



Roadside Elements Ground Truthing

Jennifer Brandenburg, PE
Brian Mayhew, PE
Joe Hummer, PhD, PE
with
Daniel Findley and Chris Cunningham, PE of ITRE
(co-authors of paper)

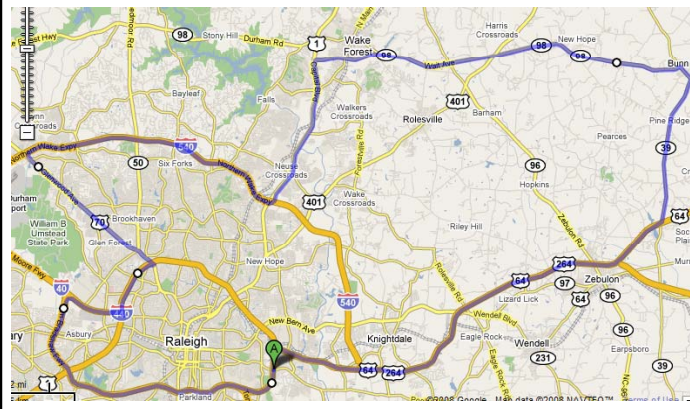


Session Agenda

- Review of Test Track
- Review of Elements Collected
- Data Collection Vendors
- Results

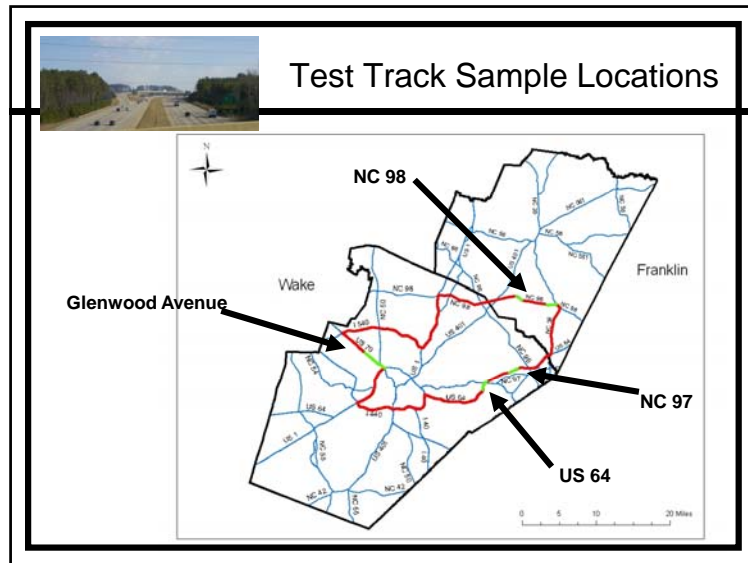


North Carolina's Test Track



North Carolina's Test Track

- 90 miles across 2 counties
- Covered various roadway types
 - Lane configurations
 - Pavement types
 - Urban and Rural
 - Terrain
- 20 different categories of features
- 13 different roadway elements



-
- Sample Locations**
- US 70 (Glenwood Ave.)
 - Urban Multilane
 - High traffic
 - Abundance of features
 - NC 98
 - Hilly terrain
 - Rural
 - Two lane facility with turn lanes

-
- Sample Locations**
- NC 97
 - Narrow lanes
 - Secondary Road characteristics
 - Abundance of horizontal & vertical curves
 - US 64
 - Newer facility
 - Multilane
 - Rural
 - Abundance of features

-
- Roadway Elements**
- Roadside Features
 - Shoulders
 - Barriers
 - Drainage
 - Lighting
 - Medians
 - Signs
 - Pavement Markings/Markers
 - Roadway Geometry



NC State Highway System

- 79,009 road miles
- 158,592 paved lane miles
- 4,876 miles of unpaved roads
- 17,147 structures
- 86.5 M sf bridge deck area



Roadside Features

Condition Assessment & Funding Needs for North Carolina's Highway System



Report to the
Joint Legislative Transportation Oversight
Committee

December 12, 2006

Lacy D. Love, PE



2008 MCAP Sample Size

System	Mileage	Number of Samples	Level of Survey
Statewide (Interstates, etc.)	1,154	5,630	County
Regional (Primary)	13,652	7,344	County
Subregional (Secondary)	64,204	10,289	County
Total Sample Size		23,263	



Roadside Features

Shoulders

- Type and width
- Presence of low or high shoulders
- Presence and location of rumble strips

Barriers (Guardrail, Concrete or Attenuators)

- Type and height
- Offset from travel lane
- Condition



Roadside Features

Drainage

- Curb location and condition
- Drop Inlet location and condition

Driveway

- Presence and location

Median Opening

- Presence and location



Roadside Features

Roadway Lighting

- Presence

Medians

- Type
- Width

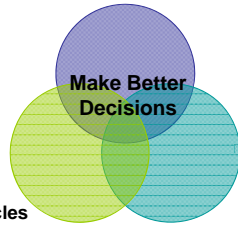


Signs, Pavement Markings and Roadway Geometry



Signs, Pavement Markings and Roadway Geometry

Meet Federal Standards
State Policies & Guidelines



Budgets
Replacement Cycles
Product Warranties

Location
Quantity
Condition



Signs, Pavement Markings and Roadway Geometry

•Improve Safety

- Relate Crash Data to Features (Elements)
- Relate Crash Data to Condition
- Relate Crash Data to Geometry
- Develop Predictive Safety Analysis Tools

•Link with Other Data Sets



Signs

Sign Location, MUTCD type, Size, Retroreflectivity

- Data collected by the NCDOT Signing Section
 - No traffic control, typical worker safety measures
- Data collected along entire course (370 signs)
- Right shoulder only (no overhangs)
- Sign retroreflectivity
 - Collected with handheld RetroSign 4500
 - 5 measurements per sign (averaged)



Edge Line Striping

Lateral Location, Color, Width, Type, Retroreflectivity

- Data collected on NC 98 and US 64
- Collected by NCDOT Work Zone Traffic Control Unit
 - Only edge line data was collected for worker safety
 - Lane closure was present
- Latitude/Longitude (every 100')
- Color (every 100')
- Width (every 100')
- Material (every 100')
- Retroreflectivity (every 20')
 - Handheld LTL-X Retroreflectometer



Special Pavement Markings

Special Markings: Location, Description

- Data collected from a 3.5-mile segment on US 70 Glenwood Avenue
 - Collected by NCDOT State Road Maintenance Unit
 - No lane closure, observed from shoulder
- Markings collected in all lanes in the direction of travel
- Latitude and Longitude collected from the shoulder
- Descriptions included:
 - Left/RightThru Arrow
 - Thru+Right Arrow
 - “ONLY” text
- 140 special markings observed



Raised Pavement Markers

Location, Number, Type

- Data collected from small segments on NC 98 and US 64
 - Collected by NCDOT Work Zone Traffic Control Unit
- Data collected on the lane line to the left of the travel lane
 - Lane closure was present
- Latitude/Longitude
- Number of markers (in 400')
- Type of marker
 - Snowplowable
 - Stick-On



Road Geometry

Centerline Bearing, Grade

Vertical Curve Location & Length

Horizontal Curve Location, Length, Radius, Cross Slope

- Data collected from small segments on NC 39 & NC 98
 - Collected by NCDOT Location & Surveys Unit
 - Typical Survey Crew Work Zone was used
- XYZ field shots collected by conventional survey methods
 - Leica TCR 702 total station and data collector.
- Setup on the shoulder
 - Prism rod directly on centerline
 - EP's to collect the shots
- The control for the operation was established by using GPS



Road Geometry

Number and Width of Lanes

- Data collected from two segments of NC 98 and one segment of US 64
 - Collected by NCDOT Work Zone Traffic Control Unit
 - Lane closure was present
- Latitude/Longitude (every 100')
- Width of lane (every 100')
- Number of lanes (every 100')
 - Included fully developed auxiliary and turning lanes
- Measured from the center of the lane line to the center of the edge line for a multilane facility.
- Measured from the center of the roadway to the center of the edge line for a two lane roadway



Road Geometry

Intersection location, number of approaches, skew angle

- Data collected along the entire course (133 observed)
- Number of approaches (two, three, or four)
- Skew
 - Light ($< 90^\circ \pm 20^\circ$)
 - Medium ($90^\circ \pm 20^\circ - 40^\circ$)
 - Heavy ($> 90^\circ \pm 40^\circ$)



Vendor Data Collection

- Many invited, 11 drove the course
- May through July
- Given “Catalog” describing variables and manual methods
- Given map of course just before drive
- Not given manual data collection sites until now



Six Vendors Submitted Roadside Data

- Geo-3D
- NAVTEQ
- Pathway
- Precision Scan
- Roadware
- Yotta

Descriptions of each in Proceedings

Thanks for the big effort!



Post Processing Hours

Vendor	Number of hours
Geo-3D	100
NAVTEQ	300
Pathway	72
Precision Scan	4
Roadware	228
Yotta	360



General Areas in which Data Provided

Vendor	Signs		Pavement markings		Geometry	Roadside
	Retro	Other	Retro	Other		
Geo-3D		*		*		*
NAVTEQ		*		*	*	*
Pathway		*		*	*	*
Precision Scan			*			
Roadware		*		*	*	*
Yotta		*		*		*



Objectives of Analysis

- Summarize vendor data
- Compare vendor to manual data
- Unbiased and fair
- Make no judgments



Key Statistics Reported

- Number and percent of items found by manual collectors also found (“matched”) by vendor
- Number and percent of extra items reported by vendor



Matching Criteria

- Distances between manual point and each vendor point calculated electronically
 - From lat and long, using standard distance formula
- Match declared if:
 - Nearest
 - Within 200 feet
- Checked manually by NCSU staff



Other Key Statistics

- For quality variables, number and percent of items found by manual collectors to be of quality X also found by vendor to be of quality X
- For quantity variables, average difference between manual and vendor estimates and percent of manual that this difference represents



When Viewing Results, Remember...

- Sample sizes vary widely
 - Causing percentages to change quickly
- Manual data could be inaccurate
- Raw data available on line



When Viewing Results, Remember...

- Percentages calculated as percent of possible or percent of items matched
 - Example: Vendor A found 6 of 8 items recorded by manual collectors = $6/8 = 75\%$
 - 5 of 6 items found by Vendor A correctly scored for functionality = $5/6 = 83\%$
 - No double jeopardy



Signs

Factor	Level	Manual # Observed	Vendor Observed/Classified									
			Geo-3D		Navteq		Pathway		Roadware		Yotta	
			#	%	#	%	#	%	#	%	#	%
# of Signs	Total	370	344	93%	242	65%	341	92%	314	85%	358	97%
MUTCD Code Designation	Regulatory	67	123	83%	110	64%	134	73%	130	69%	140	77%
	Warning	82										
Average Width Difference, in	Average	---	9	26%	d	n/a	15	37%	34	92%	7	16%
Average Height Difference, in	Average	---	7	26%	d	n/a	18	91%	29	91%	9	27%



Long Pavement Markings

Factor	Level	Vendor Observed/Classified									
		Manual	Geo-3D		Navteq		Precision Scan		Yotta		
		# Observed	#/Width/Retro	%	#/Width/Retro	%	#/Width/Retro	%	#/Width/Retro	%	
# of marking segments	Total	29	29	100%	29	100%	29	100%	8	28%	
Color	White	29	29	100%	29	100%	d	n/a	8	100%	
Material	Paint	13	d	n/a	d	n/a	d	n/a	4	50%	
	Thermo.	16									
Average width difference, ft	Average	----	d	n/a	d	n/a	d	n/a	d	n/a	
Average Retro-reflectivity difference, mcd/m2/lux	Average	----	e	n/a	d	n/a	36	13%	d	n/a	



Raised Pavement Markers

Factor	Level	Vendor Observed/Classified					
		Manual	Roadware		Yotta		
		# Observed	#	%	#	%	
# of Raised Pavement Markers	Total	293	b	n/a	246	84	
Type	Snowplowable	4	c	n/a	b	n/a	
	Stick-on	289	c	n/a	b	n/a	



Special Markings

Factor	Level	Vendor Observed/Classified											
		Manual	Geo-3D		Navteq		Pathway		Roadware		Yotta		
		# Observed	#	%	#	%	#	%	#	%	#	%	
# of Special Markings	Total	140	140	100%	140	100%	0	100%	137	98%	137	98%	
Special Marking Description	Left Arrow	45	139	99%	135	96%	0	n/a	121	88%	112	82%	
	Thru Arrow	54											
	Right Arrow	29											
	Thru + Right Arrow	6											
	'Only' Text	6											



Centerline Geometry

Factor	Level	Vendor Observed/Classified							
		Manual	Navteq		Pathway		Roadware		
		# Observed	#/Azimuth/Grade	%	#/Azimuth/Grade	%	#/Azimuth/Grade	%	
# of Centerline Data Points	Total	347	347	100%	347	100%	347	100%	
Average Azimuth Difference, degree	Average	n/a	0.6	0.4%	0.7	0.4%	0.5	0.3%	
Average Grade Difference, %	Average	n/a	0.2	34%	0.5	60%	0.3	41%	



Horizontal Curves

Factor	Level	Vendor Observed/Classified							
		Manual	Navteq		Pathway		Roadware		
		# Observed	#/ Length	%	#/ Length	%	#/ Length	%	
# of Horizontal Curves	Total	4	4	100%	4	100%	4	100%	
Avg. Length Difference, ft	Average	----	652	97%	549	90%	414	60%	
Avg. Radius Difference, ft	Average	----	571	26%	1987	99%	1145	49%	
Avg. Cross Slope Difference, %	Average	----	d	n/a	2	28	1	23%	



Vertical Curves

Factor	Level	Vendor Observed/Classified							
		Manual	Navteq		Pathway		Roadware		
		# Observed	# or Length	%	# or Length	%	# or Length	%	
# of Vertical Curves	Total	12	12	100%	7	58%	12	100%	
Avg. Length Difference, ft	Average	12	147	19%	1381	177%	285	40%	



Attenuators

Factor	Level	Vendor Observed/Classified									
		Manual	Geo-3D		Pathway		Roadware		Yotta		
		# Observed	#	%	#	%	#	%	#	%	
# of Attenuators	Total	6	5	83%	5	83%	6	100%	1	17%	
Type	End Treatment	5	5	100%	5	100%	5	83%	0	0%	
	Attenuator	1									
Condition	Functioning	4	4	80%	4	80%	4	67%	0	0%	
	Non-Functioning	2									
Extra Data Points	Total	----	2	40%	0	0%	4	67%	0	0%	



Barriers

Factor	Level	Vendor Observed/Classified											
		Manual	Geo-3D		Navteq		Pathway		Roadware		Yotta		
		# Observed	#/ Height/ Offset	%	#/ Height/ Offset	%	#/ Height/ Offset	%	#/ Height/ Offset	%	#/ Height/ Offset	%	
# of Barriers	Total	30	30	100%	28	93%	30	100%	15	50%	18	60%	
Type	Concrete	1			27	90%	28	100%	30	100%	12	80%	
	W-Beam	29									17	94%	
Condition	Functioning	30			29	97%	d	n/a	30	100%	12	80%	
	Non-Functioning	0									18	100%	
Average Height Difference	Average	----	4	13%	d	n/a	3	10%	d	n/a	8	28%	
Average Offset Difference	Average	----	10	145%	4	72%	4	51%	6	83%	8	89%	



Curbs

Factor	Level	Manual # Observed	Vendor Observed/Classified									
			Geo-3D		Navteq		Pathway		Roadware		Yotta	
			#	%	#	%	#	%	#	%	#	%
# of curbs	Total	188	188	100%	180	96%	188	100%	188	100%	188	100%
Type	Vertical	15	15	8%	142	79%	15	8%	13	7%	15	8%
	Sloping	173										
Blockage	Blocked	7	175	94%	c	n/a	99	53%	171	91%	176	94%
	Not Blocked	180										
Damage	Damaged	3	185	98%	c	n/a	174	93%	185	98%	178	95%
	Not Damaged	185										



Driveways

Factor	Manual # Observed	Vendor Observed/Classified							
		Geo-3D		Navteq		Pathway		Roadware	
		#	%	#	%	#	%	#	%
# of Driveways	52	43	83%	44	85%	47	90%	40	77%
Extra Data Points	----	0	0%	2	5%	3	6%	0	0%



Drop Inlets

Factor	Level	Manual # Observed	Vendor Observed/Classified									
			Geo-3D		Pathways		Roadware		Yotta			
			#	%	#	%	#	%	#	%		
# of Drop Inlets	Total	53	52	98%	36	68%	49	92%	50	94%		
Damage	Damage	0	51	98%	25	69%	47	96%	48	96%		
	No Damage	53										
Blockage	Blockage	2	42	100%	15	56%	33	85%	38	95%		
	No Blockage	41										
Extra Data Points	No Damage	53	15	29%	4	11%	3	6%	2	4%		
	Total	----										



Intersections

Factor	Level	Manual # Observed	Vendor Observed/Classified									
			Geo-3D		Navteq		Pathway		Roadware		Yotta	
			#	%	#	%	#	%	#	%	#	%
# of Intersections	Total	133	88	66%	78	59%	41	31%	92	69%	33	25%
Approaches	2	22	75	85%	69	88%	32	78%	79	86%	0	0%
	3	74										
	4	37										
Skew	Light	103	67	76%	59	76%	34	83%	70	76%	21	23%
	Medium	21										



Lanes

Factor	Level	Manual # Observed	Vendor Observed/Classified							
			Navteq		Pathway		Roadware		Yotta	
			#/ Width	%	#/ Width	%	#/ Width	%	#/ Width	%
# of Segments	Total	154	154	100%	154	100%	154	100%	138	90%
Approach Lanes	1	92	154	100%	154	100%	137	89%	138	100%
	2	62								
Average Width Difference, ft	Average	----	0.4	4%	1.3	13%	0.6	6%	3.2	30%



Median Openings

Factor	Manual # Observed	Vendor Observed/Classified									
		Geo-3D		Navteq		Pathway		Roadware		Yotta	
		#	%	#	%	#	%	#	%	#	%
Median Openings	6	4	67%	1	17%	6	100%	3	50%	6	100%
Extra Data Points	----	2	50%	0	0%	4	67%	0	0%	1	17%



Rumble Strips

Factor	Manual # Observed	Vendor Observed/Classified									
		Geo-3D		Navteq		Pathway		Roadware		Yotta	
		#	%	#	%	#	%	#	%	#	%
Rumble Strips	6	6	100%	6	100%	6	100%	6	100%	5	83%



Shoulders

Factor	Level	Manual # Observed	Vendor Observed/Classified									
			Geo-3D		Navteq		Pathway		Roadware		Yotta	
			# or diff. in width	%	# or diff. in width	%	# or diff. in width	%	# or diff. in width	%	# or diff. in width	%
# of Shoulders	Total	115	50	43%	39	34%	94	82%	6	5%	69	60%
Type	Paved	91	50	100%	39	100%	87	93%	6	100%	69	100%
	Unpaved	24										
Condition	Low	11	c	n/a	c	n/a	91	97%	6	100%	69	100%
	Normal	102										
	High	2										
Avg. Width Difference, ft	Average	----	0.8	15%	c	n/a	0.9	22%	1.0	16%	1.4	29%



Summary

- Sign retro only desired variable not submitted
- One vendor submitted pavement marking retro
- Three vendors submitted geometry data
- Five vendors submitted roadside data
- Thank you vendors!



Summary

- We now have data to serve as baseline
 - Accuracy you should expect
- Mobile data looks viable for most variables
- Matching tasks of generally higher quality than judgment tasks
 - More training, better specs should help
- Data generally better closer to or on roadway



Lessons Learned

- Write good specs
 - You cannot be too clear
- Have vendor submit test section data first
 - Be sure what you are getting
- Be careful of variables that change quickly in time