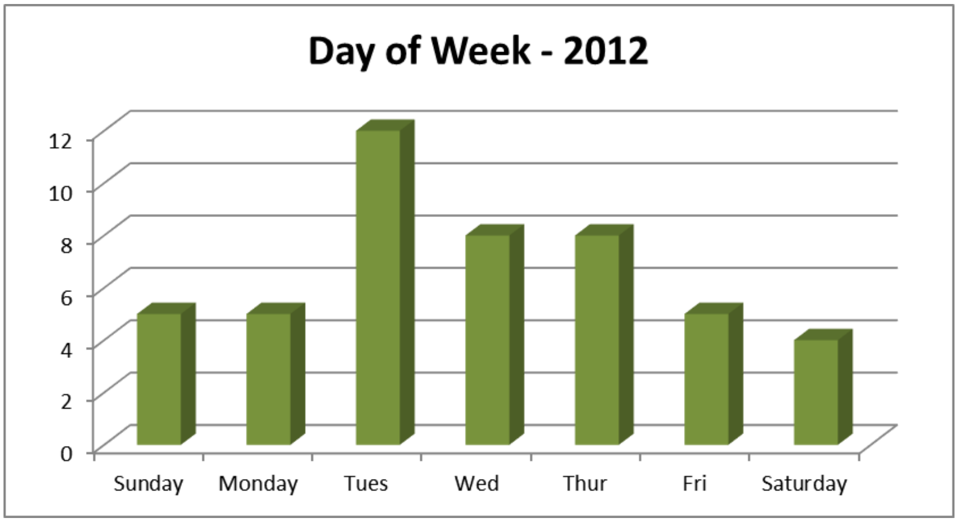



*Figure 4: 2012 Crash Breakdown by Day of Week*

Figure 5 presents the day of week average crashes throughout Atlantic County for 2003-2012. The crashes were extremely equal throughout the week, with Friday showing the highest percentage at 16% of the total crashes. This does not correlate to the Airport Circle weekly crash data.

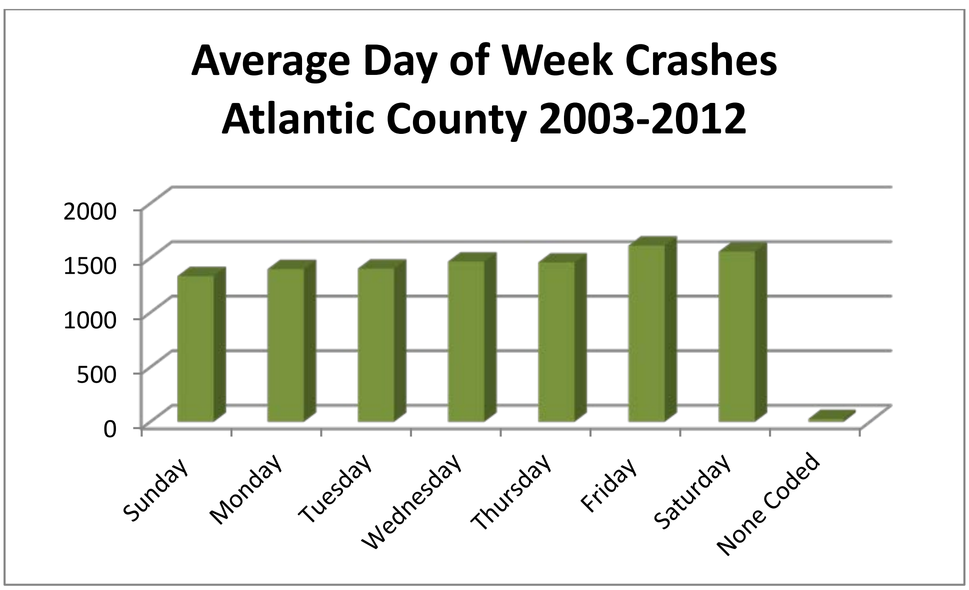



*Figure 5: Average Day of Week Crashes, Atlantic County 2003-2012*

## 2012 Crash Analysis: Time of Day:

As shown in Figure 6, the hours between Noon and 2 PM at Airport Circle showed the largest number of crashes with 21% of the total, with a drop off in mid-afternoon, but picking up again at the start of the later afternoon peak period. No significant patterns were revealed at other times as related to particular locations within the study area.

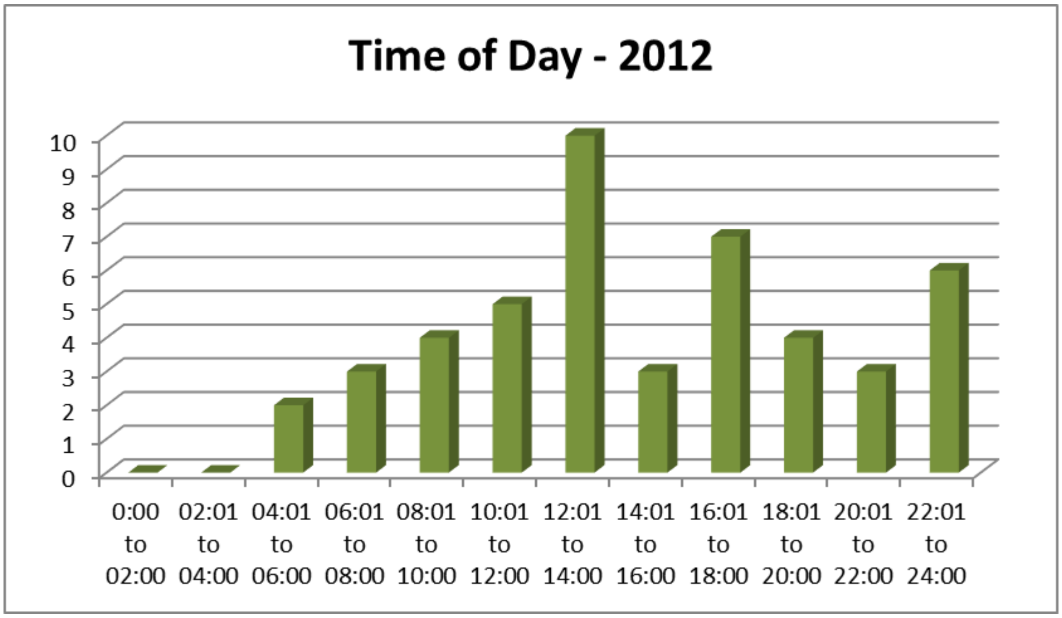



*Figure 6: Airport Circle Time of Day Analysis-2012 Crashes*

The TWT team completed an analysis of Atlantic County crashes (the entire County) by time of day between 2003 and 2012. Figure 7, below shows that 30 percent of the crashes occurred between 2 PM and 6 PM (PM commuter peak) with 13 percent occurring during the noon to 2 PM timeframe.

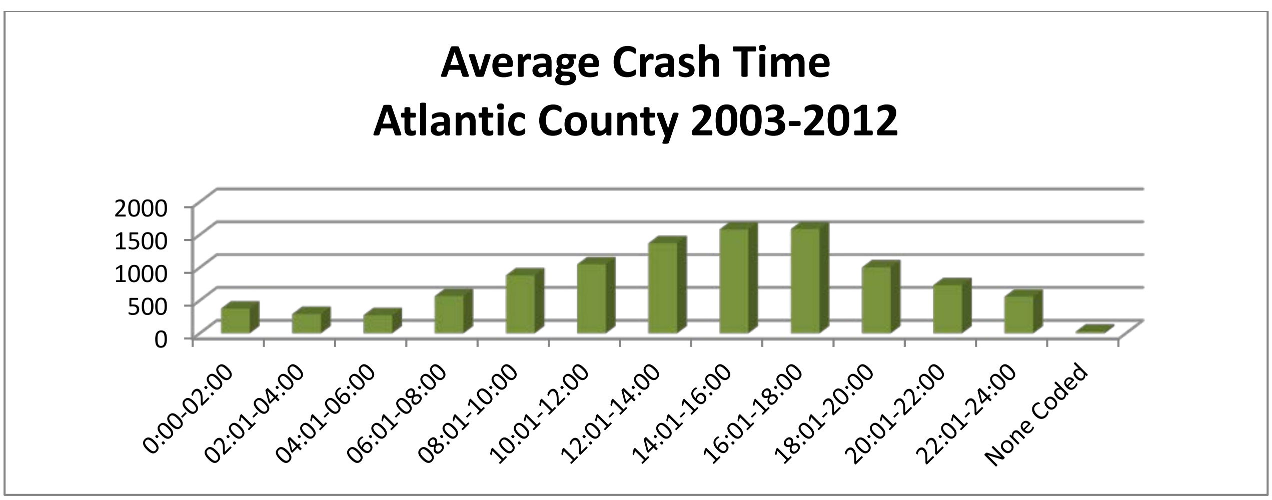



*Figure 7: Average Crash Time (Time of Day), Atlantic County, 2003-2012*

## 2012 Crash Analysis—Weather Conditions:

The weather conditions did not contribute significantly to the crash cause at Airport Circle, as 79% of all 2012 crashes occurred in clear and dry weather. Figure 8 is a graphic depiction of the crash cause at Airport Circle in 2012.

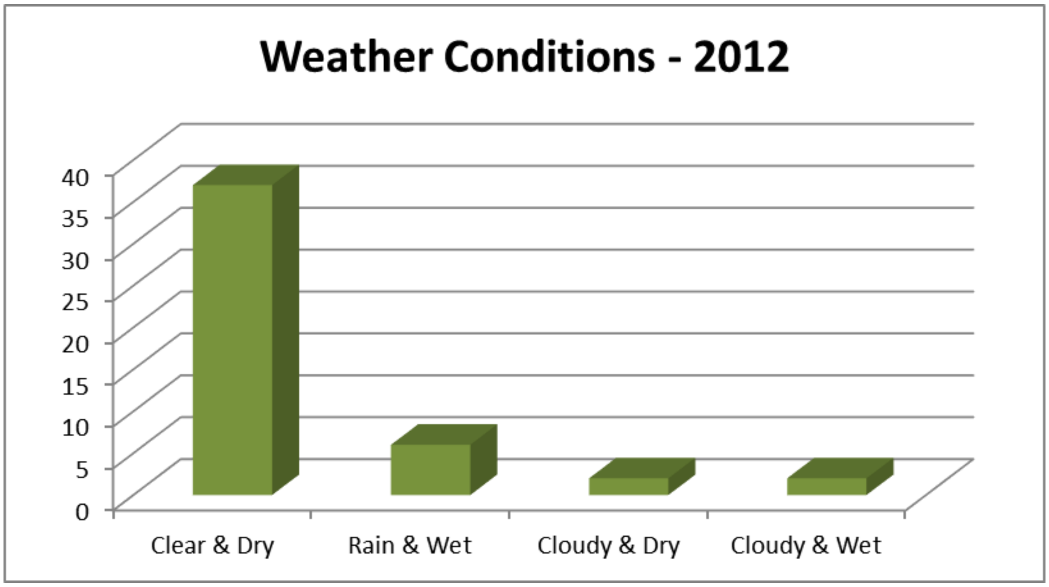



*Figure 8: Airport Circle Crash Weather Conditions, 2012*

Similar to the Airport Circle 2012 results, an analysis of Atlantic County crashes (county-wide) over the 2003-2012 time period indicated 75% of all the crashes occurred in clear and dry weather. Weather did not play a significant role in the crash history at Airport Circle or in Atlantic County as a whole. Figure 9 is a graphic depiction of county-wide crash conditions related to weather.

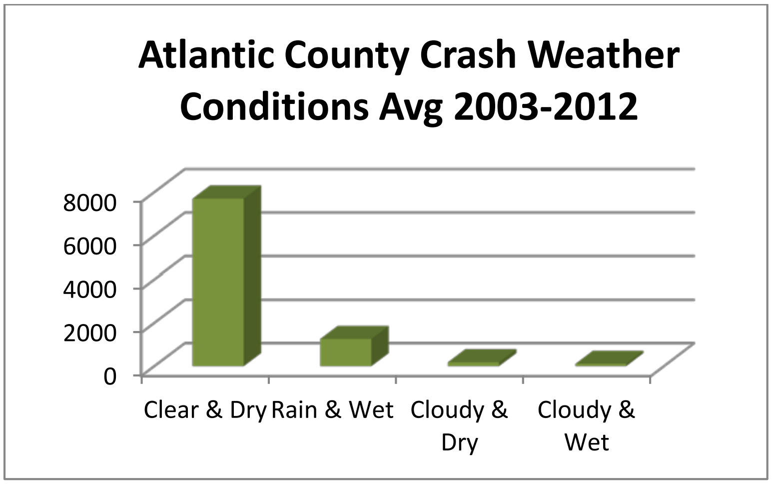



*Figure 9: Atlantic County Crash Weather Conditions Average, 2003-2012*

## 2012 Crash Analysis—Personal Injury/Fatality Analysis

Figure 10 indicates that 83% of all the crashes had no injuries reported in the crash. Only one personal injury occurred during the 2012 post-construction period at Airport Circle. Seven motorists reported complaints of pain (possible minor injury). This data supports the same direction and side swipe crash types found at this intersection. These type crashes are typically minor in nature with property damage only.

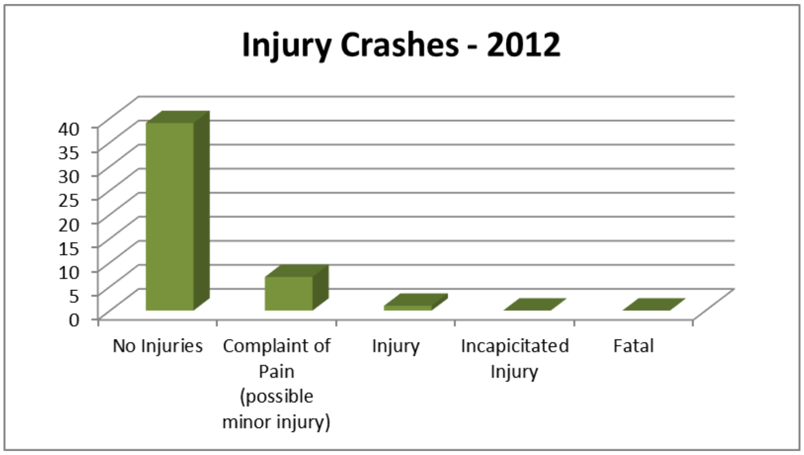



*Figure 10: Airport Circle--2012 Personal Injury/Fatality Analysis*

The TWT team completed an analysis of Atlantic County crashes in the time period 2003-2012 with respect to injury severity. 84% of all crashes resulted in no injuries, with 13% with complaint of pain, usually very minor injuries. This follows the previously identified pattern at Airport Circle where 83% of the crashes indicated no injuries. Figure 11 is a graphic representation of the analysis.

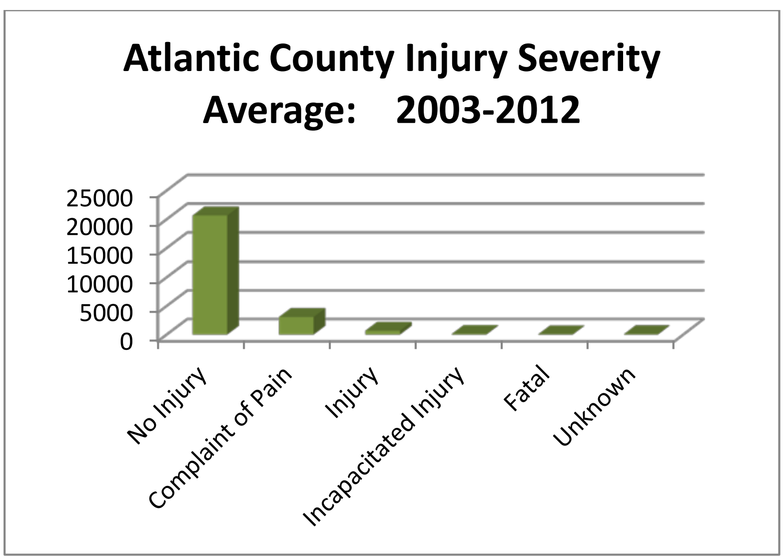



*Figure 11: Atlantic County Injury Severity Average: 2003-2012*

## 2012 Crash Analysis--Location

Figure 13 is a crash diagram of 2012 crashes in the immediate vicinity of Airport Circle. The crashes are distributed on all the approaches to the circle, as well as internally within the circle. There are several areas that are of note, such as the northbound Tilton Road movement at Amelia Earhart, eastbound and westbound Delilah Road at Tilton Road, and westbound in the Circle at Tilton Road. With the heavy westbound Delilah Road and northbound Tilton Road movements in the PM peak period, and the reverse movement in the AM peak period, there is no surprise to the location of the crashes at the noted areas. Figure 12 is a graphical chart depicting the location and frequency of recorded 2012 crashes.

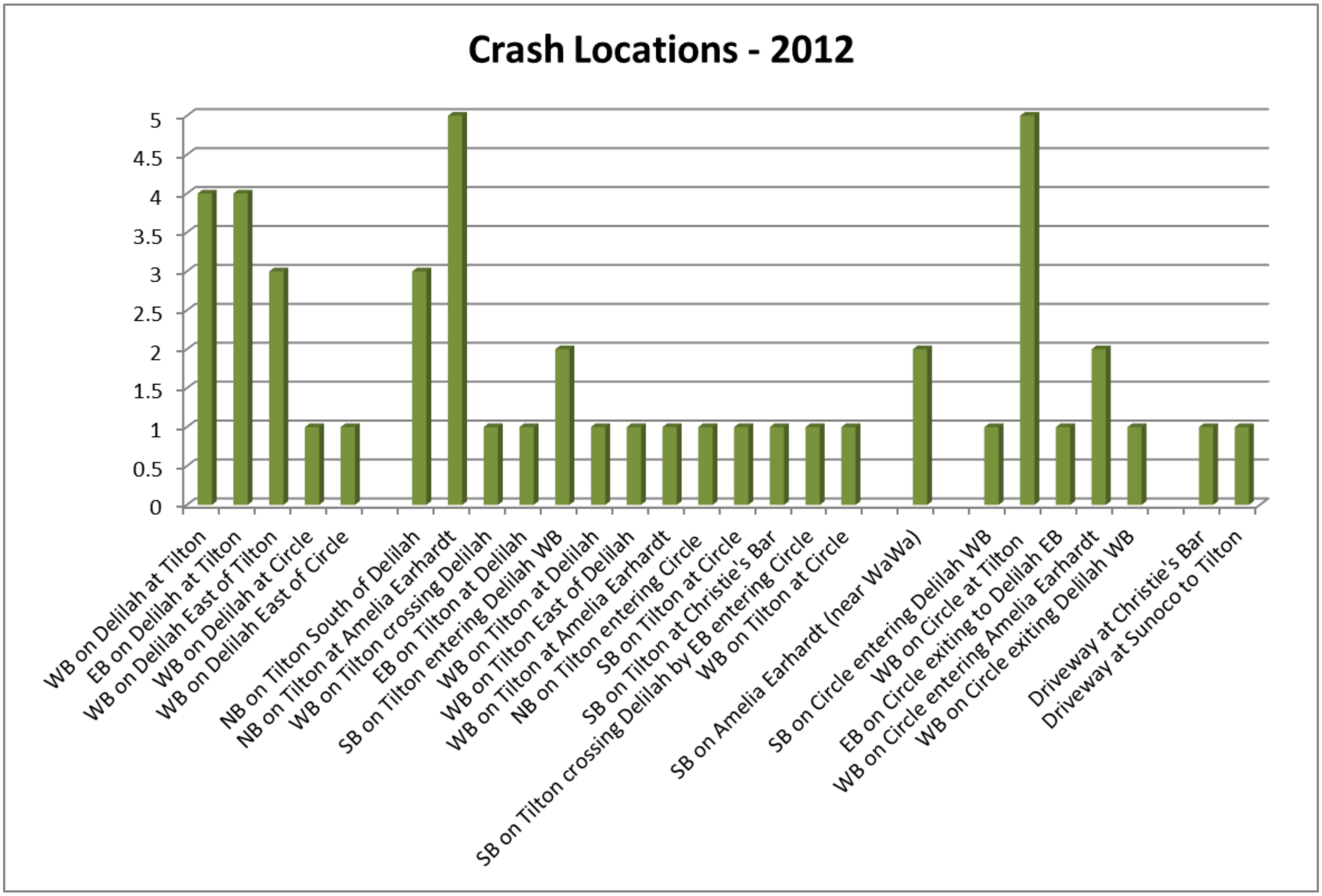



*Figure 12: 2012 Airport Circle Crash Locations (bar graph)*

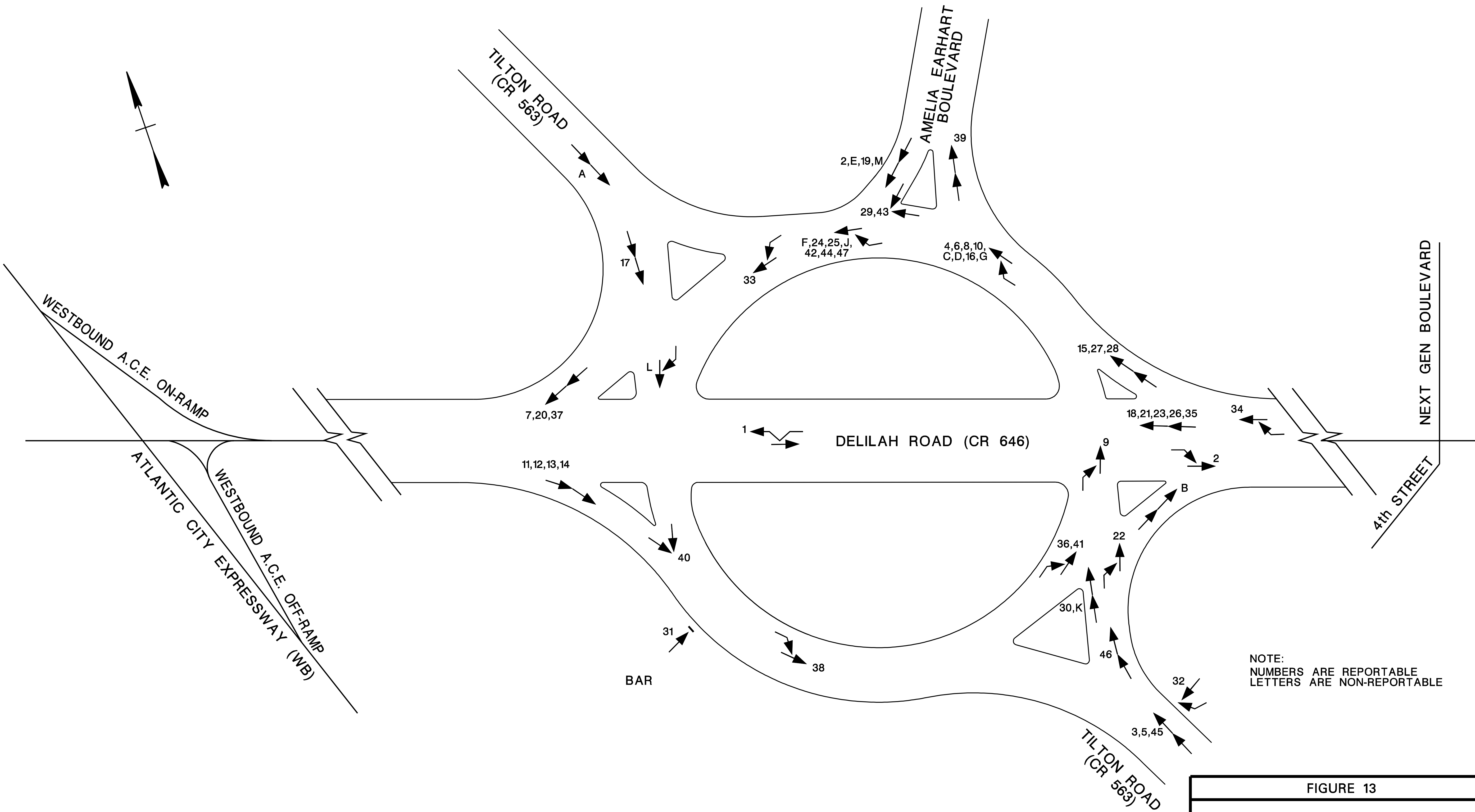



FIGURE 13

2012 CRASH RECORDS

AIRPORT CIRCLE SAFETY AND OPERATIONAL ANALYSIS

EGG HARBOR TOWNSHIP, ATLANTIC COUNTY, N.J.

*Taylor Wiseman Taylor*

*ENGINEERS /SURVEYORS /SCIENTISTS*

JUNE 2013

## 2012 Crash Analysis—Likely Causation Factors:

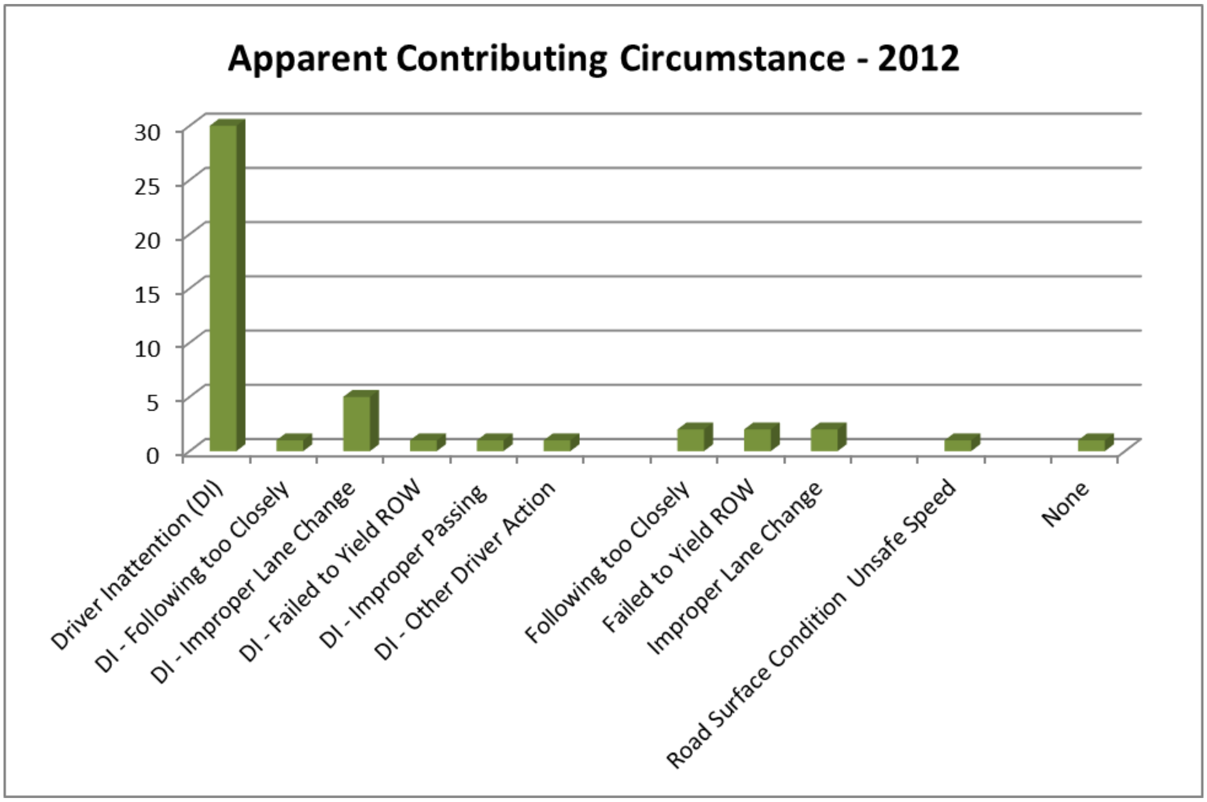



*Figure 14: 2012 Crash Analysis--Likely Causation Factors, Airport Circle*

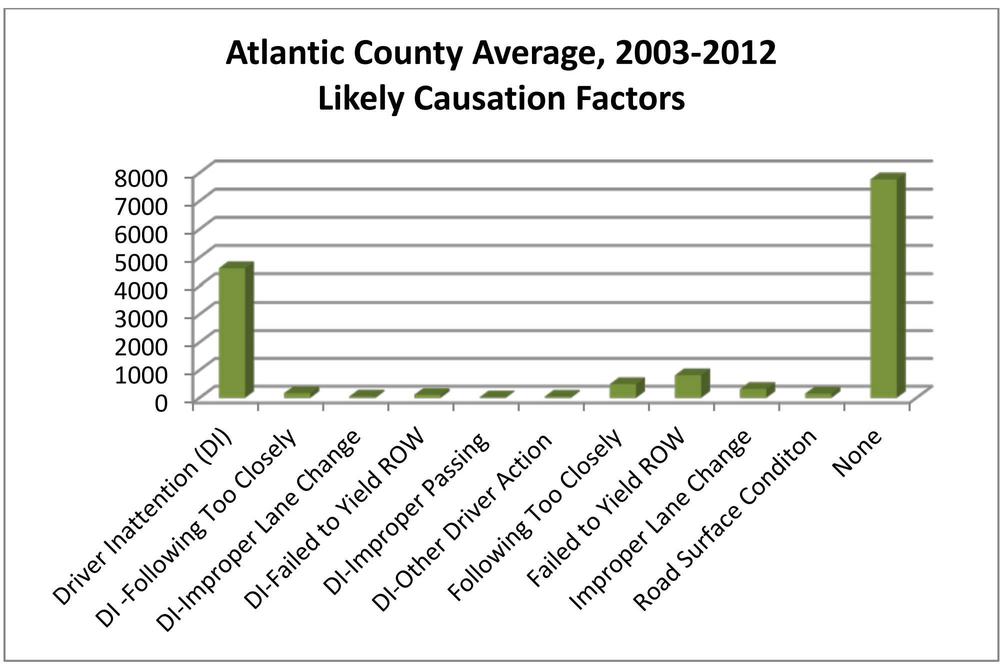



*Figure 15: Atlantic County Average, 2003-2012, Likely Causation Factors*

64% of the crashes were due to driver inattention, followed by 11% coded as improper lane change, as seen in Figure 13. It is unclear as to the role that cellular phones may have had in the crashes in which driver inattention was cited.

In comparing the Atlantic County average crashes over the period 2003-2012 in Figure 14 (above), it can be seen that 25% of all the crashes were attributed to driver inattention, while 41% were coded with no apparent contributing circumstance or causation. Improper lane change and following too closely contributed to only 1% of the crash causes reported County-wide.

As seen from the crash data above, the types of crashes that are occurring at the Circle, same direction (rear-end) and side swipe are what can be expected at this type of intersection/circle. This Circle has a significant number of lane movements, possibly contributing to the amount of crashes, especially with drivers unfamiliar with the location. Additionally, the signal timing is longer than the average timing, possibly increasing driver frustration and leading to crashes. Field observations noted drivers making creative and illegal moves throughout the Circle to "beat" the signal timing and to avoid queues due to peak period congestion. For example, creative drivers on Delilah Road that wished to stay on Delilah Road were observed going around the circle to avoid the excessive wait created by the long signal timing.

As can be seen in the above Figures, comparison of the Airport Circle with Atlantic County as a whole revealed some similarities in crash weather conditions and no injuries reported. Little else among the analyses showed similar patterns. It may be surmised, as stated earlier, that the Airport Circle is a unique intersection configuration, unlike anything else in the county, suggesting a unique set of crash patterns local to that location. It should be noted that all of the 2003-2012 analyses were prepared from the Plan4Safety web application.

## 2012 CRASH RATE PER MILLION ENTERING VEHICLES:

As presented on the FHWA Safety website (US Department of Transportation, Federal Highway Administration, 2013), "The ratio of crash frequency (crashes per year) to vehicle exposure (number of vehicles entering the intersection) results in a crash rate. Crash rate analysis can be a useful tool to determine how a specific intersection compares to the average intersection on the roadway network.

The intersection crash rate based on one million entering vehicles entering the intersection is calculated as:

$$R = \frac{1{,}000{,}000(C)}{365(N)(V)}$$

Where:

R = Crash rate for the intersection expressed as crashes per million entering vehicles (MEV)

C = Number of years of data

V = Traffic volumes entering the intersection daily”[1]

Populating the equation with appropriate values[2] yields a result of **4.2907 crashes per million entering vehicles**. We would expect that this crash rate is actually decreasing with time, as drivers become more familiar with the intersection and how to negotiate it safely.

## SAFETY ANALYSIS CONCLUSIONS:

As seen from the crash data below, the types of crashes that are occurring at the Circle, same direction (rear-end) and side swipe are what can be expected at this type of intersection/circle. This Circle has a significant number of lane movements, possibly contributing to the amount of crashes, especially with drivers unfamiliar with the location. Additionally, the signal timing is

*Table 4: Crash Type by Year, Airport Circle, 2003-2012*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing | Other | No Crash Type Coded |
|---|---|---|---|---|---|---|---|---|---|
| **2003** | **28** | 17 | 3 | 1 | | | | 2 | 5 |
| **2004** | **31** | 12 | | 1 | | | | | 18 |
| **2005** | **29** | 16 | 1 | 5 | | | 1 | | 6 |
| **2006** | **47** | 31 | 5 | 9 | | 1 | | 1 | |
| **2007** | **54** | 35 | 3 | 14 | 1 | | | 1 | |
| **2008** | **24**** | 13 | 2 | 6 | 1 | | 1 | 1 | |
| **2009** | **30** | 24 | 3 | 2 | 1 | | | | |
| **2010** | **23** | 21 | 1 | 1 | | 1 | 1 | | |
| **2011*** | **22** | 17 | 2 | | | 2 | | | |
| **2012** | **47** | 25 | 1 | 19 | | 1 | | 1 | |

* No crashes reported 1/1/11 through 4/27/11

[1] US Department of Transportation, Federal Highway Administration; “FHWA Safety”, http://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/ch3.cfm. Accessed June, 2013

[2] Number of crashes = 47. When possible used average daily traffic. Results used: WB Delilah: 8,122; EB Delilah: 7,916; Amelia Earhart Boulevard SB: 3,646; Tilton Southern Leg: 5,791; Tilton Northern Leg: 4,536. Total entering daily traffic into circle, based on 2013 TWT recorder counts = 30,011. Number of years data =1.

**Crashes 1/1/08 through 5/14/08 only (projected over an entire year = 52 total crashes)

Actual crash reports

P4S

*Table 5: Crash Types as a Percentage of Total Crashes, Airport Circle, 2003-2012*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing | Other | No Crash Type Coded |
|---|---|---|---|---|---|---|---|---|---|
| **2003** | **28** | 61% | 11% | 4% | | | | 7% | 18% |
| **2004** | **31** | 39% | 0% | 3% | | | | | 58% |
| **2005** | **29** | 55% | 3% | 17% | | | 3% | | 21% |
| **2006** | **47** | 66% | 11% | 19% | | 2% | | 2% | |
| **2007** | **54** | 65% | 6% | 26% | 2% | | | 2% | |
| **2008** | **24**** | 54% | 8% | 25% | 4% | | 4% | 4% | |
| **2009** | **30** | 80% | 10% | 7% | 3% | | | | |
| **2010** | **25** | 84% | 4% | 4% | | 4% | 4% | | |
| **2011*** | **22** | 77% | 9% | 0% | | 9% | | | |
| **2012** | **47** | 53% | 2% | 40% | | 2% | | 2% | |

* No crashes reported 1/1/11 through 4/27/11
**Crashes 1/1/08 through 5/14/08 only
(projected over an entire year = 52 total crashes)

Actual crash reports

longer than the average timing, possibly increasing driver frustration and leading to crashes. Field observations noted drivers making creative and illegal moves throughout the Circle to "beat" the signal timing and to avoid queues due to peak period congestion. For example, creative drivers on Delilah Road that wished to stay on Delilah Road were observed going around the circle to avoid the excessive wait created by the long signal timing.

In comparing the pre- and post-construction data from the actual crash reports (2006-2008 and 2012), the average number of crashes for the pre-construction 3 year period is 51. Post-construction crashes are 47, representing a slight drop in overall crashes of 8%. Rear-end and right angle crashes decreased after the implementation of the new configuration, but side-swipe crashes saw an increase of almost 50%. This increase may be due to motorists unfamiliar with which lane to be in while in the circle and while exiting. Observations of the circle traffic revealed significant weaving movements within the circle possibly contributing to the side-swipe crash increase. Informing the motorists of the appropriate lane prior to entering the circle through signing would be a potential countermeasure for this location.

A review of the crashes county-wide for 2012, as can be seen below, revealed a consistency with years past. Again, this is informational only and caution should be used in comparing the unique Airport Circle location with others within the County.

*Table 6: Crashes Atlantic County-Wide as a Percentage of Total Crashes, 2003-2012*

| Year | Total Crashes | Rear End | Right Angle | Side Swipe | Left/ U Turn | Fixed Object | Backing |
|---|---|---|---|---|---|---|---|
| **2003** | **10304** | 25% | 16% | 11% | 3% | 1% | 3% |
| **2004** | **10850** | 25% | 17% | 11% | 3% | 1% | 3% |
| **2005** | **10508** | 25% | 16% | 11% | 4% | 1% | 2% |
| **2006** | **10405** | 25% | 16% | 11% | 4% | 17% | 2% |
| **2007** | **10596** | 25% | 14% | 11% | 4% | 16% | 5% |
| **2008** | **10464** | 25% | 13% | 11% | 3% | 17% | 8% |
| **2009** | **10685** | 26% | 12% | 10% | 3% | 18% | 9% |
| **2010** | **9906** | 25% | 13% | 11% | 3% | 16% | 9% |
| **2011** | **9188** | 26% | 13% | 11% | 3% | 24% | 8% |
| **2012** | **9598** | 26% | 13% | 11% | 3% | 15% | 9% |

P4S

# EXISTING TRAFFIC CONDITIONS:

## TRAFFIC DATA COLLECTION:

In order to evaluate existing traffic conditions within the project area, the consultant team conducted extensive traffic data collection in February, 2013. The traffic data collection included:

- Manual turning movement counts, taken at five distinct locations within the Airport Circle, Delilah Road and eastbound Atlantic City Expressway on/off ramps; Delilah Road and westbound Atlantic City Expressway off ramp; Delilah Road, Wawa driveway and Sunoco driveway (AM peak only); and Delilah Road, Fourth Street and Next Generation Boulevard.

- Automatic traffic recorder counts: Automatic traffic recorder counts were taken on Delilah Road, Tilton Road northern leg, Tilton Road southern leg, Amelia Earhart Boulevard, and Next Generation Boulevard. Counts were taken over a period of one week.

- Autoscope Video Cameras: The project team reprogrammed existing video detectors at Airport Circle to determine link volumes and gather data on lane utilization.
- Origin-and Destination Studies: Origin-destination information was collected, compiled and analyzed using five mini Blue-Toad™ MAC address detection units provided by the project team.
- Saturation flow measurements: Saturation flow measurements (47) were taken on approaches to Airport Circle during the peak hours in order to calibrate the modeling of intersection operations.

The data collection phase of this project was extensive, with the primary goal of developing and calibrating an accurate Synchro/SimTraffic model of the project area. Manual turning movement counts were taken to estimate individual turning movements at the circle. Automatic traffic recorder counts provided insight as to daily traffic patterns, as well as providing a quality check on manual turning movement counts. Use of the Autoscope video cameras provided valuable lane utilization information. The Blue-Toad™-based origin destination study gave the project team insight as to where people were coming from and going to, which was very important facet of the Amelia Earhart Boulevard relocation scenario. Saturation flow studies provide a critical indication of how aggressive the drivers are as they negotiate the roadways within the project area.

### Manual Turning Movement Counts:

The project team completed manual turning movement counts at Airport Circle; Delilah Road and eastbound Expressway on/off ramps; Delilah Road and westbound Expressway off ramp, Delilah Road, Wawa driveway and Sunoco driveway (AM Peak only); and Delilah Road, Fourth Street and Next Generation Boulevard. Traffic counts were taken on Thursday, February 28, 2013 from 7:00 AM to 9:00 AM, 11:00 AM to 1:00 PM and 2:00 PM to 6:00 PM. Weather conditions were sunny and dry. Local schools were in session. All counts were taken concurrently.

System peak hours were identified as 7:15 to 8:15 AM during the morning peak hour and 4:00 to 5:00 PM in the afternoon peak hour. The noon peak occurred from 12 Noon to 1:00 PM. Figure 10 shows a summary of am/noon/pm volumes within Airport Circle. Copies of the electronic files, as well as Adobe PDF files of the traffic counts are provided in the appendix of the report.

### Automatic Traffic Recorder Counts:

The project team also collected automatic traffic recorder counts over a one week period in February-March 2013. The count data was collected using JAMAR traffic recorders and accompanying computer software. Counts were taken on every approach to Airport Circle, as well as Next Generation Boulevard. Table 7 summarizes average daily traffic within the project area in February/March 2013:

*Table 7: Average Daily Traffic in vicinity of Airport Circle*

| Location | Direction of Traffic | Average Daily Traffic (vehicles) |
|---|---|---|
| Delilah Road, east of Airport Circle | Westbound | 8,122 |
| Delilah Road, east of Airport Circle | Eastbound | 7,916 |
| Amelia Earhart Boulevard | Northbound | 3,342 |
| Amelia Earhart Boulevard | Southbound | 3,646 |
| Next Generation Boulevard | Northbound | 146 |
| Next Generation Boulevard | Southbound | 155 |
| Tilton Road, northern leg | Northbound | 5,558 |
| Tilton Road, northern leg | Southbound | 5,791 |
| Tilton Road, southern leg | Northbound | 4,536 |
| Tilton Road, southern leg | Southbound | 5,375 |

Copies of TraxPro electronic files, as well as Adobe PDF files of the traffic counts are presented in the appendix of the report.

### Autoscope Count Detectors:

The consultant team attempted to use the existing Autoscope cameras (used for vehicle detection) to verify automatic traffic counts taken by conventional recorders. The data was approximately double that counted by both the manual and automatic counters. The manual and machine counts correlated closely, however the Autoscope video based counts were twice as high as the actual counts. The video counts were successfully utilized to verify visual observations of lane utilization within the circle. We would recommend that the County redraw the count detectors within the Autoscope field of view to enhance accuracy.

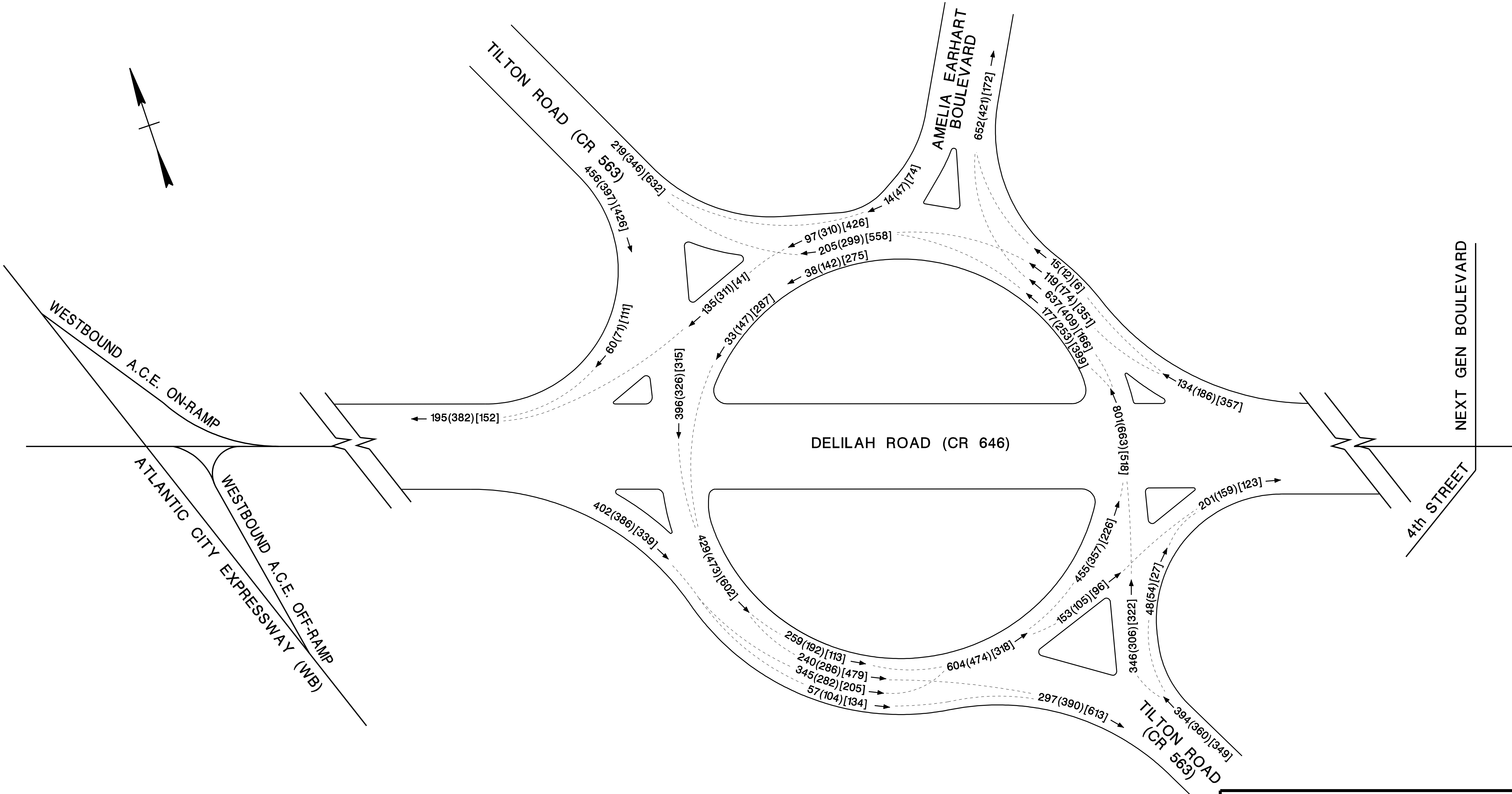



FIGURE 16

EXISTING (2013) VOLUMES

AIRPORT CIRCLE SAFETY AND OPERATIONAL ANALYSIS

EGG HARBOR TOWNSHIP, ATLANTIC COUNTY, N.J.

TWT *Taylor Wiseman Taylor*

*ENGINEERS /SURVEYORS /SCIENTISTS*

JUNE 2013

### Origin-Destination Studies:

Origin-destination information was collected, compiled, and analyzed based for the five legs of Airport Circle using five mini-BlueToad™ MAC address detection units deployed by the project team. The battery operated BlueToad™ devices were deployed in the project area from February 19 through February 26, 2013. Data for Tuesday, February 26, 2013 was used in our detailed analysis as it was the closest day available to Thursday, February 28, 2013, which was the day the manual turning movement counts were conducted.

BlueToad™ (Bluetooth Travel-time Origin and Destination) detects anonymous MAC addresses, which are wireless identifications broadcast by Bluetooth™ technologies on mobile devices in vehicles such as mobile phones, tablets, navigation units, headsets and music players. The system calculates travel time through analysis of subsequent technologies. This technology is commonly deployed on variable message signs, giving drivers approximate travel times to key destinations in real-time.

Using the recorded stop bar counts, upstream tube counts, and these percentages, the link-specific origin-destination volumes were estimated for both the morning and evening rush hour periods. This information was used to appropriately code volumes in the Synchro™ model prior to export to SimTraffic™.

Table 8 summarizes the morning peak hour period percentages between the hours of 7:00 and 9:00am on Tuesday, February 26, 2013. For the most part, traffic travels through the circle on the same route (i.e: the majority of westbound Delilah Road traffic travels to the east leg of Delilah Road). The exception during the AM peak is the southern leg of Delilah Road, in which the majority of the traffic is oriented to Amelia Earhart Boulevard (60%).

*Table 8: AM Peak Origin/Destination Results--Airport Circle*

| ***AM Peak Period Origins / Destinations*** | ***TO Tilton (North Leg)*** | ***TO Delilah (West Leg)*** | ***TO Tilton (South Leg)*** | ***TO Delilah (East Leg)*** | ***TO AE Boulevard*** |
|---|---|---|---|---|---|
| ***From Tilton (North Leg)*** | *0.0%* | *23.6%* | *36.4%* | *20.0%* | *20.0%* |
| ***From Delilah (West Leg)*** | *8.5%* | *0.0%* | *5.4%* | *56.6%* | *29.5%* |
| ***From Tilton (South Leg)*** | *10.0%* | *20.0%* | *0.0%* | *10.0%* | *60.0%* |
| ***From Delilah (East Leg)*** | *7.8%* | *60.9%* | *3.1%* | *0.0%* | *28.1% ** |
| ***From Amelia Earhart Boulevard*** | *16.7%* | *41.7%* | *25.0%* | *16.6%* | *0.0%* |

Notes:* The mini-BlueToad™ located along Delilah Road adjacent to Amelia Earhart Boulevard may have captured a number of cut-through motorists using Next Generation Boulevard during the morning peak hour period, hence this slightly higher percentage relative to the total volume of traffic from the east heading towards Airport Circle.

Table 9 summarizes the evening peak hour period percentages between the hours of 2:00pm and 7:00pm on Tuesday, February 26, 2013. It should be noted that due to peak congestion and travel time between the data collection units, a 5—hour window for OD derivations provided more consistent results. During the PM peak, the corresponding through movement is the primary movement on the four major legs to the intersection. Amelia Earhart Boulevard traffic is primarily oriented towards the west leg of Delilah Road.

*Table 9: PM Peak Origin/Destination Results--Airport Circle*

| ***PM Peak Period Origins / Destinations*** | ***TO Tilton (North Leg)*** | ***TO Delilah (West Leg)*** | ***TO Tilton (South Leg)*** | ***TO Delilah (East Leg)*** | ***TO AE Boulevard*** |
|---|---|---|---|---|---|
| ***From Tilton (North Leg)*** | 0.0% | 28.8% | 40.5% | 20.7% | 9.9% |
| ***From Delilah (West Leg)*** | 15.1% | 0.0% | 18.4% | 54.7% | 11.7% |
| ***From Tilton (South Leg)*** | 39.8% | 35.5% | 0.0% | 17.2% | 7.5% |
| ***From Delilah (East Leg)*** | 18.8% | 69.4% | 6.9% | 0.0% | 5.0% |
| ***From Amelia Earhart Boulevard*** | 15.5% | 40.1% | 26.0% | 18.3% | 0.0% |

## Saturation Flow Checks:

Saturation flow can be defined as the flow in vehicles per hour that can be accommodated by a specified lane group assuming the green phase was displayed 100 percent of the time. The default value of 1900 passenger cars per hour green per lane (pcphgpl) is provided by the Highway Capacity Manual (TRB, 2010) for the ideal saturation flow rate in areas with a population greater than 250,000.

Saturation flow rates were field verified at the approaches to Airport Circle (Tilton Road, Amelia Earhart Boulevard, and Delilah Road). Measurement of saturation flow was accomplished using a JAMAR TDC-8 data collection device. The procedure involves measuring the number of cars moving across the stopbar during the green phase for the approach. The countboard/software calculates a saturation flow rate for the approach.

Approximately forty-seven field measurements of saturation flow were taken, resulting in an aggressive saturation flow rate of 2,100 passenger cars per hour per lane. Use of a field-verified saturation flow rate is a key component to calibrating the Synchro/SIM Traffic modeling software, which results in more accurate results.

## OPERATIONAL ANALYSIS (2013 AM AND PM COMMUTER PEAK HOURS):

Delay and capacity analyses have been completed for four (4) scenarios for both the average weekday morning and weekday evening peak hour periods at Airport Circle. These scenarios include: existing conditions, optimized timing, optimized timing and phasing (assumes actuation of the SW overlap phase and possible actuation of Amelia Earhart Boulevard), and an extra scenario for the relocation of the Amelia Earhart Boulevard intersection to a location outside of Airport Circle. Additional details pertaining to the modeling of these scenarios follow.

### EXISTING CONDITIONS:

This scenario reflects existing geometric and operational conditions at Airport Circle, based on the traffic counts completed on February 28, 2013. No seasonal adjustments or background growth were applied to the counts. Signal timing and phasing are based on the available traffic signal controller report dated April 1, 2013, field observations and spot measurements of phase times on February 28, 2013, and the signal plan dated June 2009, as modified on December 5, 2011 and January 10, 2012. For purposes of the existing conditions model and for consistency with adjacent intersections, arbitrary modifications to the existing configuration were made in accordance with the following table. These phase designations are arbitrary and follow the existing ring and barrier design. Per the April 1, 2013 controller report and the ring and barrier design provided therein, the overlap phase for the southwest Circle approach, Phase 9, is assumed to operate within its own barrier (#3) as an actuated phase on maximum recall. The extension or passage time for this phase is assumed to be 2 seconds. Based on field observations and the controller report cited above, Phase 9 does not operate concurrently with Phase 7.

*Table 10: Modeling Assumptions, Existing Conditions Scenario*

| Approach | Signal Controller Report | Synchro™ / SimTraffic™ Model | Synchro™ Model Maximum Green Times | Synchro™ Yellow, All-Red Times |
|---|---|---|---|---|
| Eastbound Delilah Road | Phase Φ6 | **Phase Φ2** | 33 sec | 5 sec, 2 sec |
| Westbound Delilah Road | Phase Φ2 | **Phase Φ6** | 33 sec | 5 sec, 2 sec |
| Northbound Tilton Road | Phase Φ8 | **Phase Φ8** | 35 sec | 4 sec, 3 sec |
| Southbound Tilton Road | Phase Φ4 | **Phase Φ3** | 45 sec | 4.5 sec, 4 sec |
| NE Circle Approach | Phase Φ7 | **Phase Φ7** | 35 sec | 4 sec, 3 sec |
| SW Circle Approach | Phases Φ9, Φ3 | **Phases Φ9, Φ4** | 25 sec, 35 sec | 4 sec, 3 sec |
| Amelia Earhart Boulevard | None | **None** | N/A | N/A |

It should be noted that since the modeling work for this project was completed, some timing and phasing modifications were completed at Airport Circle, evidently including removal of Phase 9 (the overlap phase) during the AM peak period. This change impacts the accuracy of the AM peak analysis in all scenarios except the Amelia Earhart Boulevard relocation.

## TIMING MODIFICATIONS:

This scenario is based on the "Existing Conditions" model with only optimized phase times at Airport Circle, including adjustments to green times by phase at Airport Circle. The existing ring and barrier design, phasing, and detector configuration at Airport Circle remains the same as under existing conditions. Under this scenario, separate timing plans for the morning and evening peak hour periods have been identified using the initial optimization results from Synchro™ and additional adjustments from simulation in SimTraffic™. It should be noted that since the modeling work for this scenario was completed, some timing and phasing modifications were completed at Airport Circle, evidently including removal of Phase 9 (the overlap phase) during the AM peak period. The following AM and PM maximum green times were developed and are as follows:

*Table 11: Modeling Assumption for Timing Modifications Scenario*

| Approach | Signal Controller Report | Synchro™ / SimTraffic™ Model | Synchro™ AM Model Maximum Green Times | Synchro™ PM Model Maximum Green Times |
|---|---|---|---|---|
| Eastbound Delilah Road | Phase Φ6 | Phase Φ2 | 27 sec | 26 sec |
| Westbound Delilah Road | Phase Φ2 | Phase Φ6 | 27 sec | 26 sec |
| Northbound Tilton Road | Phase Φ8 | Phase Φ8 | 36 sec | 27 sec |
| Southbound Tilton Road | Phase Φ4 | Phase Φ3 | 33 sec | 27.5 sec |
| NE Circle Approach | Phase Φ7 | Phase Φ7 | 43 sec | 29 sec |
| SW Circle Approach | Phases Φ9, Φ3 | Phases Φ9, Φ4 | 6 sec, 33 sec | 35 sec, 27 sec |
| Amelia Earhart Boulevard | None | None | N/A | N/A |

TIMING AND PHASING MODIFICATIONS: This scenario is based on the "Existing Conditions" model, and incorporates both timing and phasing changes at Airport Circle, and coordination of the Delilah Road corridor. The existing phasing at other intersections along Delilah Road remains the same as under existing conditions. Under this scenario, separate timing and phasing plans for only the morning and evening peak hour periods have been identified. This scenario involves minor modifications to the ring and barrier design and phasing configuration of Airport Circle, while maintaining clustered operation of Delilah Road. Additional detection is added to the north side of Airport Circle such that vehicles turning from Amelia Earhart Boulevard can call and extend the southwest Circle phase.

AMELIA EARHART BOULEVARD RELOCATION: – This scenario is based on the "Timing and Phasing Modifications" model and includes relocation of the existing Amelia Earhart Boulevard from the Circle to a new intersection along Delilah Road, approximately 800 feet east of Airport Circle and approximately 1,100 feet east of Next Generation Boulevard. The existing Amelia Earhart Boulevard intersection with Airport Circle has been removed and existing traffic as counted on February 28, 2013 has been partially redistributed to the relocated intersection based on the available field data and origin-destination data. The existing phasing at other intersections along Delilah Road remains the same as under existing conditions. Under this scenario, separate timing and phasing plans for only the morning and evening peak hour periods have been identified. This scenario involves minor modifications to the ring and barrier design and phasing configuration of Airport Circle, while maintaining clustered operation of Delilah Road. This scenario has not been fully calibrated. This scenario involves fairly significant changes to the base model, and due to the absence of available volume data at some model intersections (i.e. Wawa driveways, Sunoco station, etc.) several assumptions had to be made. Default values for peak factors, critical gap and follow-up times, and saturation flow rates were used. The link distances and lane geometries were approximated based on a sketch plan provided by the South Jersey Transportation Authority.

## ANALYSIS SOFTWARE:

These calculations have been completed in accordance with the recommendations provided by the Transportation Research Board's (TRB) 2010 Highway Capacity Manual (HCM2010), as implemented by Trafficware, LLC's Synchro™ and SimTraffic™ Version 8.0, Build 804.795. The TRB HCM2010 represents the latest in the state of practice with regard to the operational and level of service analysis procedures for unsignalized and signalized intersections.

Trafficware's Synchro™ Version 8.0 is a deterministic optimization and traffic analysis software program based in part on previous versions of the TRB Highway Capacity Manual, as well as some of the methods contained within the newer HCM2010.

Trafficware's companion SimTraffic™ Version 8.0 is a stochastic roadway and intersection micro-simulation software package, based in part on the formative research as well as the lane-changing and car-following logic in the FHWA's NETSIM software, now included as part of TSIS-CORSIM™ (currently owned and maintained by the University of Florida, McTrans Center). SimTraffic™ simulates the movement of individual vehicles every tenth of a second through a modeled system, based on driver behavior, vehicle characteristics, and the geometric and operational conditions coded within a network, without the reliance on limited HCM-based capacity equations. It is a powerful tool capable of much more than animation, and may be used to overcome limitations of traditional deterministic models when employed as a project's analytical tool.

While the HCM2010 includes many procedural enhancements, additional capabilities, and multimodal analysis methods for pedestrians and bicyclists as compared with the previous 2000 Edition, there are also many methodological limitations that must be understood and applied while in conduct of an analysis of Airport Circle. Imbalanced lane utilization, queue spillback, spillover from turn lanes, and the interaction between adjacent intersections are not explicitly addressed by the HCM2010 methods, and consequently, these issues are not capable of being explicitly modeled in Synchro™ Version 8.0. Not only that, but the HCM2010 procedures for clustered signalized intersections with diagonal approaches, as is the case with Airport Circle, are also not currently supported by Synchro™ Version 8.

Considering both the software and procedural issues, it is appropriate to consider an alternative approach. Per the recommendations contained with Chapter 6 of the HCM2010, it is appropriate to consider the application of an alternative analysis tool (i.e. micro-simulation). As such this study, completed level of service and capacity analysis based on the delays and measures of effectiveness provided by SimTraffic™ Version 8.0. Using simulated delays, level of service (LOS) for the Airport Circle intersections may be assigned based on the HCM2010 thresholds as defined in Chapter 18 Exhibit 18-4 and Chapter 19 Exhibit 19-1. In this case, it should be noted that the emerging practice of the HCM2010 alternative analysis procedure is based on acceptable derivation of control delay from vehicular trajectories produced by the microsimulation tool. At this time, SimTraffic™ Version 8.0 may not be compliant with the HCM2010 and caution should be exercised when relating LOS to simulated delay. As such only the delays are used to describe performance. For the reasons provided above, it is the project team's opinion that micro-simulation is the appropriate analytical tool in order to assess operations for the project.

## MODELING NOTES:

This section is very technical, and is relevant for transportation engineering professionals only interested in the assumptions made in developing the Synchro model of the project area.

1. Based on the results of the field data collection and observations, it appears that u-turning traffic does not travel through Airport Circle (i.e. vehicles departing one of the five legs only to travel through the circle to return to that same leg). Therefore the null origin and destination pairs were assumed to be zero percent.
2. During the morning peak hour from 7:15am to 8:15am, the northbound Tilton Road and southbound Tilton Road approaches were at and over capacity, respectively. The Amelia Earhart Boulevard approach during most of the evening peak hour from 4:00pm to 5:00pm was also over capacity. The upstream tube counts at these locations were used to derive demand estimates as opposed to simply utilizing the stop bar counts, which would have only recorded the number of vehicles successfully served under existing conditions.

3. In order to balance volumes between adjacent intersections, the analysis used a system-wide peak hour period (7:15am to 8:15m in the morning peak hour period, and 4:00pm to 5:00pm for the evening peak hour period). Peak hour factors network-wide equal to 1.0 and heavy vehicle percentages equal to 10 percent during the morning peak hour and 5 percent during the evening peak hour. Due to link-specific origin-destination (OD) by total volume, some heavy vehicle and vehicle imbalance between adjacent intersections can occur during simulation. This imbalance is due to software limitations that only permit OD volumes by total volumes; not vehicle type. This imbalance has a negligible effect on results.
4. At least ten randomly-seeded 60-minute simulation runs per scenario were used to derive results. Occasion model failures will occur due to closely spaced intersections, short links, and some vehicle and driver types who are unable to complete lane maneuvers within the model's targeted mandatory lane positioning distances. Model failures can be defined as those runs that become gridlocked because of 'stuck' vehicles within the Circle (not to be confused with operational failures). Those situations are not realistic but may be produced by SimTraffic™ due to the link-node structure of the model, and various limitations inherent to this tool. Simulation runs with model failures are not included within the results. Additional calibration work was completed to produce realistic results.
5. Each simulation run used an estimated percentile distribution for traffic volumes through the peak hour based on the traffic count data collected in the field: 25$^{th}$ percentile volumes for the first 15-minute period, 75$^{th}$ percentile volumes for the second 15-minute period, 50$^{th}$ percentile volumes for the third 15-minute period, and 25$^{th}$ percentile volumes for the fourth 15-minute period. Each simulation run is also using 15 minutes of seeding time to appropriately load the network.
6. Limited, spot measurements of actual saturation flow rates were collected for select lanes at Airport Circle, including Delilah Road, northbound Tilton Road, southbound Tilton Road, and the circle approaches. These spot measurements were conducted in accordance with the recommendations contained in HCM2010 Chapter 31, Section 6 (Field Measurement of Saturation Flow Rates); however, only 5 to 15 cycles per phase were measured. Additional field measurements would be necessary for a complete saturation flow rate study of Airport Circle. These limited spot measurements during the morning and evening peak hours demonstrate base saturation flow rates up to 2,100 passenger cars per hour per lane (pcphpl). These base saturation flow rates were back-calculated based on the average headways recorded, accounting for the percentage of heavy vehicles, percent grades, and lane widths. In total 47 spot measurements were

collected, recording more than 1,000 headway values for 5 of the 6 approaches at Airport Circle. It should be noted that some cycles demonstrated considerably lower base saturation flow rates, in part due to slow or impeded vehicle departures, especially for vehicles on the southbound Tilton Road approach during the AM peak hour period. The base saturation flow for the southbound Tilton Road during the AM peak hour, neglecting these cycles, was observed to be approximately 1,800 pcphpl. All base saturation rates were coded as 2,100 pcphpl.

7. During the PM peak hour period, a small number of westbound Delilah Road motorists entered the circle when the westbound Delilah Road signal indications were red, only to return to westbound Delilah Road, using the southwest Circle overlap phase. This number was not directly measured in the field and for purposes of this analysis, it was assumed to be zero.
8. During the AM peak hour period, some southbound Tilton Road motorists as well as eastbound Delilah Road right-turners were observed to slow or otherwise become impeded by a standing queue of traffic already on the south side of the Circle. Most vehicles on the south side of the circle were using the middle lane and at times during the simulation this traffic prevents southbound Tilton Road from discharging from the stop bar because their target lane may be occupied. The modeling may be conservative here and potentially overstates the delay for the southbound Tilton Road approach because of the regular queuing on the south side of Airport Circle.
9. During data collection and field observations, no pedestrian activity was recorded. For purposes of the analysis, the pedestrian timing and phasing were not entered into the model.
10. Southbound Amelia Earhart Boulevard traffic entering the circle is yield-controlled. During field observations, it was observed that traffic from this approach would enter the Circle even if conflicting vehicles were queued or slowed. In order to best replicate this condition during modeling, the SimTraffic™ model was coded to allow vehicles from this approach to block the intersection during the PM peak hour period; however, due to limitations with the SimTraffic™ model itself, explicitly modeling the overly-aggressive gap acceptance on this approach is not possible. As a result, the results produced by the model may overstate delay and queuing as compared with actual conditions.
11. The protected-permitted left-turn phase for the eastbound approach at the intersection with Delilah Road and the eastbound Atlantic City Expressway off ramp and on-ramp has been modeled as a permitted-only left turn phase. During some simulation runs, the protected portion of this left-turn phase was observed to cause unrealistic queuing along

Delilah Road. This is likely due to the lack of additional calibration data outside of Airport Circle, including modifications for saturation flow rates and extension of effective green values. This change was not found to materially impact results at Airport Circle, and with additional study, more calibration of the system-wide model can be completed.

12. Results and timing plans were derived for the weekday morning and evening peak hours. Additional time periods can also be modeled with the available data and some supplemental data collection efforts, including weekend days, the mid-day peak hour period, and weekday off-peak conditions; however, additional calibration data should also be collected, including saturation flow rate measurements, travel time measurements using the available OD data, and spot delay studies.
13. Synchro™ does not currently support modeling of variable operation between MAX II and MAX III green times. Based on field observations, the MAX III green times were observed during the majority of cycles, and as such, MAX III values were used as the maximum phase green times at Airport Circle.
14. There are some inconsistencies between the controller report, field observations, and the signal plan, including differences between all-red clearance times, yellow times, split times, and extension times. Table 10 previously provided details the values used by the model.

## LANE UTILIZATION:

By way of the spot saturation flow rate measurements, field observations, and count estimates from the Autoscope™ video detectors at Airport Circle, lane utilization estimates were developed. It should be noted that the Autoscope™ volume counts do not appear to be accurate when compared with the available tube and manual counts completed during the same time periods; however, the detection zones yielded comparable lane utilization proportions as the manual counts. The lane utilization factors used as part of the analysis in Synchro™ , or other HCM-based analysis tools for that matter, have a substantial impact on capacity and the results. The use of default values may potentially overstate the capacity and performance of approach. These factors are relevant when initially coding the Synchro™ model in order to help derive timing plan estimates, but they are not used by the SimTraffic™ model because the simulation automatically determines lane usage.

Generally it was observed that approximately 5 to 10 percent percent of NB Tilton and SB Tilton Road traffic entering Airport Circle would use the inside or left-most lane, with the reaming 90 to 95 percent of traffic using the outside or right-most lane. This high degree of imbalance with regard to lane utilization has a major impact on capacity and it is reflected to some degree in the saturation flow rate adjustments made within the Synchro™ model. It is more explicitly addressed in the simulation analysis completed in SimTraffic™. Similarly the WB Delilah Road approaches at both the inside and outside locations at the Circle experience imbalanced lane utilization. During both the morning and evening peak hour periods, approximately 66 percent of through vehicles use the left-most through lane. This imbalance is directly related to the lane drop for the WB On-ramp with the AC Expressway, just west of Airport Circle. The following table summarizes observed stop bar lane utilization percentages for five of the approaches at Airport Circle.

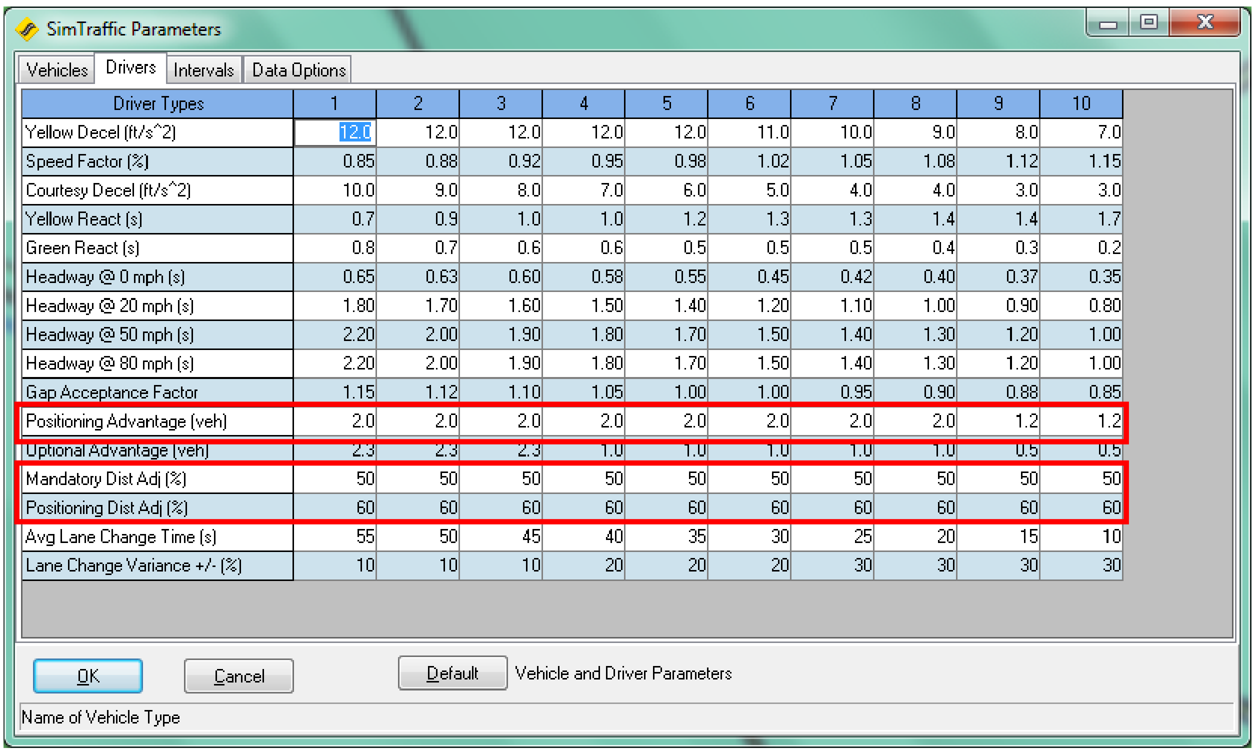
*Table 12: Lane Utilization Adjustments, Airport Circle*

| Observed Lane Utilization (Percent of Approach Traffic by Lane from Manual and Video Autoscope™ Counts) | MANUAL (Left Lane) | MANUAL (Right Lane) | AUTOSCOPE (Left Lane) | AUTOSCOPE (Right Lane) | $F_{LU}$ Adjustment Factors in Synchro™ Model (Default / AM / PM) |
|---|---|---|---|---|---|
| **NB Tilton Road** | 10% | 90% | 5% | 95% | 0.95 / **0.52** / **0.52** |
| **SB Tilton Road** | 6% | 94% | 7% | 93% | 0.95 / **0.54** / **0.52** |
| **EB Delilah Road** | 53% | 47% | 54% | 46% | 0.95 / **0.95** / **0.93** |
| **WB Delilah Road** | 66% | 34% | 68% | 32% | 0.95 / **0.72** / **0.77** |
| **NE Circle Approach** | N/A | N/A | 45% | 55% | 0.95 / **0.89** / **0.94** |

The SW Circle Approach has three lanes at the stop bar; the inside left and center lanes continue through the circle and the outside right lane exits the circle for westbound Delilah Road. The Autoscope™ counts demonstrated a split of 81%, 3% and 16% between the right, center, and lefts lanes on this approach, respectively, which was also confirmed by field observations. In summary, imbalanced lane utilization has the potential to produce skewed results without careful calibration of the Synchro™ model, and as such, these percentages above were used to derive observed saturation flow rate adjustment factors ($f_{LU}$) for use in the Synchro™ model for both the AM and PM peak hour periods. This step was necessary for initial signal optimization and preparation of the Synchro™ model. The SimTraffic™ analysis explicitly addresses the unbalanced lane utilization observed in the field by assigning vehicles to the correct lane. The simulation model does not rely on field estimates for lane use since the simulation automatically assigns vehicles into their desired lanes based on their origin, destination, and the link-specific mandatory and positioning lane change distances provided by the user. These values for $F_{LU}$ are ignored by SimTraffic™.

## CALIBRATION:

In order to match field conditions, some adjustments were made to the default driver parameters used by SimTraffic™. The mandatory positioning advantage in vehicles was changed from the default values to 2.0 vehicles for driver types 1 through 8. The mandatory and positioning lane change percentage adjustment factors were changed from the default values to 50 and 60 percent, respectively, for all driver types. All other default driver parameters remained the same. It should be noted that these changes do not change gap acceptance or reaction times and do not result in a fleet that is entirely more aggressive. These changes essentially allow all ten driver types used by the model to execute lane changes in shorter distances. Considering the close proximity of decision points within the Airport Circle model, these changes were necessary in order to make lane changing behavior more realistic, while minimizing the occurrence of model failures. The following screen capture shows the calibrated driver parameters.




| Driver Types | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Yellow Decel (ft/s^2) | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 11.0 | 10.0 | 9.0 | 8.0 | 7.0 |
| Speed Factor (%) | 0.85 | 0.88 | 0.92 | 0.95 | 0.98 | 1.02 | 1.05 | 1.08 | 1.12 | 1.15 |
| Courtesy Decel (ft/s^2) | 10.0 | 9.0 | 8.0 | 7.0 | 6.0 | 5.0 | 4.0 | 4.0 | 3.0 | 3.0 |
| Yellow React (s) | 0.7 | 0.9 | 1.0 | 1.0 | 1.2 | 1.3 | 1.3 | 1.4 | 1.4 | 1.7 |
| Green React (s) | 0.8 | 0.7 | 0.6 | 0.6 | 0.5 | 0.5 | 0.5 | 0.4 | 0.3 | 0.2 |
| Headway @ 0 mph (s) | 0.65 | 0.63 | 0.60 | 0.58 | 0.55 | 0.45 | 0.42 | 0.40 | 0.37 | 0.35 |
| Headway @ 20 mph (s) | 1.80 | 1.70 | 1.60 | 1.50 | 1.40 | 1.20 | 1.10 | 1.00 | 0.90 | 0.80 |
| Headway @ 50 mph (s) | 2.20 | 2.00 | 1.90 | 1.80 | 1.70 | 1.50 | 1.40 | 1.30 | 1.20 | 1.00 |
| Headway @ 80 mph (s) | 2.20 | 2.00 | 1.90 | 1.80 | 1.70 | 1.50 | 1.40 | 1.30 | 1.20 | 1.00 |
| Gap Acceptance Factor | 1.15 | 1.12 | 1.10 | 1.05 | 1.00 | 1.00 | 0.95 | 0.90 | 0.88 | 0.85 |
| Positioning Advantage (veh) | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 1.2 | 1.2 |
| Optional Advantage (veh) | 2.3 | 2.3 | 2.3 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 0.5 | 0.5 |
| Mandatory Dist Adj (%) | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 |
| Positioning Dist Adj (%) | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 | 60 |
| Avg Lane Change Time (s) | 55 | 50 | 45 | 40 | 35 | 30 | 25 | 20 | 15 | 10 |
| Lane Change Variance +/- (%) | 10 | 10 | 10 | 20 | 20 | 20 | 30 | 30 | 30 | 30 |

*Figure 17: Calibrated Driver Parameters, Airport Circle*

## RESULTS:

As coded within the base Synchro™ and SimTraffic™ model, a total of three intersections and their upstream links comprise Airport Circle. These intersections are:

1. Delilah Road – SB Tilton Road – SW Circle;
2. Delilah Road – NB Tilton Road – NE Circle; and
3. Delilah Road – AE Boulevard.

These intersections and their adjoining links were aggregated together into a single zone, which is a designation used by Synchro™ and SimTraffic™ to group results. The aggregated results for this zone include vehicles hours of delay, total average delay in vehicles per second, total number of stops, and average speed. It should be noted that SimTraffic™ does not explicitly report level of service. The following table provides the SimTraffic™-derived values of average delay by node for the morning peak hour per each of the four analysis scenarios.

*Table 13: Morning Peak Hour Results, Airport Circle, SimTraffic™*

| Morning Peak Hour Results (SimTraffic™) | A. Existing (Average Delay) | B. Timing Modifications (Average Delay) | C. Timing and Phasing (Average Delay) | D. AE Boulevard Relocation (Average Delay) |
|---|---|---|---|---|
| **3. Delilah – SB Tilton – SW Circle (Stop Bar)** | 76.8 | 37.3 | 43.5 | 34.5 |
| 32. SB Tilton Link (Upstream from Circle) | 493.7 | 258.3 | 76.4 | 45.3 |
| **4. Delilah – NB Tilton – NE Circle (Stop Bar)** | 34.9 | 29.5 | 25.3 | 24.1 |
| 33. NB Tilton Link (Upstream from Circle) | 305.3 | 68.4 | 77.4 | 55.6 |
| **23. Amelia Earhart Blvd – Circle (Stop Bar)** | 4.4 | 3.7 | 3.9 | N/A |
| 24 Amelia Earhart Blvd Link (Upstream from Circle) | 0.1 | 0.1 | 0.1 | N/A |

The following table provides the SimTraffic™-derived values of average delay by node for the evening peak hour per each of for the four analysis scenarios.

*Table 14: Evening Peak Hour Results, Airport Circle, SimTraffic™*

| Evening Peak Hour Results (SimTraffic™) | A. Existing (Average Delay) | B. Timing Modifications (Average Delay) | C. Timing and Phasing (Average Delay) | D. AE Boulevard Relocation (Average Delay) |
|---|---|---|---|---|
| **3. Delilah – SB Tilton – SW Circle (Stop Bar)** | 29.1 | 26.0 | 27.7 | 28.7 |
| 32. SB Tilton Link (Upstream from Circle) | 37.0 | 33.7 | 146.3 | 45.6 |
| **4. Delilah – NB Tilton – NE Circle (Stop Bar)** | 72.1 | 55.0 | 56.3 | 48.8 |

| | | | | |
|---|---|---|---|---|
| 33. NB Tilton Link (Upstream from Circle) | 115.9 | 134.5 | 120.0 | 56.9 |
| **23. Amelia Earhart Blvd – Circle (Stop Bar)** | 66.9 | 65.9 | 60.9 | N/A |
| 24 Amelia Earhart Blvd Link (Upstream from Circle) | 341.7 | 292.5 | 202.7 | N/A |

The following tables provide the cumulative morning and evening peak hour period results from the SimTraffic™ analysis. These tables aggregate the delay results shown in the previous two tables. For more detailed results, refer to the Synchro™ and SimTraffic™ reports.

*Table 15: Morning Peak Hour Total Zone Performance, Airport Circle, SimTraffic™*

| Morning Peak Hour Total Zone Performance (SimTraffic™) | **A. Existing (Average Delay)** | **B. Timing Modifications (Average Delay)** | **C. Timing and Phasing (Average Delay)** | **D. AE Boulevard Relocation (Average Delay)** |
|---|---|---|---|---|
| **Total Delay (veh-hr)** | 169.2 | 96.4 | 78.8 | 67.1 |
| **Average Delay (sec / veh)** | 937.3 | 539.7 | 447.4 | 145.2 |
| **Total Number of Stops *** | 4218 | 3811 | 3856 | 4134 |
| **Average Speed (mph)** | 6 | 10 | 11 | 12 |

*Table 16: Evening Peak Hour Total Zone Performance, Airport Circle, SimTraffic™*

| Evening Peak Hour Total Zone Performance (SimTraffic™) | **A. Existing (Average Delay)** | **B. Timing Modifications (Average Delay)** | **C. Timing and Phasing (Average Delay)** | **D. AE Boulevard Relocation (Average Delay)** |
|---|---|---|---|---|
| **Total Delay (veh-hr)** | 182.0 | 149.8 | 148.3 | 112.3 |
| **Average Delay (sec / veh)** | 450.7 | 379.8 | 375.0 | 156.1 |
| **Total Number of Stops *** | 5607 | 5655 | 5901 | 6078 |
| **Average Speed (mph)** | 7 | 8 | 8 | 11 |

It should be noted that in some cases the number of stops increases as compared with the previous scenario. This situation may occur because of the introduction of additional capacity and the arrival and delay of more vehicles per cycle, thus creating more stops and stop opportunities. Likewise, the vehicle-hours of delay is a useful measure because it combines the number of vehicles on the network and their time in a delayed state, and thus also reflects the additional (or subtraction) of traffic within the model because of increased (or decreased) capacity. In some cases, the total delay in vehicle-hours may increase.

It should also be noted that the four preceding tables are based on the results of the analysis before the purported changes to AM timing and phasing at the Circle, which occurred after the completion of this analysis.

## ADDITIONAL SCENARIOS:

Additional scenarios have also been identified during the course of this modeling work that may demonstrate some operational benefits in terms of delays and queues; however, they have not been fully analyzed and would require additional calibration and simulation-based analysis before results can be provided. These scenarios include:

1. The provision of direct left turns onto westbound and eastbound Delilah Road from both the northbound and southbound Tilton Road approaches, respectively. This scenario includes the diversion of these volumes from entering Airport Circle at both the northbound and southbound Tilton Road approaches to instead use of the inside or left-most lanes on these two approaches. This diversion would put more Tilton Road traffic into the inside or left-most lane, which is currently under-utilized, if at all, during the AM and PM peak periods; however, on both of the Tilton Road approaches the inside or left-most lane is relatively short and regularly blocked by queuing in the adjacent right-most lane. The vast majority of motorists enter Airport Circle from both of the Tilton Road approaches using the outside, or right-most lane. Hence, the arbitrary use of Synchro™ as an analytical tool for this scenario may yield better results than would otherwise occur because Synchro™ actually ignores this blocking issue. More detailed analysis in SimTraffic™ would be appropriate. Preliminary results for this scenario were presented at the May 30, 2013 design charrette at Atlantic County; however this analysis revealed marginal to negligible operational benefits during the AM and PM peak hour periods for the Tilton Road approaches because of these blocking issues. As such, this scenario was not fully analyzed. It should be noted, however, that this scenario has the potential to provide some operational benefit during off-peak periods when the Tilton Road approaches are adequately under capacity such that blocking of the left-most or inside lanes would occur with less frequency. Additional analysis for off-peak and weekend time periods would be appropriate in order to assess this option. Therefore, the full benefits of this scenario have not been identified at this time.

2. Signalization of Airport Circle at the existing Amelia Earhart Boulevard approach. This scenario would include stop-and-go signal operation of the Amelia Earhart Boulevard approach during the PM peak hour period. It should be noted that the volumes during the AM peak hour period on the Amelia Earhart Boulevard approach are very low in comparison with the PM peak hour period. This scenario would involve signal equipment installation and modification work that may also present some design issues, including but not limited to potential placement of commensurate signal indications and appurtenances to control Airport Circle traffic. The benefits of this scenario have not been identified at this time.
3. Signalization of the westbound Delilah Road right-turning movement (westbound Delilah Road traffic entering Airport Circle). This scenario includes the stop-and-go control of the traffic entering Airport Circle from westbound Delilah Road by way of an exclusive phase that runs concurrently with the westbound Delilah Road phase. This phase would help to meter traffic conflicting with the Amelia Earhart Boulevard approach during the PM peak hour period; however, the resultant impacts to westbound Delilah Road may offset these benefits. Additional analysis and considerations are required, including lengthening of the westbound right-turn lane and various phasing modifications to afford this movement additional green time. Conversely, signalization of the eastbound Delilah Road right-turning movement (eastbound Delilah Road traffic entering the south side of the Circle for eventual access to Tilton Road and Amelia Earhart Boulevard), may also have some benefits; however, this scenario derivative has also not been modeled. In summary, the benefits of this scenario have not been identified at this time.

## CONCLUSIONS/RECOMMENDATIONS:

The purpose of this analysis was to review the available crash records as well the existing traffic signal operation at the Airport Circle in Egg Harbor Township, Atlantic County, New Jersey. From a safety perspective, the types of crashes that are occurring at the Circle, same direction (rear-end) and side swipe are what can be expected at this type of intersection/circle. This Circle has a significant number of lane movements, possibly contributing to the amount of crashes, especially with drivers unfamiliar with the location. Additionally, the signal timing is longer than the average timing, possibly increasing driver frustration and leading to crashes. Field observations noted drivers making creative and illegal moves throughout the Circle to “beat” the signal timing and to avoid queues due to peak period congestion. For example, creative drivers on Delilah Road that wished to stay on Delilah Road were observed going around the circle to avoid the excessive wait created by the long signal timing.

## USE OF HIGHWAY SAFETY MANUAL (HSM):

The TWT team did review the potential application of the AASHTO Highway Safety Manual (HSM) within this study. The Highway Safety Manual is a ground-breaking tool that is just beginning to be used within the traffic engineering profession. The manual is the synthesis of more than thirty years of traffic safety research and data. It may be used by the practice to augment traditional study and preliminary engineering efforts by actually predicting the potential number of crashes for various geometric and operational conditions at intersections and along roadway segments. These methods are based on vetted national research and can truly help to advance the state of the practice by quantifying safety impacts, while removing some of the subjectivity that many safety studies see. The use of the manual may provide a strong defense against torts and other legal claims. The TWT team did explore use of the HSM in this project, but given the unique geometric configuration of the Airport Circle, we did not find applicable CMF's during our work.

### Crash Modification Factors:

The Crash Modification Factor (CMF) Clearinghouse provides information regarding the potential improvement of crashes as a result of a countermeasure implementation. A crash modification factor (CMF) is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. It is important to note that a CMF represents the long-term expected reduction in crashes and this estimate is based on the crash experience at a limited number of study sites; the actual reduction may vary.

CMFs are expressed in decimal form and are explained in the following example:

*An intersection is experiencing 100 angle crashes and 500 rear-end crashes per year. If you apply a countermeasure that has a CMF of 0.80 for angle crashes, then you can expect to see 80 angle crashes per year following the implementation of the countermeasure (100 x 0.80 = 80). If the same countermeasure also has a CMF of 1.10 for rear-end crashes, then you would also expect to also see 550 rear-end crashes per year following the countermeasure (500 x 1.10 = 550).*

The Crash Modification Factors Clearinghouse houses a Web-based database of CMFs along with supporting documentation to help transportation engineers identify the most appropriate countermeasure for their safety needs. A review of the Crash Modification Factor Clearinghouse (CMF) for "roundabouts" revealed 131 possible notations of varying categories. A more in depth review of the Intersection Geometry category did not yield many similarities to the existing Airport Circle configuration.

Potential recommendations from this study included signal timing adjustments; reducing cycle lengths and phase times; and phase overlap. A CMF review for signal timing and clearance interval changes revealed (the most applicable found) indicated that CMFs ranging from 0.643 to 0.937 would provide a reduction in rear-end crashes, as well as all crashes in some cases. The range of crash severity was from minor to serious. Channelizing the right turn movement from Amelia Earhart to NB Tilton would provide a range of CMFs from 0.81 to 0.98, reducing all types of crashes and minor and serious injuries. Improvements to lane delineation would provide a CMF of 0.82, although the Clearinghouse reference was for multilane roadway segments, it may still be applicable to the circle with its multi-lanes in and around the Circle area. CMFs for coordinating signal systems did not exist nor was there any reference for roundabout signing/diagrammatic signing. Providing advance warning signing provided a CMF of 0.65 with a reduction in angle crashes, but caution should be used here as the reference was a bit dated (1995).

## SIGNING IMPROVEMENTS:

Signing at the Airport Circle is a complicated problem. The five roadways which comprise the circle all have relatively high speed limits (40-50 miles per hour), and there are numerous destinations signed for within the project area. Destinations signed for on the respective approaches are presented in Table 17.

*Table 17: Observed Destinations on Airport Circle Approaches, 2013*

| West leg, Delilah Road | South leg, Tilton Road | East leg, Delilah Road | Amelia Earhart Boulevard | North leg, Tilton Road |
|---|---|---|---|---|
| Uptown Atlantic City | Egg Harbor City | West Atlantic County 646/To 40/322 | Uptown Atlantic City | Atlantic City International Airport |
| Brigantine | Hammonton | Mays Landing | Brigantine | F.A.A Tech Center |
| A.C. International Airport | North Atlantic County 563/To US Route 30 | Williamstown | East Atlantic County 646/To US Route 30 | Uptown Atlantic City |
| F.A.A. Technical Center | A.C. International Airport | Egg Harbor City | East Atlantic County 646 | Brigantine |
| New Jersey Air Guard | F.A.A. Tech Center | Hammonton | Atlantic City | East Atlantic County 646/To US Route 30 |
| Margate | N.J. Air Guard | A.C. International Airport | Brigantine | Mays Landing |
| | Uptown Atlantic City | F.A.A. Tech Center | | Williamstown |
| | Brigantine | N.J. Air Guard | | To US 40/322 |

The numerous destinations associated with the five intersection approaches require multiple signs, contributing to an easily understood "information overload" experienced by motorists navigating the Airport Circle.

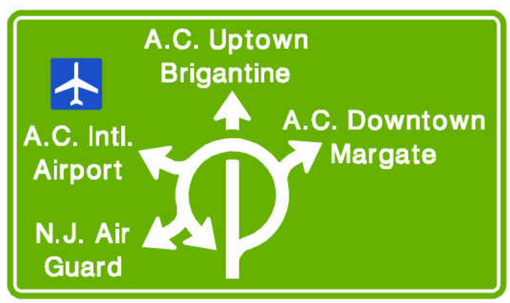
The complicated nature of signing at the existing intersection is illustrated by the following photos:


*Photos 4, 5, 6, 7: Representative Destination Signing, Airport Circle, Atlantic County.*



In reviewing the signing at Airport Circle, the TWT team believes that that diagrammatic circular intersection signing should be considered. The existing signing is acceptable, however, overhead placement of signing sized according to the roadway speed limit may convey a clearer meaning. The TWT team has developed conceptual signing, using the 2009 Manual on Uniform Traffic Control Devices for guidance, section 2D.38: Destination Signs at Circular Intersections.


**24'-0" x 17'-0" (Overhead)**
**12" UC/9" LC/36" Shields**
**Place over Delilah Road approaching circle from ACEX.**




**26'-0" x 15'-0" (Overhead)**
**12" UC/9" LC/36" Shield**
**Place over Delilah Road approaching circle from ACEX.**


**26'-0" x 15'-0" (Overhead)**
**12" UC/9" LC**
**Place over Earhart Blvd. approaching circle.**


*Figure 18: Diagrammatic Sign Panels, Airport Circle, Atlantic County (NOT FOR CONSTRUCTION).*

The conceptual sign panels do not represent a final design product, but are a graphic representation of the type signing which the consultant team recommends for consideration by Atlantic County.

## MINOR GEOMETRIC IMPROVEMENTS:

During the course of the project, the TWT team identified a minor geometric improvement on the Amelia Earhart approach to the Airport Circle. This improvement, depicted in yellow in Figure 19, would facilitate two lane egress from Amelia Earhart Boulevard with the possibility of one lane provided for traffic oriented to the northern leg of Tilton Road and another lane for all other destinations. This improvement should not be considered if Amelia Earhart Boulevard is relocated east of the Airport Circle.

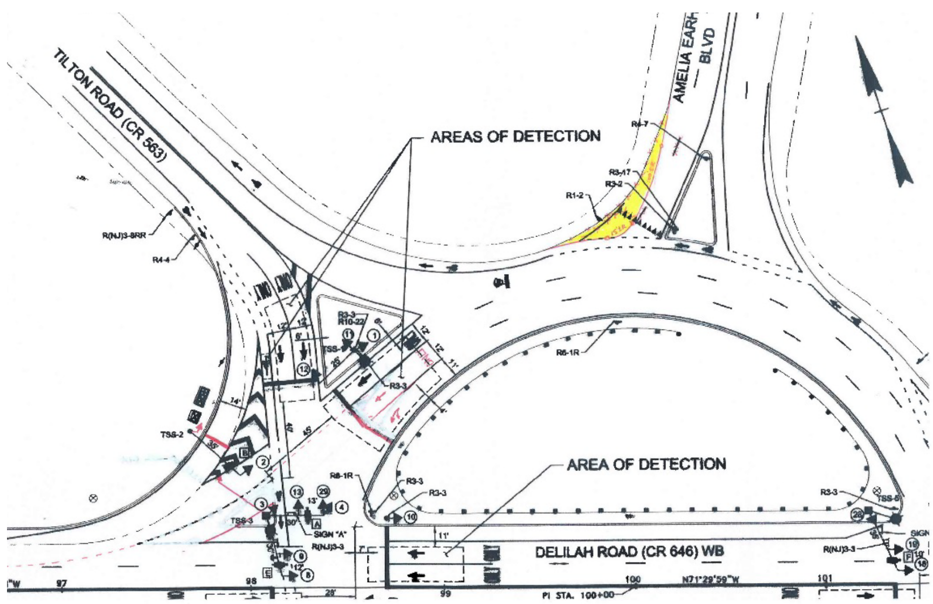



*Figure 19: Proposed Geometric Improvements, Amelia Earhart Boulevard at Airport Circle.*

## ACCESS MANAGEMENT AT SUNOCO/WAWA DRIVEWAYS:


*Photo 8: Sunoco Driveway, located on south leg of Tilton Road.*

On the eastern leg of Delilah Road, major driveways exist for a Sunoco mini-mart and Super Wawa. The Sunoco has two full movement driveways on both the southern leg of Tilton Road and the eastern leg of Delilah Road, providing a convenient cut-through for motorists wishing to avoid the long cycle length at the Airport Circle. As depicted in Photo 8, the Sunoco station Tilton Road driveway is very close to the intersection with left-turn in/out traffic functioning on courtesy gaps only. In order to reduce the cut-thru traffic pattern which was observed during all time periods by the TWT team, conversion of the Tilton Road driveway to right-turn in, right-turn out is highly recommended. Should Amelia Earhart Boulevard be relocated to the east of the Wawa property, modifications to the Delilah Road driveway should be considered, forcing left-turn in and out traffic to utilize the signal at relocated Amelia Earhart Boulevard, limiting Delilah Road traffic to right turn-in/out.

## PEDESTRIAN/CYCLE OPERATIONS:

The Airport Circle has been designed to facilitate pedestrian and cycle operations. There is no post-construction crash history involving pedestrians or cycles. Walk/Don't Walk times were checked by the TWT team and were found to be in compliance with current NJDOT/FHWA standards. The TWT noted that pedestrian actuation is provided along the eastern side of the circle, while omitted from the western side. Use of the No Pedestrian Crossing sign (R9-3) might be considered on the western side of the circle to persuade pedestrians to cross on the eastern leg of Delilah Road. Appropriate access ramps are provided for the eastern leg crossing at the Circle. With respect to cyclists, cycle lanes and signs are provided through the Airport Circle intersection.

## SIGNAL OPERATIONS:

From an operational perspective, the existing signal installation at Airport Circle currently provides four distinct phases to accommodate traffic. The intersection is fully actuated, although the SW Circle overlap (northern half of the circle), designed to provide access to Amelia Earhart Boulevard appears to be on recall. The TWT team checked clearance times (amber and all-red) currently installed at the intersection, and found them to comply with NJDOT/FHWA standards. Cycle lengths at the intersection were measured as high as 180 seconds, which contribute to excess delay and driver frustration.

Some recommendations for operational improvements include:

- Reduce the cycle length and phase times at the Circle, reducing both delay and driver frustration.
- Removal of the left-turn restrictions internal to Circle do not appear to greatly enhance intersection operations due to observed lane utilization. It is very difficult, almost impossible to access the left-most lane on the Tilton Road approaches during AM and PM peak periods, hence the benefits are negligible.
- There may be merit in modifying the existing phasing to allow the “overlap” phase for the northern half of the circle to be actuated. This may require additional loop detection on Amelia Earhart Boulevard, allowing the controller to detect queues on the roadway.
- Atlantic County should consider installation of a coordinated signal system between Delilah Road and the EB Atlantic City Expressway ramps and Delilah Road, Fourth Street and Next Generation Boulevard.

Tables 18 and 19 present optimized signal timing for the Airport Circle intersection. We noted that subsequent to completion of this analysis, timing changes have been made to the AM peak program (omitting the overlap phase) which have improved operations dramatically.

| Approach | Signal Controller Report | **Synchro™ / SimTraffic™ Model** | Synchro™ Model Maximum Green Times | Synchro™ Yellow, All-Red Times |
|---|---|---|---|---|
| Eastbound Delilah Road | Phase Φ6 | **Phase Φ2** | 27 sec | 5 sec, 2 sec |
| Westbound Delilah Road | Phase Φ2 | **Phase Φ6** | 27 sec | 5 sec, 2 sec |
| Northbound Tilton Road | Phase Φ8 | **Phase Φ8** | 33 sec | 4 sec, 3 sec |
| Southbound Tilton Road | Phase Φ4 | **Phase Φ3** | 41.5 sec | 4.5 sec, 4 sec |
| NE Circle Approach | Phase Φ7 | **Phase Φ7** | 43 sec | 4 sec, 3 sec |
| SW Circle Approach | Phases Φ9, Φ3 | **Phases Φ9, Φ4** | 4 sec, 33 sec | 4 sec, 3 sec |
| Amelia Earhart Boulevard | None | **None** | N/A | N/A |

*Table 18: Optimized Signal Timing, Airport Circle AM Peak Hour*

| Approach | Signal Controller Report | **Synchro™ / SimTraffic™ Model** | Synchro™ Model Maximum Green Times | Synchro™ Yellow, All-Red Times |
|---|---|---|---|---|
| Eastbound Delilah Road | Phase Φ6 | **Phase Φ2** | 26 sec | 5 sec, 2 sec |
| Westbound Delilah Road | Phase Φ2 | **Phase Φ6** | 26 sec | 5 sec, 2 sec |
| Northbound Tilton Road | Phase Φ8 | **Phase Φ8** | 27 sec | 4 sec, 3 sec |
| Southbound Tilton Road | Phase Φ4 | **Phase Φ3** | 27.5 sec | 4.5 sec, 4 sec |
| NE Circle Approach | Phase Φ7 | **Phase Φ7** | 29 sec | 4 sec, 3 sec |
| SW Circle Approach | Phases Φ9, Φ3 | **Phases Φ9, Φ4** | 35sec, 27 sec | 4 sec, 3 sec |
| Amelia Earhart Boulevard | None | **None** | N/A | N/A |

*Table 19: Optimized Signal Timing, Airport Circle PM Peak Hour*

Relocation of Amelia Earhart Boulevard east of Airport Circle appears to have potential to significantly improve Airport Circle operations. Detailed operational analysis of any final alignment and signal modifications should be completed by the County prior to approval of the improvements. As noted previously, the relocation of Amelia Earhart Boulevard will also impact the adjacent Wawa. Access management for the Wawa should be a component within the relocation project.

# SOURCES/BIBLIOGRAPHY:

Fogletto, B. (2010, October 8). *pressofAtlanticCity.com*. Retrieved from Construction work to begin week of Oct. 11 on airport traffic circle in Egg Harbor Township: http://www.pressofatlanticcity.com/communities/eht/construction-work-to-begin-week-of-oct-on-airport-traffic/article_72c7be30-d2fa-11df-af24-001cc4c002e0.html?mode=story

McKelvey, W. (2011, November 21). *pressofAtlanticCity.com*. Retrieved from Reconfigured Airport Circle in Egg Harbor Township to debut next week: http://www.pressofatlanticcity.com/communities/eht/reconfigured-airport-circle-in-egg-harbor-township-to-debut-next/article_fd218404-14a7-11e1-9483-001cc4c002e0.html?mode=image&photo=

US Department of Transportation, Federal Highway Administration. (2013, September 10). *FHWA Safety*. Retrieved from Intersection Safety: A Manual for Local Rural Road Owners: http://safety.fhwa.dot.gov/local_rural/training/fhwasa1108/ch3.cfm