NORTHERN ARIZONA UNIVERSITY

Background Research

Joseph Davis, Jace Elkins,

Jordan Weyrauch and Zach Crimmins

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1.0 Description of Technical Aspects

The following technical aspects outline general research topics needed for the study and redesign of the Old Walnut Canyon Road and Country Club Drive intersection in Flagstaff that is currently controlled by basic stop signs. The research topics include aspects for studying the intersection, justifying the implementation and budgeting the overall cost for a traffic signal installation. These descriptions serve as a basis of understanding for the transportation capstone group to build upon over the course of the project.

2.0 Traffic Studies

When designing an intersection in the traffic engineering industry, traffic studies need to be conducted to determine the constraints and parameters of the intersection. The results of these studies yield the warrants needed to justify a change the current stop sign control system of the intersection to utilize a traffic signal.

2.1 Volume Study

A volume study can be used to determine different types of volumes that an intersection experiences. For example, a volume study can determine the average daily traffic (ADT), average annual daily traffic (AADT), and peak hour volume (PHV). Pneumatic road tubes can be used to gather these counts. Two tubes are placed on the desired approach at a specified distance from each other. These tubes measure the speed, volume and classification of vehicles as they roll over them by calculating the axel distance as a function of time. [1]. A single tube may also be placed when traffic volume is the only desired data. In the case of Old Walnut Canyon Road and Country Club Drive, single tubes will be placed in the minor streets as speed is not a factor with a stop sign present and pairs of tubes will be used on the major route of Country Club Drive.

2.2 Turning Movement Count

The purpose of a turning movement count (TMC) is to determine the number of vehicle movements on each of the approaches. This study will be performed for twelve hours ranging from the morning to evening hours. This range of hours will take into account peak travel times such as lunch breaks and also normal operation hours for the adjacent golf driving range. The data collected during this study will influence the traffic control device, signal timing, markings, capacity analysis, and geometric design of the intersection [2].

2.3 Speed Study

A speed study is used to establish speed limits (85^{th}-percentile speed) and speed zones. The data collected during this study influences the signal timing, capacity analysis, and effectiveness of improvements. This study will be performed during off peak hours such as mid-morning and afternoon. The study can be performed manually or by using automatic devices such as pneumatic tubes described in the volume study [2].

2.4 Stopped Delay Study

The purpose of the stopped delay study is to determine magnitude of traffic delays. Delay is the amount of time a vehicle spends driving at a speed less than five miles per hour. In this situation, the primary stopped delay data set will be the vehicles either waiting at the Old Walnut Canyon stop signs waiting to turn onto Country Club Drive, or vehicles waiting behind those are the stop signs. The data collected during this study is used to perform a capacity analysis and signal

warrant analysis (warrant 2 and warrant 10). This study determines how efficiently an intersection is allowing traffic to enter and pass through [2].

3.0 Warrants

Warrants are what traffic engineers use to determine if a certain intersection is in need of a traffic control signal. Warrants are set standards that are specified in the Manual on Uniform Traffic Control Devices (MUTCD) [3]. There are eight different types of warrants and if any are met, a traffic control signal could be considered. The eight different warrants consist of: Eight-Hour Vehicle Volume, Four-Hour Vehicle Volume, Peak Hour, Pedestrian Volume, School Crossings, Coordinated Signal System, Crash Experience and Roadway Network. Based on engineering judgement and a basic understanding of the Walnut Canyon and Country Club intersection, the following warrants may not need to be conducted due to location and lack of traffic volume: Peak Hour, Pedestrian Volume, School Crossing, Coordinated Signal System, and Roadway Network. However the following warrants will most likely be conducted for the intended intersection: Eight-Hour Vehicle Volume, Four-Hour Vehicle Volume, and Crash Experience.

3.1 Warrant 1, Eight-Hour Vehicle Volume

A traffic signal may be considered if the volume on the major and minor streets is over the set MUTCD limits (Table 1) for each of any eight hours of an average day [3]. The major street in this case will be considered Country Club Dr. while the minor street will be Old Walnut Canyon Road.

Table 1: Eight-Hour Vehicular Volume Limits

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	500	400	350	280	150	120	105	84
2 or more.....	1.....	600	480	420	336	150	120	105	84
2 or more.....	2 or more.....	600	480	420	336	200	160	140	112
1.....	2 or more.....	500	400	350	280	200	160	140	112

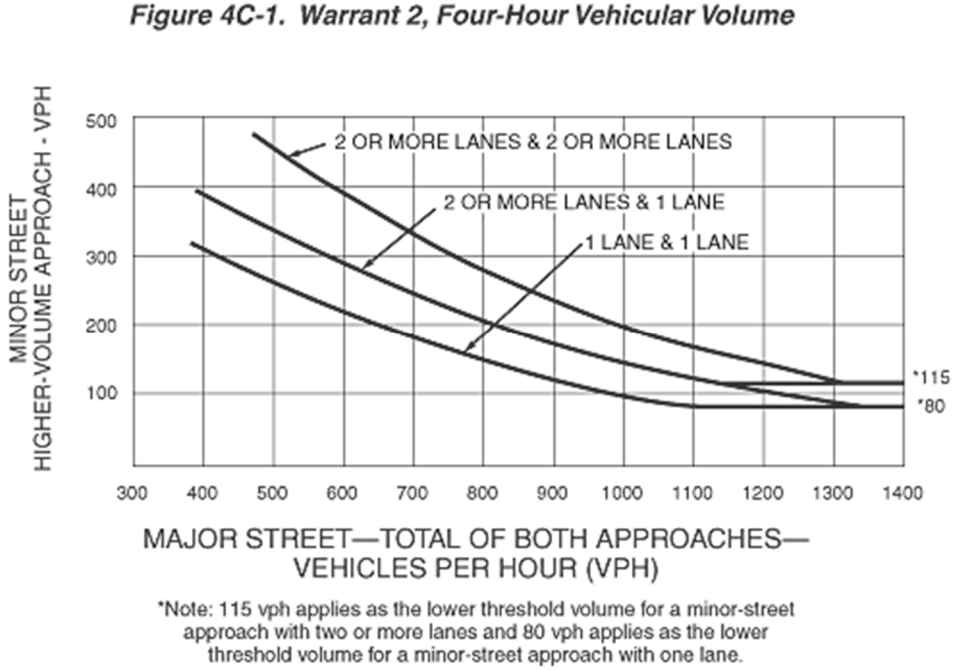
Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition B—Interruption of Continuous Traffic									
Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1.....	1.....	750	600	525	420	75	60	53	42
2 or more.....	1.....	900	720	630	504	75	60	53	42
2 or more.....	2 or more.....	900	720	630	504	100	80	70	56
1.....	2 or more.....	750	600	525	420	100	80	70	56

3.2 Warrant 2, Four-Hour Vehicle Volume

Based off a given graph (Figure 1) in the MUTCD for each of any four hours of an average day where the volume of intersecting traffic is high enough that a signal may be considered [3]. The current layout of the intersection is one through lane on Country Club Dr. therefore the "1 LANE & 1 LANE" curve will be used for analysis.

Figure 1: Four-Hour Vehicular Volume Limits



3.3 Warrant 7, Crash Experience

A traffic signal may be considered if alternate methods do not reduce the crash rate, and if five or more crashes occurred in a twelve month period [3]. Crash data is compiled through the City of Flagstaff from police reports which include severity and type of accidents. This data can be used in combination with crash reduction factors to determine if alternate methods can be used to reduce crashes. Alternate crash reduction methods include enhanced intersection lighting, signing/pavement markings and reflective sheeting on sign posts [4].

4.0 Economic Efficiency

In this section the technical aspects for an economically efficient design of a traffic signal intersection will be discussed. These technical aspects are as follows: economic focus, economic constraints and economic competition.

4.1 Economic Focus

In traffic-engineering industries when designing an intersection, budgeting to ensure an intersection is economically efficient is one of the first technical aspects of design. If an intersections budget is set too low, and in turn affects the design quality the individuals that own the intersection may have to pay more for the intersection in the long run due to high crash rates or overall safety issues. For example, the City of Flagstaff estimates collisions to cost them approximately: $6,033,740 for fatalities; $416,120 for incapacitating injuries; $83,120 for non-

incapacitating injuries, $43,693 for possible injuries; and $4,161 for non-injury collisions [5]. If collisions are not mitigated properly via a safe intersection design, collisions will occur more frequently which will cost the City of Flagstaff overall more. Furthermore, if an intersections design cost is too high, the design will not be implemented regardless of travel efficiency or safety. To eliminate economic issues the traffic analysis capstone team will need to remain within the allowable budget while designing the safest and most efficient intersection possible.

4.2 Economic Constraints

The traffic analysis capstone team determined that the City of Flagstaff has budgeted for the intersection located at Country Club / Oakmont to cost approximately $1,115,000 for redesign [6]. Furthermore, the City of Flagstaff, estimates a traffic signal intersection to cost approximately $400,000 [7]. Therefore, through careful budgeting and staffing, the team will deliver a design within budget. Even with a larger than needed budget, throughout the design process the team will use City of Flagstaff's bid history to determine material costs in order to ensure the project remains within budget.

4.3 Economic Competition

In the traffic-engineering world, competition between contractors often occurs which leads to the client commonly going with the more cost efficient design. Therefore, even with a design budget of $1,115,000; it is necessary for the overall design cost to remain as low as possible to ensure the team's project is chosen to implement by the City of Flagstaff.

5.0 References

[1] HCM 2000. Transportation Research Board of the National Academies. Chapter 7. Print

[2] MUTS 2000. Florida Department of Transportation. Chapters 4-14. Web

[3] MUTCD 2003. Sacrament, Calif.: California Dept. of Transportation, 2004. Chapter 14. Print

[4] "Crash Modification Factors-In Practice." Federal Highway Administration. U.S. Department of Transportation, 05 Oct. 2015. Web.

[5] Flagstaff Metropolitan Planning Organization. (2014). Crash Data. City of Flagstaff. Flagstaff, Arizona. [Report].

[6] “Capital Improvement Program Listing.” Flagstaff: City of Flagstaff, 2014. 417. Print.

[7] Sarty, Stephanie. “City of Flagstaff Capstone Meeting.” Client meeting. 22 Sept. 2015.