NAU SOUTH CAMPUS TRAFFIC STUDY

Transportation & Systems Engineering

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PROJECT OVERVIEW

CLIENT: GREG MACE

LOCATION: Flagstaff, AZ

NAU South Campus

PURPOSE: Mitigate the heavy congestion of vehicular and pedestrian traffic in the 20-25 minute intervals between classes.

Figure 1: NAU Campus

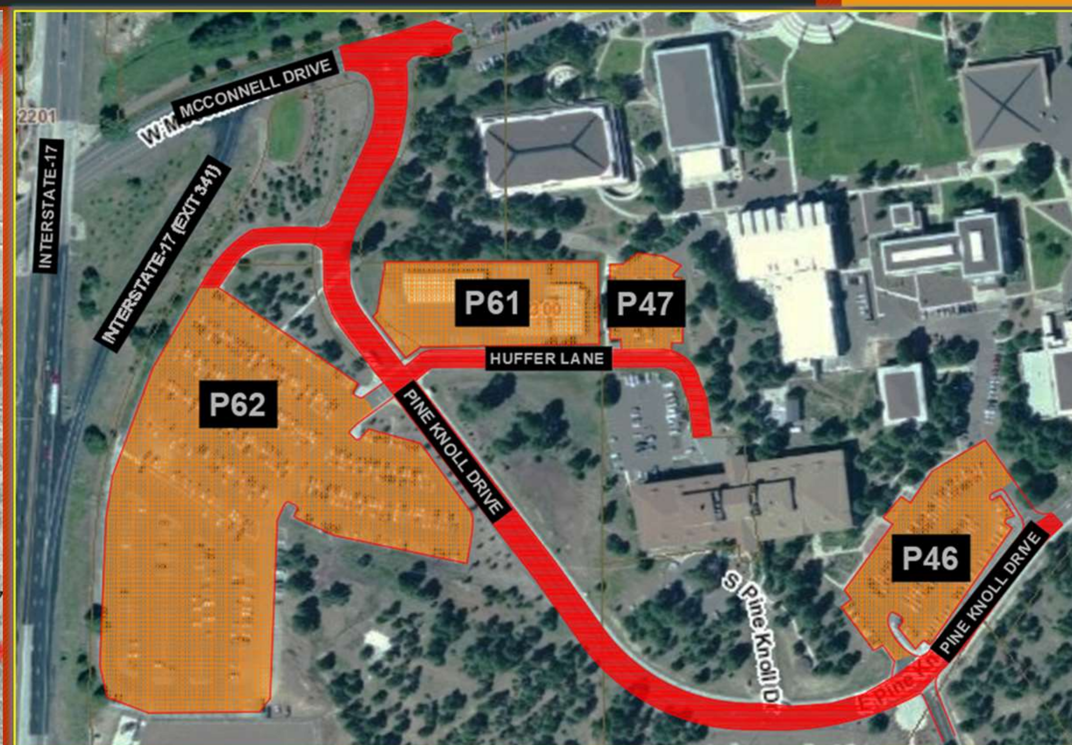

Figure 2: NAU South Campus

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EXISTING CONDITIONS

- CRASH DATA
  - Provided by the NAU Police Department
  - Mostly Property Damage Only Crashes
- PEAK HOUR FACTOR
  - Results are indicative of a very sharp peak for an urban environment ~ consistent with what was expected for a smaller town

Table 1: Crash Data

Crash Data for the Two Intersections			
Year	Pine Knoll/McConnell	Pine Knoll/Huffer	Comprehensive Crash Costs
2014	4	2	$ 81,900.00
2015	6	4	$ 149,000.00
2016	4	2	$ 119,400.00

Table 2: Peak Hour Volume

Peak Hour Volume			
Intersection	Peak Hour	Volume(veh/hr)	Peak Hour Factor
Pine Knoll/McConnell	11:00-12:00	1029	0.86
Pine Knoll/Huffer Lane	3:15-4:15	731	0.78

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LEVEL OF SERVICES (LOS): INPUT & RESULTS

Table 5: (HCS) Intersection of Pine Knoll Dr and McConnell

Highway Capacity Software Summary of Results									
	Eastbound			Westbound			Northbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes	0	1	1	0	1	0	1	0	1
Configuration		T	R		TR		L		R
Volume (veh/hr)		154	212	84	162		322		95
Percent Heavy Vehicles	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1	4.1
Approach Delay (s/veh)	19.75			15.58			28.77		
Approach LOS	C			C			D		

Table 6: (HCS) Intersection of Pine Knoll Dr and S Huffer Lane

Highway Capacity Software Summary of Results												
	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes	0	1	0	0	1	1	0	1	0	0	1	0
Configuration		LTR		LT		R		LTR			LTR	
Volume (veh/hr)	25	7	62	134	2	20	62	166	12	18	206	17
Percent Heavy Vehicles	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Approach Delay (s/veh)	10.74			11.42			10.19			9.36		
Approach LOS	B			B			B			A		

Mshary

VEHICLE CLASSIFICATION STUDY

<u>Federal Highway Administration</u>:

- Traffic Monitoring Guide

<u>Class Type</u>:

- Class 4

<u>Design Vehicle</u>:

- S-BUS-36
- Conventional School Bus
- Maximum Turning Path: 39.5 Feet
- Steering Angle: 37.2 Degrees

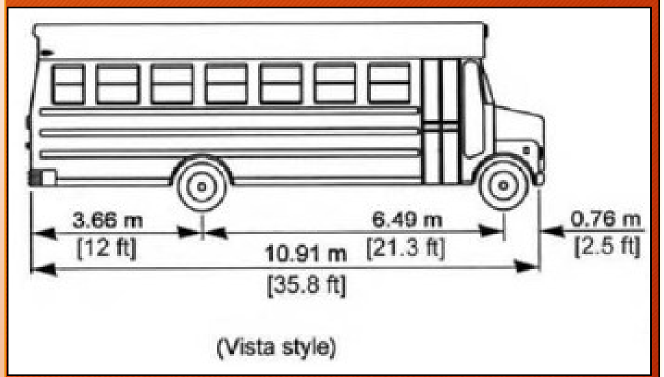

Figure 3: Design vehicle 65 passenger bus [2].

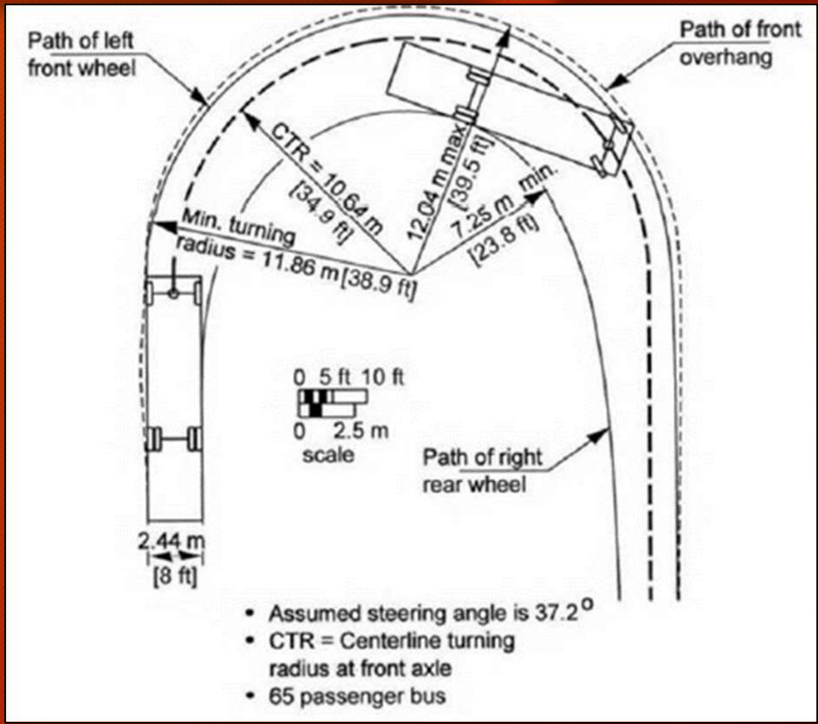

Figure 4: Vehicle Turn Radius

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POTENTIAL DESIGNS

Roundabout

- Reduces the vehicular delay at the intersection
- Increase pedestrian safety
- The total cost estimated to be $375,000

Pedestrian Bridge

- Reduces vehicular delay at both intersections in the area of Interest
- Eliminates The Variability Of Pedestrian Behavior Through The Intersection
- The Total Cost Estimated to be $985,000

Lane Addition

- Will decrease the average vehicular delay (not accounting for delay caused by pedestrians)
- Does not mitigate pedestrian traffic
- The Total Cost Estimated to be $1,112,000

ANALYSIS OF CRASH DATA

Table 7: Crash Modification Factor (CMF)

CMF Analysis						
Countermeasure	Number of Crashes	CMF	Future Crashes	Crash Costs	Savings	Cost/Benefit
Lane Addition						
2014	6	0.74	4	$ 29,600.00	$ 52,300.00	$ 556,000.00
2015	10	0.74	7	$ 89,300.00	$ 59,700.00	$ 370,666.67
2016	6	0.74	4	$ 29,600.00	$ 89,800.00	$ 556,000.00
Roundabout						
2014	6	0.38	2	$ 14,800.00	$ 67,100.00	$ 62,500.00
2015	10	0.38	4	$ 14,800.00	$134,200.00	$ 41,666.67
2016	6	0.38	2	$ 14,800.00	$104,600.00	$ 62,500.00
Pedestrian Bridge						
2014	6	0.50	3	$ 22,200.00	$ 59,700.00	$ 366,666.67
2015	10	0.50	5	$ 74,500.00	$ 74,500.00	$ 220,000.00
2016	6	0.50	3	$ 22,200.00	$ 97,200.00	$ 366,666.67

ROUNDABOUT DESIGN ALTERNATIVE

Single Lane Roundabout

- East Approach:
  - Entry width: 19ft
  - Approach Half width: 11 ft
  - Inscribed diameter: 20ft
  - Entry Angle: 33
- West Approach:
  - Entry width: 20ft
  - Approach Half width: 11 ft
  - Inscribed diameter: 26ft
  - Entry Angle: 34
- Pine Knoll:
  - Entry width: 19ft
  - Approach Half width: 11 ft
  - Inscribed diameter: 19ft
  - Entry Angle: 33.6

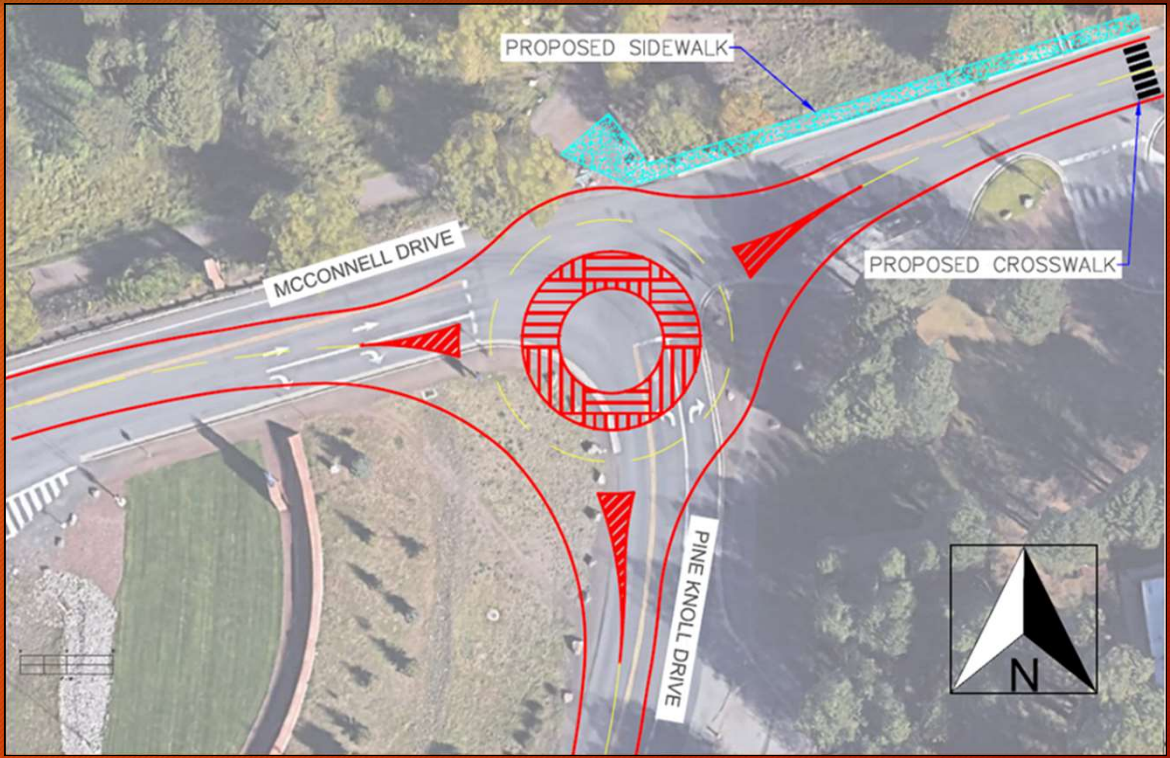

Figure 5: Proposed Roundabout Design

- Design Vehicle: Class 4 (Bus)
- Inscribed Circle Diameter: 110ft
- Circle Inner Speed: 25mph
- Raised Splitter Lanes
- Level Apron
- No pedestrian crossing on the North or West

Michael

LEVEL OF SERVICES (LOS): OUTPUT RESULTS

Table 8: Roundabout Delay Under Existing Conditions

Roundabout Design HCS Delay and LOS												
	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Approach Delay (s/veh)	5.64			7.13			6.9					
Approach LOS	A			A			A					

Table 9: 25 Year Roundabout Design Values

25 Year Design HCS Delay and LOS												
	Eastbound			Westbound			Northbound			Southbound		
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Approach Delay (s/veh)	7.82			11.61			9.2					
Approach LOS	A			B			A					

Michael

BENEFITS OF A ROUNDABOUT DESIGN

- Roundabouts reduce the amount of conflict points between vehicle and other users of the intersection by 75%
- Significantly reduce the amount of delay experienced at an intersection per vehicle.
- Reduction in delay causes a time travel savings value(VTTS) of $24.50 per hour.

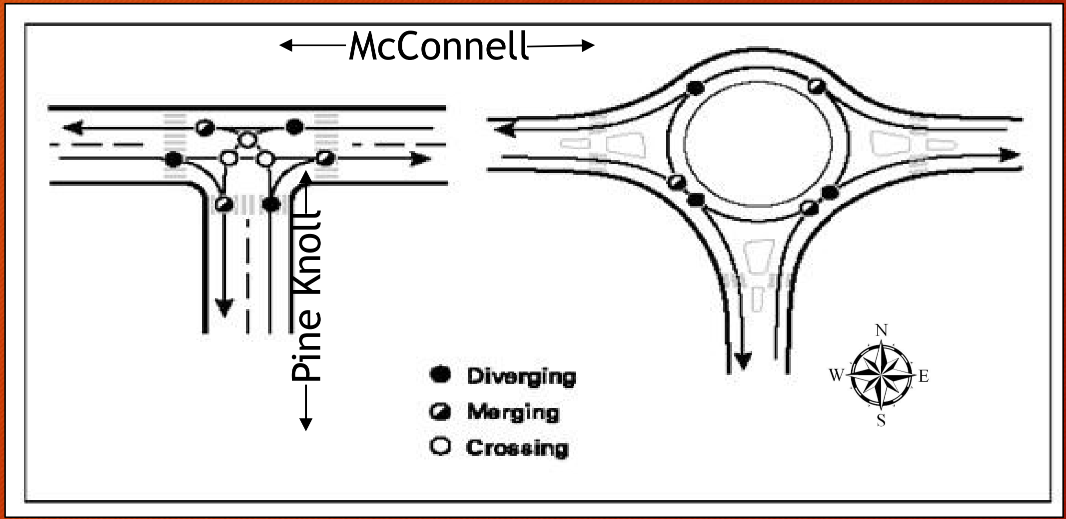

Figure 6: Conflict Points[9]

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ROUNDABOUT COSTS

- The table on the right is an approximation of the construction costs (only) of the roundabout.
- Labor costs would likely add a significant amount to the total construction cost. This is the need for the $250,000 cost estimation.

Table 10: Itemized Roundabout Costs

Item	Unit	Unit Price	Quantity	Total
Landscape Removal	Acre	$ 2,500.00	0.5	$ 1,250.00
Removal of Concrete Curb and Gutter	ft	$ 15.00	75	$ 1,125.00
Sign Removal	each	$ 200.00	4	$ 800.00
Roadway Excavation	yd^3	$ 20.00	400	$ 8,000.00
Aggregate Base, Class 2	yd^3	$ 105.00	400	$ 42,000.00
Asphalt Concrete	ton	$ 40.00	20	$ 800.00
Asphalt Rubber	ton	$ 650.00	6	$ 3,900.00
Mineral Admixture	ton	$ 90.00	1	$ 90.00
Slip Base	each	$ 250.00	8	$ 2,000.00
Sign Post	ft	$ 17.00	10	$ 170.00
Warning Marker	ft^2	$ 35.00	3	$ 105.00
Pavement Markings(White)	ft	$ 2.00	1848	$ 3,696.00
Pavement Markings(Yellow)	ft	$ 2.00	1848	$ 3,696.00
Paint Bull Nose	each	$ 175.00	4	$ 700.00
Concrete Curb(C-05.10)(Type G)	ft	$ 23.00	350	$ 8,050.00
Concrete Curb(C-05.10)(Type G)	ft	$ 27.00	1500	$ 40,500.00
Concrete Sidewalk Ramp(C-05.30 Type	each	$ 2,200.00	4	$ 8,800.00
Concrete Sidewalk(C-05.20)	ft^2	$ 12.00	800	$ 9,600.00
				$ 135,282.00

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IMPACTS

ECONOMICAL

- Least expensive design concept
- Maintenance is typically limited to landscaping
- VTTS is directly beneficial to the user of the intersection.

ENVIRONMENTAL

- Decreased delay results in decreased fuel consumption and increased VTTS for the user of the intersection
- Calming effects on traffic – Reduction in noise pollution

SOCIAL

- Initially, users of roundabouts do not like them, but repeat users are more likely to favor them.
- Public Education
- The rules for roundabouts are typically the opposite of standard traffic behavior

Michael

PEDESTRIAN BRIDGE

Design Criteria:
AASHTO Proposed Guide Specifications for the Design of FRP Pedestrian Bridges

Design Load:

- 85 psf (Pedestrian Live Load)
- 10,000 lbs (Standard H-5 Truck)

Delfection:

- Not Exceed L/500 (Service Pedestrian Live Load)

Clearance:

- 14 feet above Existing Roadway

Regulations:

- ADA Standards (Access Ramp)
- Grade (5% - 8.3%)

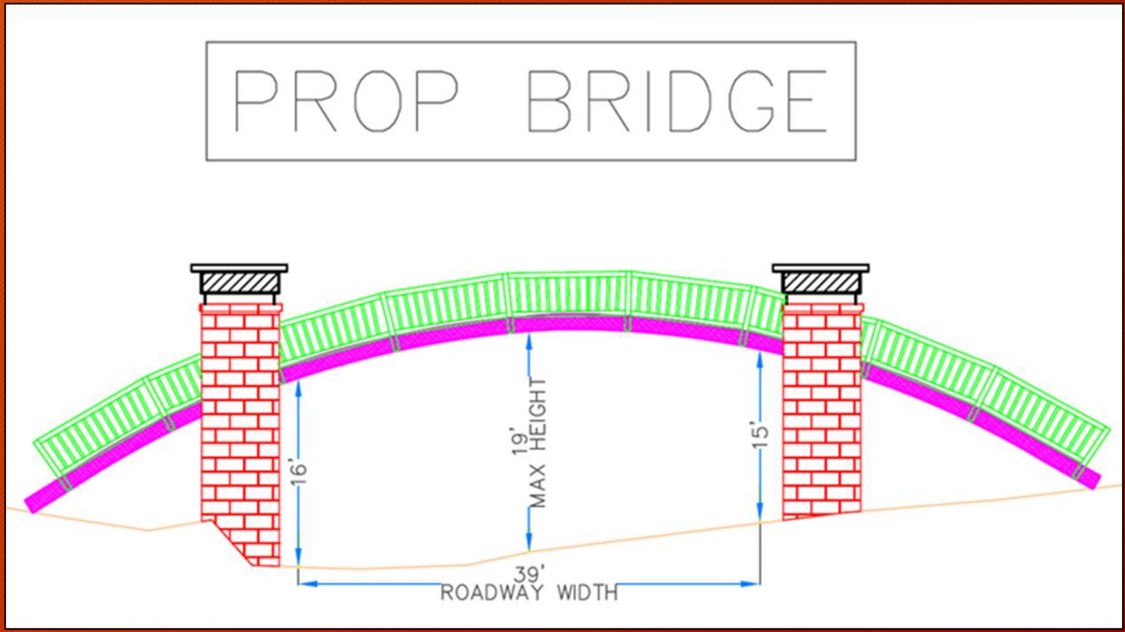

Figure 7. Pedestrian bridge proposal.

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COST OF IMPLEMENTATION

Design: Pedestrian Bridge

Build Year: 2022

Capital Cost: $985,524

Factors:

- Construction Costs
- Procurement & Installation of Equipment
- Design
- Project Administration Costs

Table 11: Total Costs for Pedestrian Bridge.

Pedestrain Bridge: Facility Costs	
Construction Cost:	$476,865
Equipment Cost:	$ 920
Operations & Maintenance (Annually):	$ 583
Project Contingency	
Administration (Construction) 6%	$ 28,667
Planning (Construction) 2%	$ 9,556
Design/Engineering 10%	$ 47,778
Field Inspection 2%	$ 9,556
Total Build Year Capital Cost:	$985,524

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ACCOMODATIONS

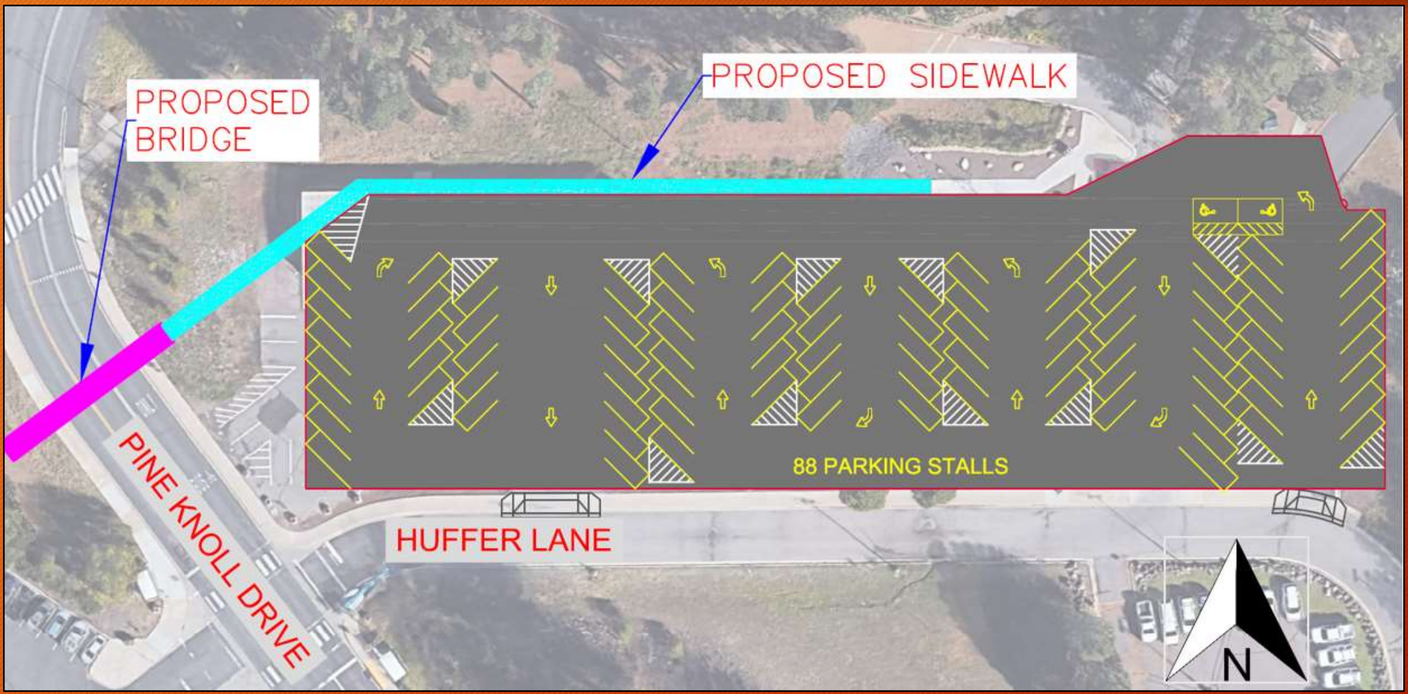

Figure 8: Proposed bridge at Pine Knoll Drive & Huffer Lane intersection.

<u>Pedestrian Bridge and Parking Lots (P61 and P47 Redesign)</u>

<u>Design Criteria</u>:

- City of Flagstaff Division 10-50.80 Parking Standards
- One-Way Drive Aisle
- Parking Stalls Angle: 45 Degrees

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IMPACT ASSESSMENT

ECONOMIC ANALYSIS

- Annual Operations and Maintenance is $593
- In a 2009 study, relationship between walking & real estate value, increase value of $700-$3,000 for every one-point increase in Walk Score (PedBikeInfo)
- The 2012 Benchmarking Report on Bicycling and Walking in the U.S. found that bicycling and walking projects create 11-14 jobs per $1 million spent, compared to just 7 jobs created per $1 million spent on highway projects.

ENVIRONMENTAL/SAFETY

- Annual Decrease in Auto-Use (Urban) area is $23
- Respects NAU's environmental issues of topographic characteristics and preserving the vegetation.

SOCIAL/FEASIBLE

- Provides Mobility
- Alleviates the traffic congestion for both pedestrian and vehicular conflicts.
- Provides access for bicyclists

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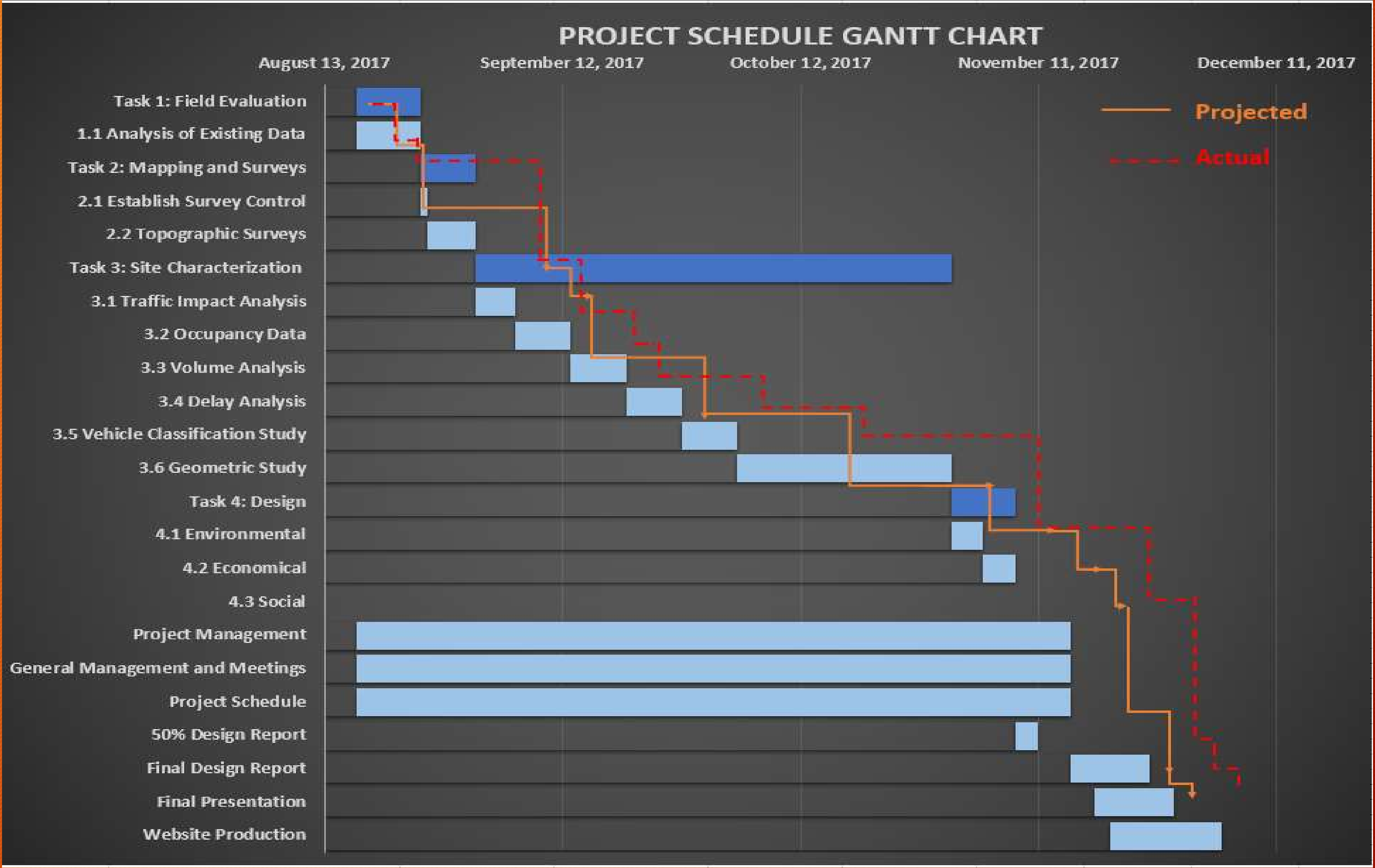
GANTT CHART



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PROJECTED HOURS

Table 12. Projected Total Hours vs Actual Hours.

Projected Hours						
Task	**Senior Engineer**	**Project Engineer**	**Engineer in Training**	**Intern**	**Total Hours**	**Actual Hours**
Task 1: Field Evaluation						
1.1 Analysis of Existing Data	10	20	35	35	100	70
Task 2: Mapping and Surveys						
2.1 Establish Survey Control	2	8	8	8		
2.2 Topographic Surveys	2	8	32	32	100	25
Task 3: Site Characterization						
3.1 Traffic Impact Analysis	Total Sum:	28	66	131		
3.1.1 Occupancy Data	3	8	25	35		
3.1.2 Volume Analysis	3	8	16	35		
3.1.3 Delay Analysis	2	8	15	35		
3.1.4 Vehicle Classification Study	1	4	10	26	234	207
Task 4: Design						
4.1 Geometric Study	3	5	20	20		
4.2 Environmental	2	8	15	16		
4.3 Social	2	6	15	16		
4.4 Economical	2	8	20	8	166	171
				Total	600	473

ENGINEERING SERVICES

Table 13. Project Personnel Position & Qualifications.

Positions	Qualifications
Senior Engineer	Transportation Specialty
Project Engineer	Traffic & Systems Specialty
Engineer In Training (E.I.T)	Traffic Systems Specialty
Intern	Traffic Data Collector Specialty

Table 14. Engineering Services for Project Personnel.

Personnel	Classification	Hours	Base Pay Rate ($/Hour)	Benefits of Base Pay Rate ($)	Actual Pay ($/Hour)	Billing Rate ($/Hour)	Cost
	Senior Engineer	34	$ 120.00	50%	$ 185.00	$ 220.00	$ 7,480.00
	Project Engineer	79	$ 100.00	20.00%	$ 133.00	$ 160.00	$12,640.00
	Engineer In Training (E.I.T)	172	$ 50.00	25.00%	$ 95.00	$ 140.00	$24,080.00
	Intern	188	$ 25.00	30.00%	$ 83.00	$ 110.00	$20,680.00
Total:							$64,880.00

Faris

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