2-27-2015

Active Transportation Research at Northern Arizona University

Edward J. Smaglik
Northern Arizona University

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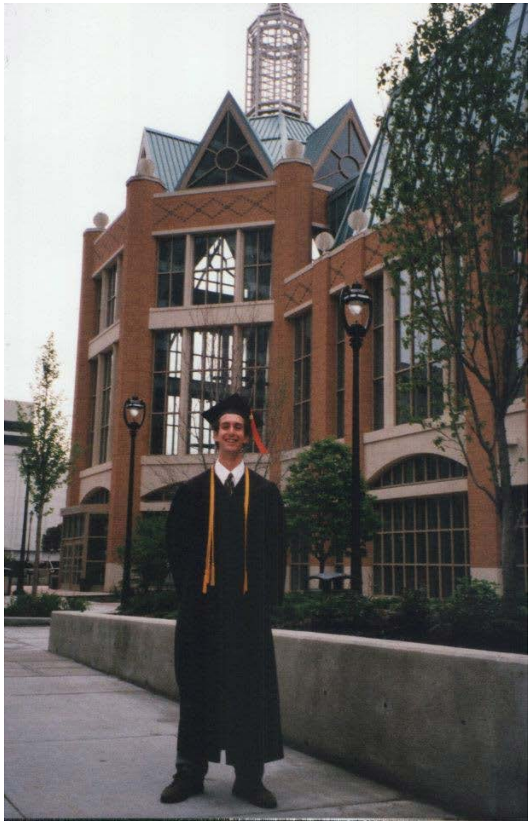
EDWARD J. SMAGLIK, PH.D., P.E.

13 FEBRUARY 2015

NORTHERN ARIZONA UNIVERSITY

Academic Background

- Born and raised in Milwaukee, WI
- Attended Marquette University
  - BS Civil Engineering, 1999

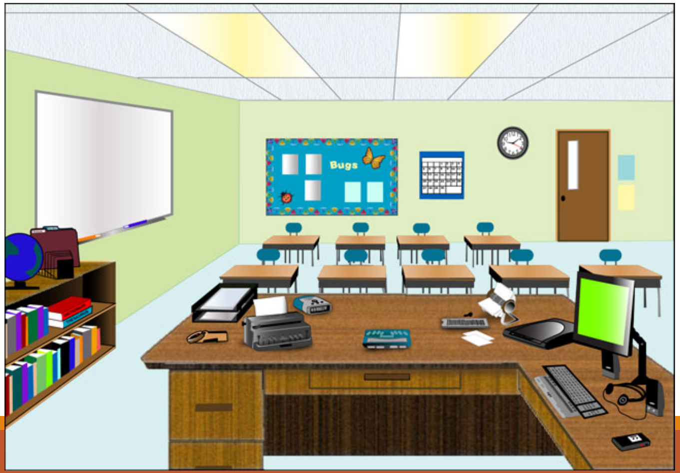


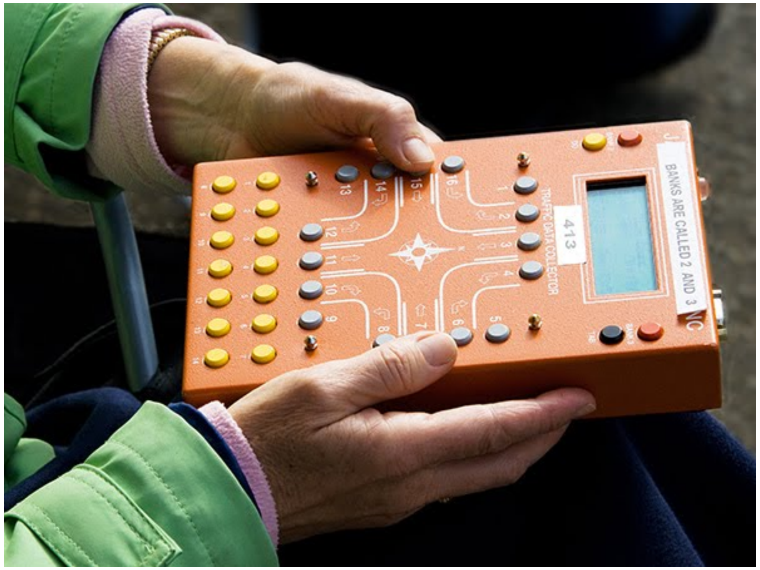
Academic Background

- Purdue University
  - MSCE Civil Engineering, 2001 (Construction Engineering and Management)
  - Ph.D. Civil Engineering, 2005 (Transportation Engineering)
  - Post-Doc (2005-2007)
- Northern Arizona University
  - Assistant Professor (2007-2013)
  - Associate Professor (2013+)

Professional Background

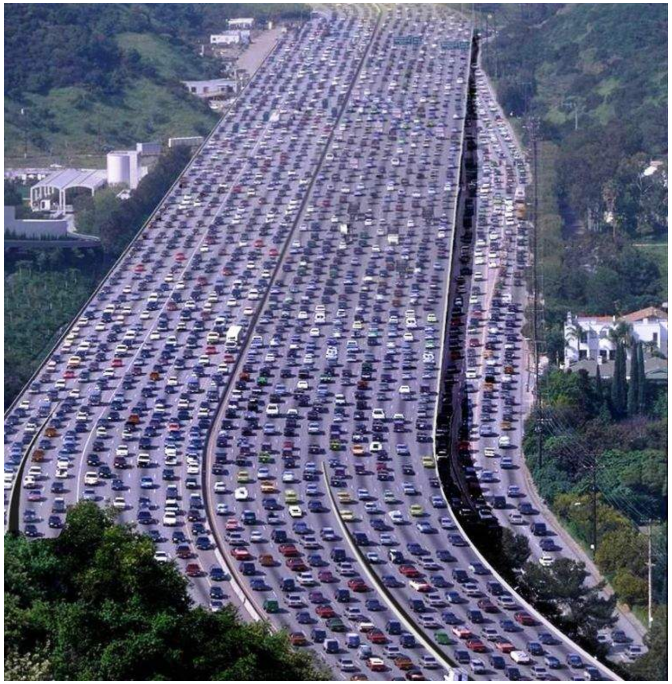
- Northern Arizona University
  - Courses Taught:
    - Traffic Signals and Studies
    - Advanced Traffic Signal Systems
    - Computer Aided Drafting
    - Urban Transportation Planning





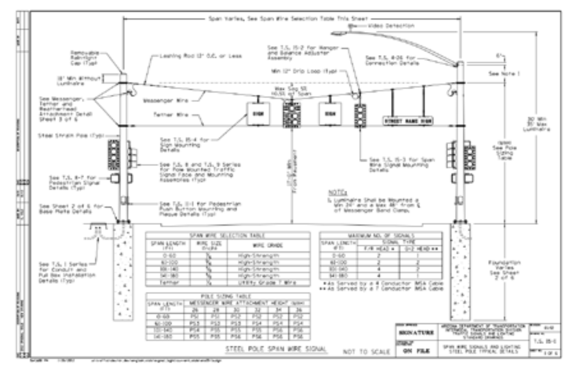
NAU Undergraduate Transportation Courses

- Required coursework
  - No survey course
  - Highway Design and Operations
    - Complete design of highway section
  - Traffic Signals and Studies



Select Past NAU Funded Research Work

- Development of Signalized Intersection Performance Measures – Phases 1 and 2
- Snowplay Congestion Analysis
- Impact of Penalty Feedback on Work Zone Speed
- Development of a Span Wire Specification For ADOT
- Observational Sign Sheeting Study



Active NAU Funded Research Work

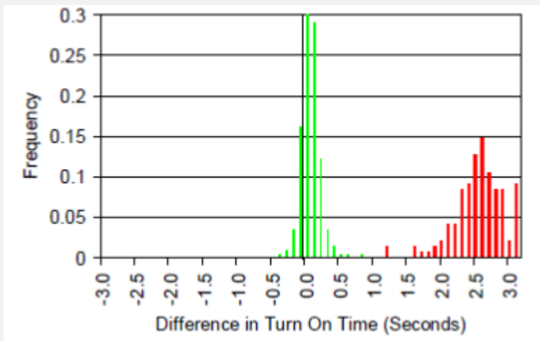
- Improving Adaptive / Responsive Signal Control Performance: Implications of Non-Invasive Detection and Legacy Timing Practices
  - Sponsor: ODOT (PSU and IA State are subs): Budget: $160,000; September 2014 – June 2016
- Improving Walkability Through Control Strategies at Signalized Intersections
  - Sponsor: NITC (PSU is prime); Budget: $109,075 (NAU: $25,643); September 2014 – January 2016
- Investigation and Prototype Development of a Self-powered Bridge Structural Health and/or Traffic Monitoring Sensor Using Magnetic Shape Memory Alloys
  - Sponsor: NAU; Budget: $70,075; April 2014 – June 2015

Implications of Detection Degradation

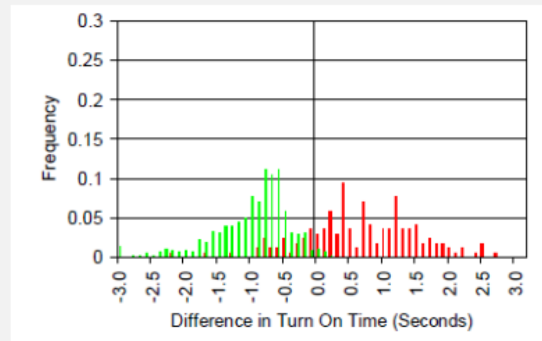
- Funding Agency: Oregon DOT
- Lead: Northern Arizona University
  - Subs:
    - Portland State University (Sirisha Kothuri)
    - Iowa State University (Anuj Sharma)

- Objective
  - Different detection sources provide varying levels of accuracy
  - The impact of less than optimal detection on traditional call and extend operation is well known
  - How does sub-optimal detection impact the operation of higher level control algorithms, such as adaptive and/or traffic responsive?

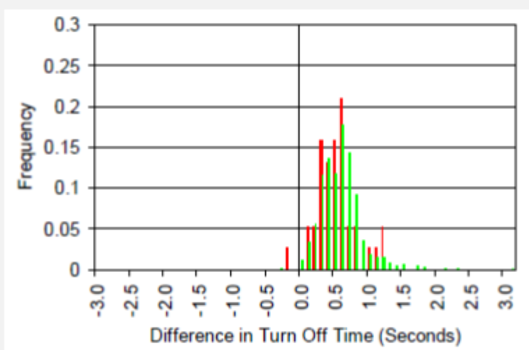
Example Latency Differences



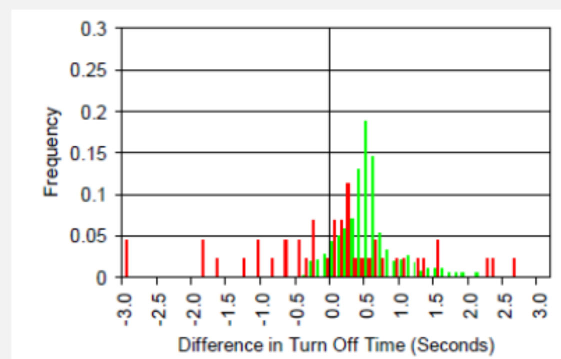
a) On-time Histogram, Day



c) On-time Histogram, Night



b) Off-time Histogram, Day



d) Off-time Histogram, Night

Detection Methodology

- Field data collection
  - Locations identified with multiple detection sources covering one or more approaches
    - 97th Ave & Lawnfield Rd, Clackamas County
      - Autoscope Encore
      - Inductive Loop
      - Wavetronix Matrix

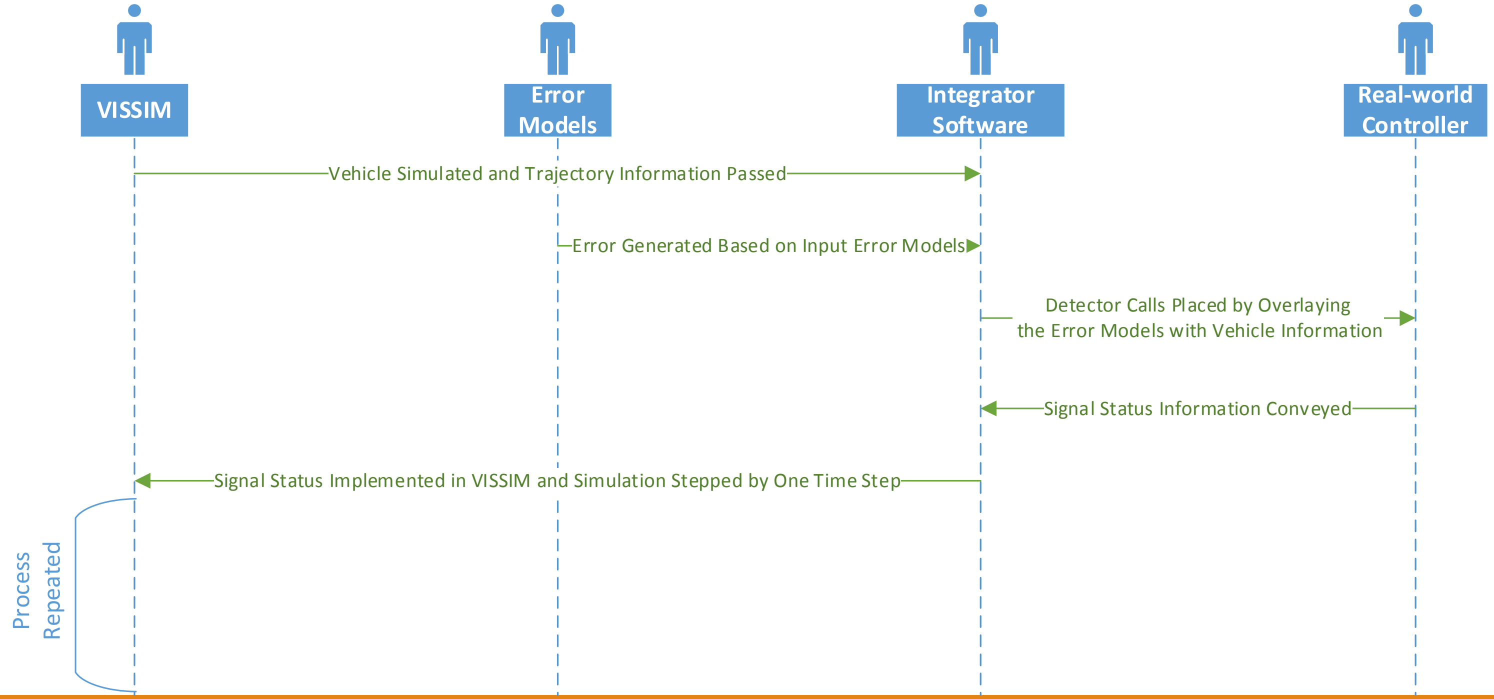
    - Wilsonville Rd & Town Center Loop West, City of Wilsonville (Clackamas County)
      - Autoscope Solo Pro
      - Inductive Loop
    - US 20 & Robal Rd, ODOT District 4
      - Iteris Vantage Vector (Radar / Video)
      - Inductive Loop
      - FLIR
    - 122nd & SE Division, PBOT
      - Autoscope Terra
      - Inductive Loop

Detection Methodology

- Field data collection
  - Collect event based operational data (detector and phase statuses) under varying traffic regimes
- Error modeling and simulation
  - Using collected field data, develop statistical error models
    - Missed Call model
    - True call start- and end-time
    - False call models
      - False call duration
      - Intra-false call duration

Detection Methodology

- Error modeling and simulation
  - Use the error models as inputs for detector error in HITL/SITL models



Detection Methodology

- Error modeling and simulation (continued)
  - Evaluate simulation models under varying traffic and operational scenarios
- Comparison and cost analysis
  - Corroborate level of detector error with impact on traffic operations
  - Perform cost/benefit analysis focusing on equipment and installation costs as well as the cost of increased delay due to degradation of detection performance
  - Provide guidance to sponsor on prototypical detection configurations with the goal of reducing performance degradation due to vehicle detection

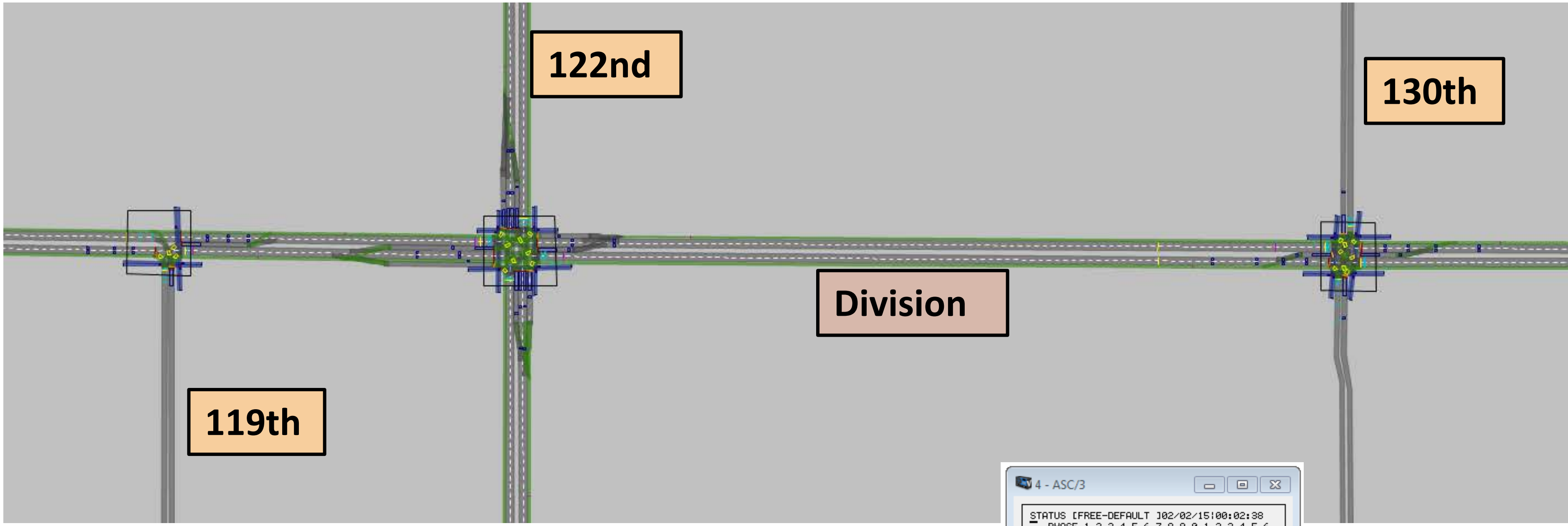
Walkability Study

- Funding Agency: NITC
- Lead: Portland State University
  - Sirisha Kothuri & Chris Monsere
- Objective:
  - Newer treatments (LPI, scramble) improve safety, but peds must still wait their turn
  - Can result in delays much longer than those for vehicles
  - Are there opportunities to improve operations through control strategies?

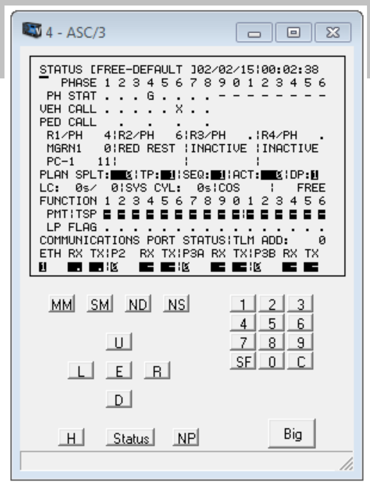
Walkability Methodology

- Two step approach
  - Software in the loop simulation of various pedestrian control treatments to identify operational sweet spots of when to implement different strategies
    - Shorter cycles lengths
    - Elimination of coordination during certain periods
    - Leading pedestrian intervals
    - Pedestrian priority
  - Field implementation of pedestrian priority feature with 2070 and NEMA controllers, with operational data collection
    - Portland, OR
    - Flagstaff, AZ and/or Mesa, AZ

Simulation



- Leading Pedestrian Interval
- Exclusive Pedestrian Phase
- Extension of Permissive Window
- Pedestrian Priority
- Cycle Length Manipulation



Pedestrian Priority Algorithm

- Two stages
  - Call the program
  - Call the pedestrian
- Options for calling program:
  - Delay threshold – Once pedestrian has waited “X” amount of time, call program
  - Specific time of day depending on local demand
  - Vehicular operational data
    - Use V/C to determine when to run ped algorithm
      - $X_i = \frac{v_i}{c_i} = \frac{v_i/s_i}{g_i/C} = \frac{v_i \cdot C}{s_i \cdot g_i}$
        - vi = flow rate (veh/h)
        - C = cycle length
        - si = saturation flow rate
        - gi = effective green time
    - Perhaps something simpler?
      - Seconds green / vehicle

General Logic Approach – ASC/3

IF / AND (conditional statements)

- DET VOLUME
- CYCLE LENGTH
- MIN/MAX Green
- Other

THEN (executable statement)

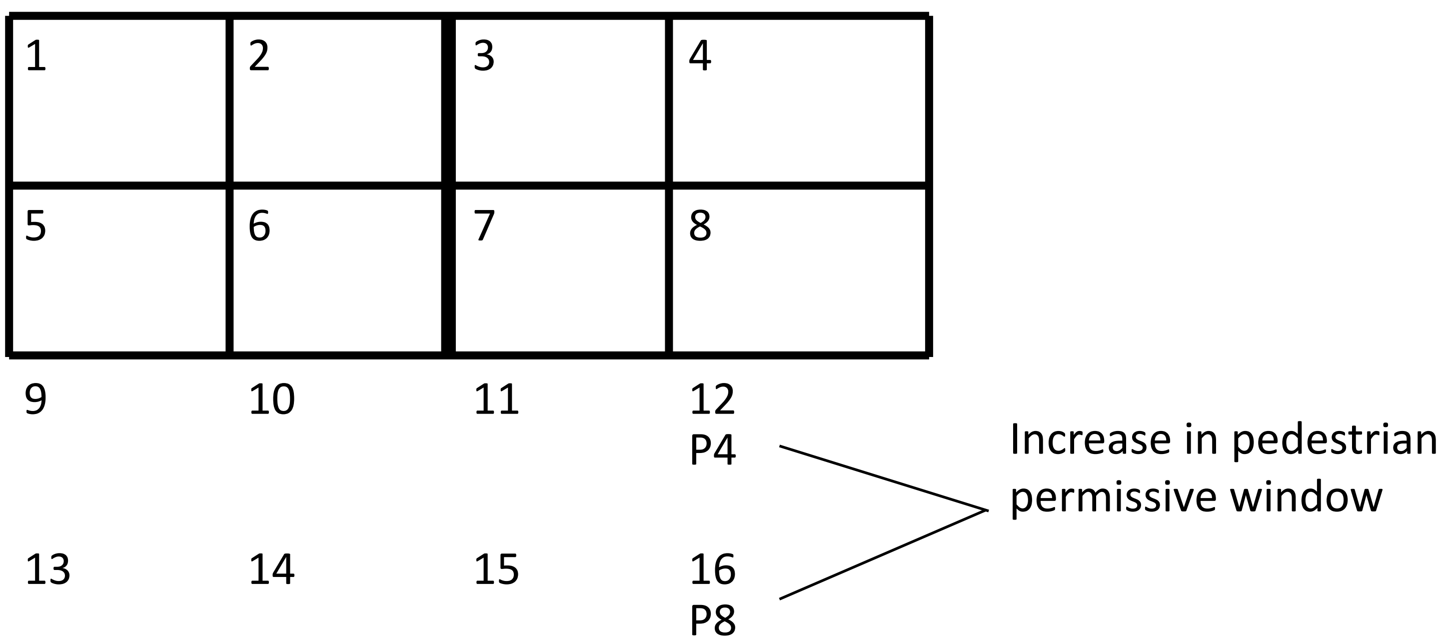
- LOGIC FLAG
- SET RING 3 / RING 4
- SET TOD PLAN
- SET PED DET ON / CALL PED PHASE
- Other

ELSE (executable statement)

Pedestrian Priority Algorithm

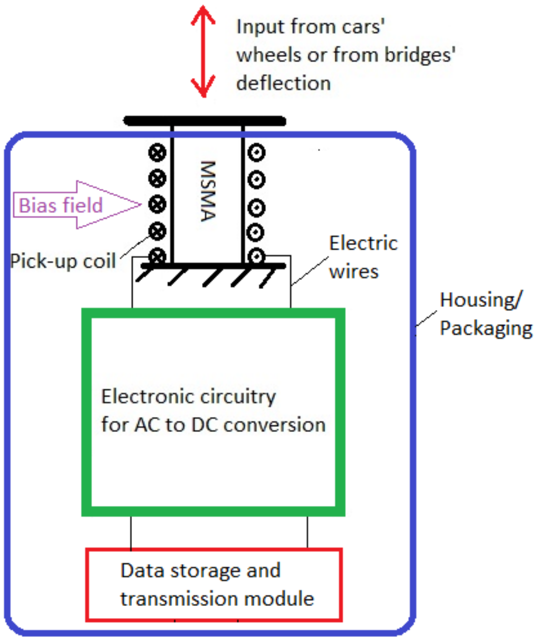
Call the pedestrian

- Increase permissive window only for P4 / P8
  - Phase 12 : P4
  - Phase 16 : P8
  - Ring / Barrier considerations?



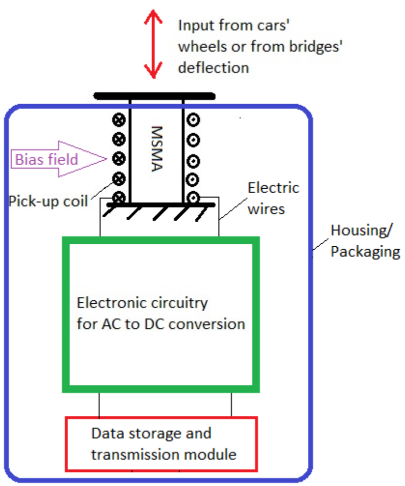
Self-Powered Detector / Sensor

- Funding Agency: NAU Office of Vice President for Research
- Co-PI's: Dr. Constantin Cicionel and Dr. Niranjan Venkatraman
- Objective:
  - Build and deploy prototype of a power harvesting sensor using MSMA materials (Magnetic Shape Memory Alloy)
- Three steps
  - Experimental Program
  - Prototype Creation
  - Field Deployment



Experimental Program

- Variables Investigated
  - Wire gauge
  - Number of turns
  - Spatial orientation of coil with respect to MSMA sample
  - Number of MSMA samples



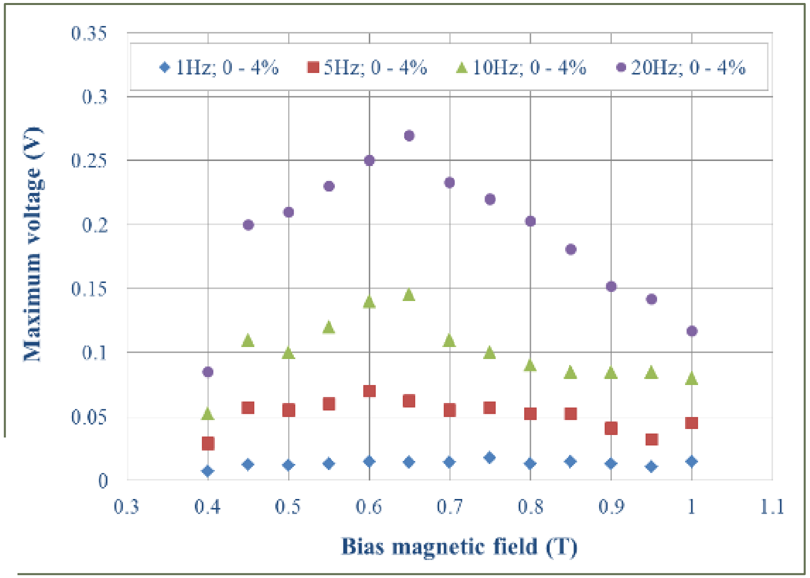
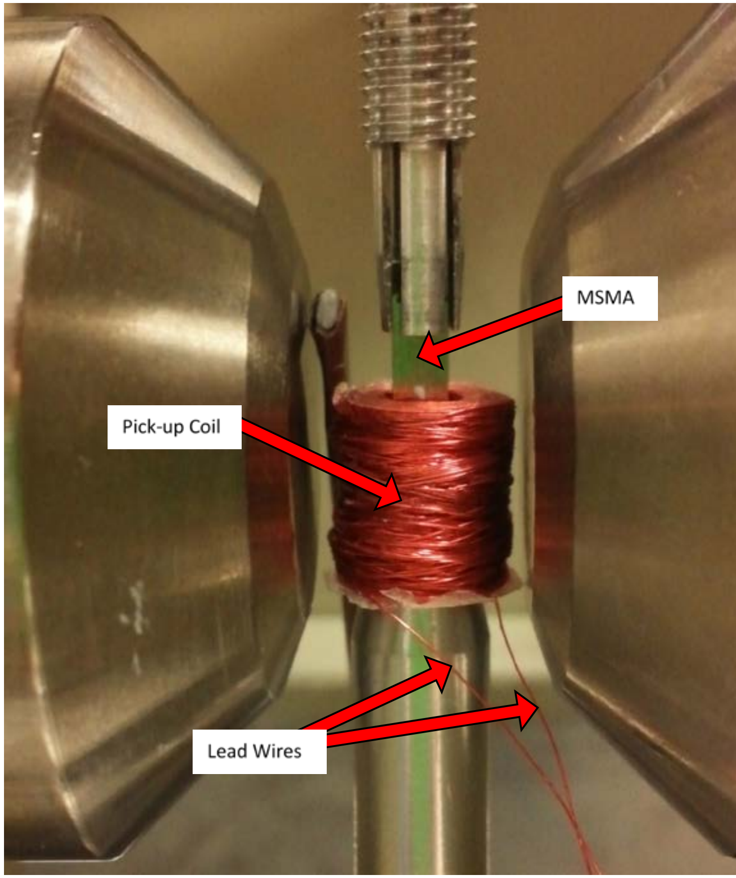
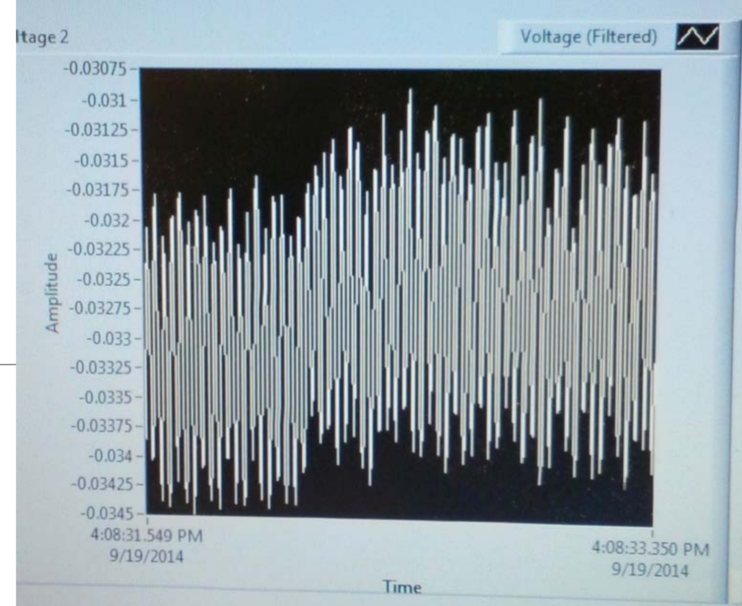
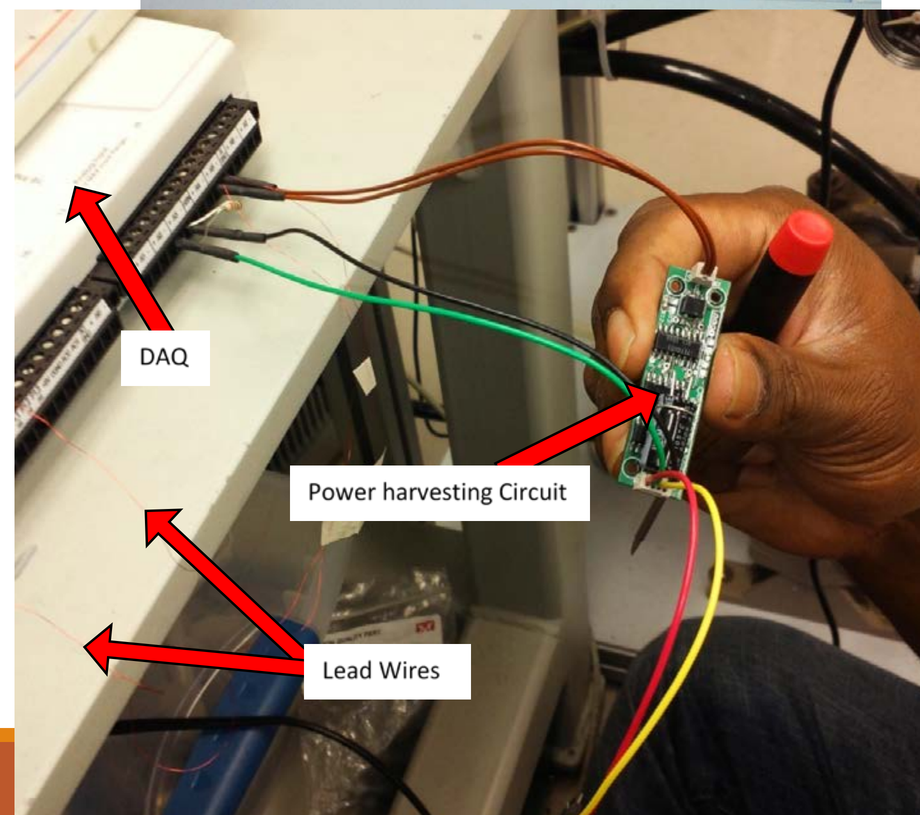
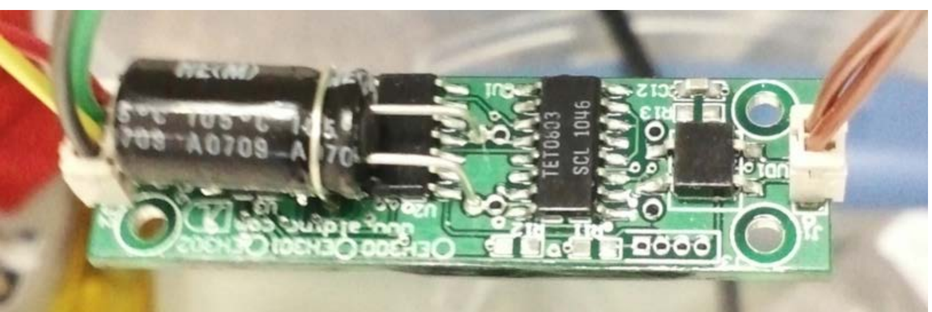


Figure 1 – Voltage output from a MSMA sample strained at 4% strain, under various bias magnetic fields and frequency levels.


MSMA
Pick-up Coil
Lead Wires


ltage 2
Voltage (Filtered)
Amplitude
-0.03075
-0.031
-0.03125
-0.0315
-0.03175
-0.032
-0.03225
-0.0325
-0.03275
-0.033
-0.03325
-0.0335
-0.03375
-0.034
-0.03425
-0.0345
4:08:31.549 PM
9/19/2014
4:08:33.350 PM
9/19/2014
Time

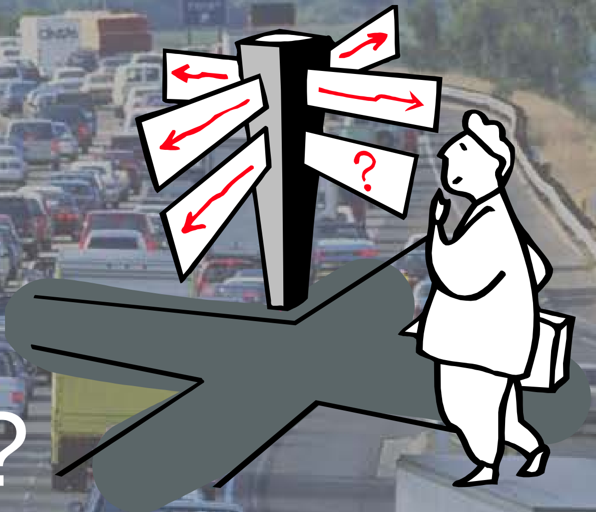

DAQ
Power harvesting Circuit
Lead Wires



Prototype Creation and Field Deployment

- Prototype design in process
- Likely some sort of canister type enclosure with dampening dependent upon application
- NAU shop used for fabrication
- Field Deployment to be undertaken upon fabrication completion
- Will focus on one application, a roadway site
- Sensor will be self-sustaining in deployment; likely need 24-48 hours to charge

Questions?
Thoughts
Suggestions?



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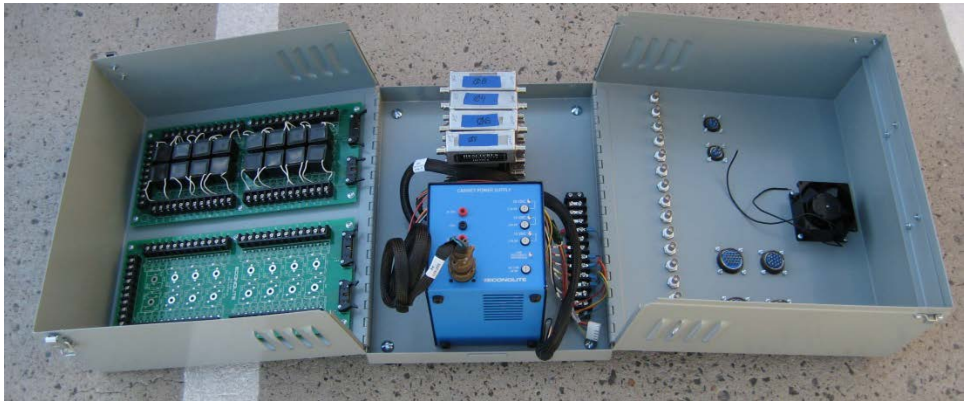
Associate Professor and Director
AZ*Trans*: The Arizona Laboratory for Applied Transportation Research

Senior Intern
Kittelson & Associates

Development of Signalized Intersection Performance Measures

- Utilize existing cabinet / intersection infrastructure to develop vehicle counts
  - ASC/3 Controller as data logger
    - Helped develop this spec at Purdue
  - Additional detector cards / racks as needed to produce a count output for each lane



Snowplay Congestion Analysis

- Objective: Provide real time travel time information to road users during times of peak congestion.
  - Using Bluetooth data collection devices, a net was cast across the study area to attempt to develop travel times on alternate routes
  - Ultimate determination was that there was not enough data available to develop travel time solely based upon Bluetooth data

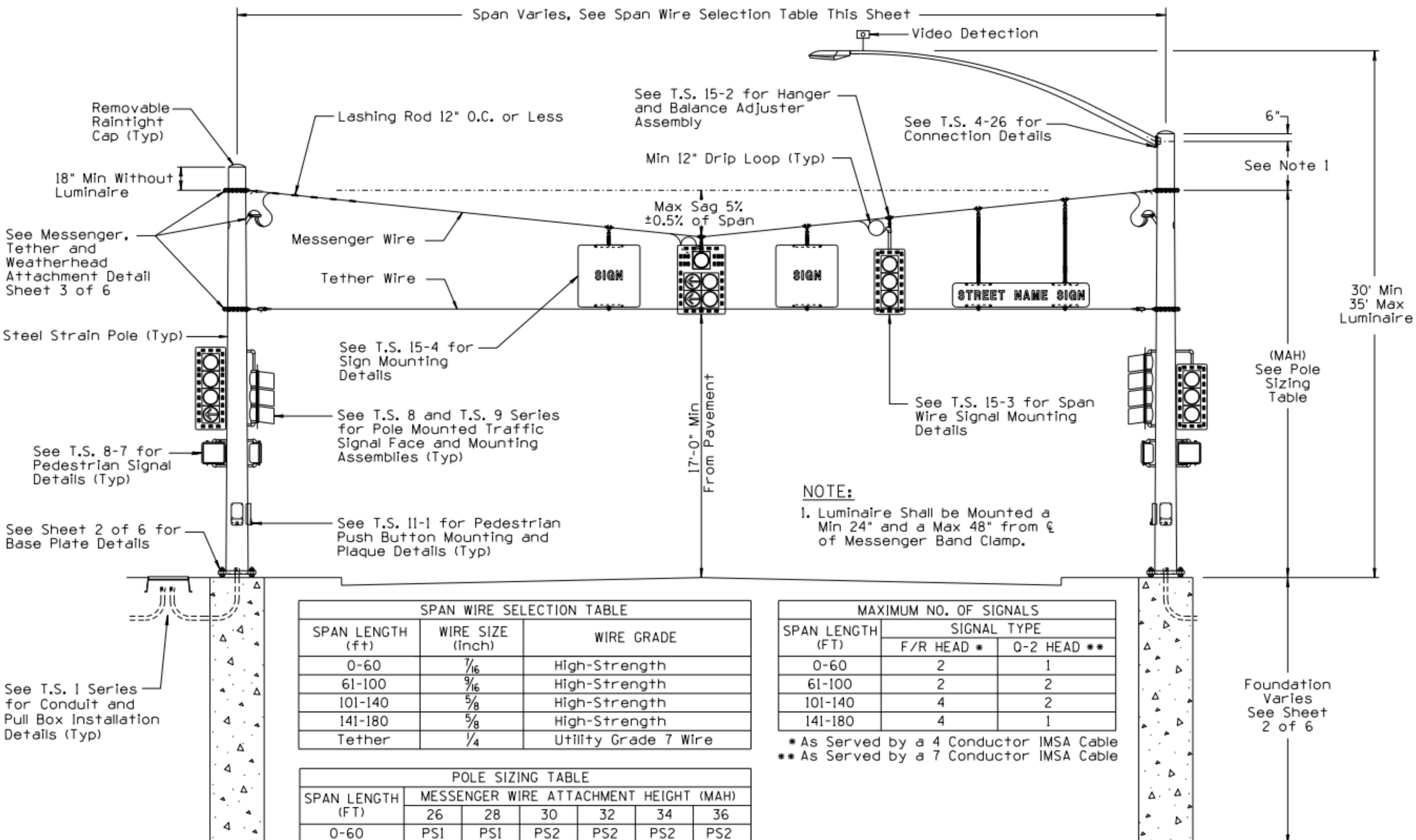
Impact of Penalty Feedback on Work Zone Speed

- Objective: Does showing road users possible fine impact vehicle speed?
  - Using a stock ADOT VMS with radar, road users were shown their current speed along with their possible fine.
  - Speed data was collected prior to the VMS, with the VMS only showing speed, VMS with speed and fine, and after with no VMS
  - Both ‘Speed’ and ‘Speed and Fine’ reduced mean speeds and very high speed vehicles, but ‘Speed and Fine’ performed better

Calibration of VMS with Radar

Development of Span Wire Specification for ADOT

- Objective: Develop a cookbook permanent and temporary span wire specification for ADOT
  - Consulting other state specifications for hardware and connections, NAU developed a span wire spec for ADOT where structural members are selected based span length and messenger wire height
  - Specification is limited to specific type and amount of items hung on the span wire, but it provides a good starting point, and much improves a virtually non-existent ADOT spec.
  - http://www.azdot.gov/business/engineering-and-construction/traffic/signals-and-lighting-standard-drawings (T.S. 15)



NOTE:

1. Luminaire Shall be Mounted a Min 24" and a Max 48" from ℄ of Messenger Band Clamp.

SPAN WIRE SELECTION TABLE		
SPAN LENGTH (ft)	WIRE SIZE (inch)	WIRE GRADE
0-60	7/16	High-Strength
61-100	9/16	High-Strength
101-140	5/8	High-Strength
141-180	5/8	High-Strength
Tether	1/4	Utility Grade 7 Wire

MAXIMUM NO. OF SIGNALS		
SPAN LENGTH (FT)	SIGNAL TYPE	
	F/R HEAD *	Q-2 HEAD **
0-60	2	1
61-100	2	2
101-140	4	2
141-180	4	1

* As Served by a 4 Conductor IMSA Cable
** As Served by a 7 Conductor IMSA Cable

POLE SIZING TABLE						
SPAN LENGTH (FT)	MESSENGER WIRE ATTACHMENT HEIGHT (MAH)					
	26	28	30	32	34	36
0-60	PS1	PS1	PS2	PS2	PS2	PS2
61-100	PS3	PS3	PS3	PS4	PS4	PS4
101-140	PS4	PS5	PS5	PS5	PS6	PS6
141-180	PS5	PS5	PS6	PS6	PS6	PS6

STEEL POLE SPAN WIRE SIGNAL

NOT TO SCALE

DESIGN APPROVED: SIGNATURE	ARIZONA DEPARTMENT OF TRANSPORTATION INTERMODAL TRANSPORTATION DIVISION TRAFFIC SIGNALS AND LIGHTING STANDARD DRAWINGS	REVISION 01/12; DRAWING NO. T.S. 15-1
APPROVED FOR DISTRIBUTION: ON FILE	SPAN WIRE SIGNALS AND LIGHTING STEEL POLE TYPICAL DETAILS	SHEET NO. 1 OF 6

NO	DATE	MADE BY	DESCRIPTION OF REVISIONS
1	2012		ORIGINAL ISSUE - NEW DRAWING
3	01/12	C. COLE	

Observational Sign Sheeting Study

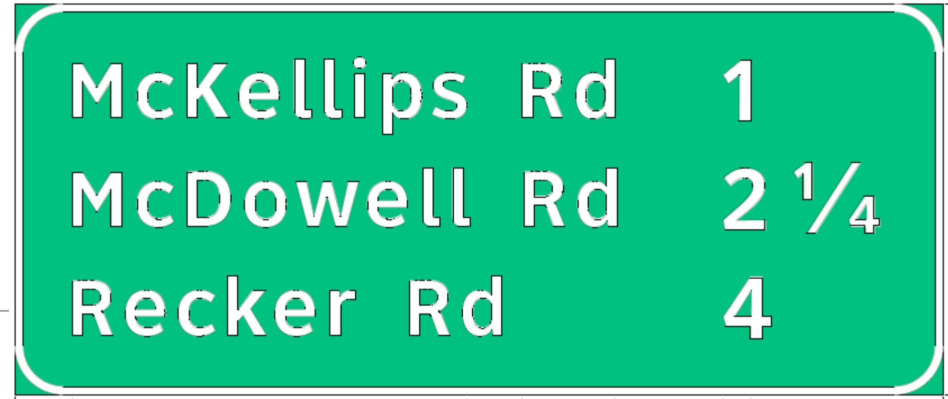
- Objective: Use observational data to compare three different sign sheetings (new "superior" sheeting vs. existing "superior")
  - Double blind test using three different sheetings on one sign
  - Test site allowed for both Static and Dynamic testing
  - Existing material shown to be superior by both types of tests
  - Dynamic testing may be an acceptable surrogate for static testing

Test Sign Layouts

Double Blind Test
(Neither Observers nor Analyst knows which material is assigned to which line on the signs)

KEY: Material by Line
- Sign 1: C, A, B
- Sign 2: A, B, C
- Sign 3: B, C, A

Sign 1:



Sign 2:

Sign 3:

Typical Sign and Briefing at Site

Professional Background

- Other Involvement / Service
  - Member of TRB Committee AHB 25: Traffic Signal Systems
  - Member of ASCE Street and Highway Operations Committee
  - NCHRP Project Oversight Panel Member:
    - 03-97: Traffic Signal Analysis with Varying Demands and Capacities (complete)
    - 03-110: Estimating the Life-Cycle Cost of Intersection Designs (in progress)

NAU Undergraduate Transportation Courses

- Traffic Signals and Studies
  - Begin with general traffic theory (Roadway – Vehicle – User Model), progress to specific applications
  - Exposure to applied / field work on the following topics
    - MUTCD
    - Vehicle Detection
    - Vehicle Delay
    - HCM: Traffic Signal Timing
    - Actuated Controller Operation

NAU Graduate Transportation Courses

- Advanced Traffic Signal Systems
  - Patterned after a course I took at Purdue
  - Course focus is to design an arterial from the ground up
    - Signal heads
    - Mast Arms / Poles
    - Vehicle Detection
    - Traffic Signal Timing
- Urban Transportation Planning
  - Four-Step process and associated material