Accuracy Comparison of Non-Intrusive, Automated Traffic Volume Counting Equipment

White Paper

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Background

For several years Albeck Gerken, Inc. has been conducting traffic volume data collection in support of traffic operations engineering projects. Data collection has included system and approach counts (aka machine counts or segment counts) and turning movement counts (aka manual counts). Typical segment counts are directional counts using road tube counters generally deployed for seven days. Typical turning movement counts have been conducted using trained personnel counting intersection traffic with an electronic count board.

There are several known issues with these legacy platforms. From the approach count perspective:

- tube counters require work in the roadway to place and recover the equipment
- tubes degrade rapidly under heavy traffic flow and if broken may be difficult to repair immediately
- tube setups have limitations on data obtained (e.g., only applicable for low-speed roadways)

From the turning movement count perspective:

- data collected typically show served traffic versus demand traffic
- turning movement counts are expensive to obtain since it requires trained personnel to be in the field during the periods of data collection
- personnel are exposed to the elements during data collection periods or they utilize vehicles, which typically requires parking near the intersection in order to observe the movements
- higher traffic volumes require more personnel (and equipment) to count all movements
- accuracy of the data collected is always in question

For approach counts and turning movement counts, risk due to personnel exposure, expense of the data obtained and accuracy of the data obtained all apply. For these reasons, Albeck Gerken, Inc. engineers have been looking for non-intrusive, automated, portable data collection platforms. This white paper outlines the technologies used and accuracy testing results for recent test cases.

Equipment Evaluated

Three technologies for automated traffic volume collection were reviewed. The technologies included:

- JAMAR TRAX I Plus Automatic Traffic Data Recorder (ATDR) with road tubes,
- Wavetronix SmartSensor HD™ for segment counts, and
- Miovision Technologies Inc. Video Collection Unit (VCU) for turning movement counts.

The **JAMAR ATDR** (http://www.jamartech.com) records the passage of each vehicle axle by receiving air impulses with up to four road tube inputs. JAMAR machine counting equipment is considered the industry standard in directional machine counts. The technology has been deployed for years and is relatively cost effective. A typical installation is demonstrated by the adjacent picture.

Tube installations are possible that yield various outputs (classification, speed, etc.), where two parallel tubes (appropriately spaced) are required instead of one.

Wavetronix SmartSensor HD™ (http://www.wavetronix.com) uses a dual-radar technology for detection with a patented auto-configuration process to define the roadway cross-section and direction of vehicles in each lane. Microwave sensors have been widely deployed as roadway sensors but recently have been evaluated for temporary installations. The main challenges have been mounting the sensor on a fixed structure to limit movement and providing the proper amp-hour capacity to ensure the unit operates for the desired time frame. Transportation Control Systems of Tampa designed and manufactured a weather proof, two-person carry battery box. Setup generally requires an agreement with the local agency to attach the sensor to existing structures as well as using an extension ladder (or bucket truck) to affix the sensor mount to the pole. The cable running from the sensor to the battery box is encased in conduit to limit vandalism and theft (see photo to right). The self learning mode of Wavetronix makes programming easy and one unit can count across 10 lanes regardless of direction. Added benefit to Wavetronix output is not only count, but occupancy, speed and classification of the traffic stream by lane without any additional equipment or complex programming.

The **Miovision Technologies VCU** (http://www.miovision.com/) uses digital video recording to capture all vehicle turning movements. The video collection equipment is manufactured using two platforms; a tripod system and the newer pole mount system. The VCU is set up to turn on and off based on user programming. Once the video is recorded, it is transferred (via SD card) to an upload interface and ultimately to the Miovision web server. Miovision has developed proprietary machine vision to count the traffic for each movement. Miovision then returns a turning moment count in various electronic formats. One of the unique aspects of Miovision's video capture is that it provides an audit trail in case the user ever wanted to go back and review a specific time period's video. The capability to capture off-line video can be used for many other purposes.

A typical Miovision VCU installation is shown to the right. Like Wavetronix, an agreement to affix the unit is generally required with the local agency. Units are only deployed for the time frame of the turning movement count, which is typically an 8-12 hour time frame. The units are easy to handle by one person. The all-weather, low-light camera unit is mounted on the top of a telescoping lightweight pole. Prior to extending the mast, the camera angle is adjusted so as to have full view of all lanes/movements being counted and to avoid direct alignment with the rising or setting sun. If the Miovision VCU screen reveals an incomplete view, then the mast can be easily lowered and the camera angle re-adjusted or relocated to another pole. Typically, only one camera is required but larger intersections may require two cameras for capturing all turning movements.

Table 1 provides a comparison of general attributes for each technology utilized for this comparison. By no means is this a complete list of attributes, however, those attributes listed are of greatest initial interest in this field performance comparison.

Table 1, General Comparison of Technologies

ATTRIBUTE	*TECHNOLOGY PLATFORM*		
	JAMAR TRAX I Plus	**Wavetronix HD**	**Miovision VCU**
Advertised Data Capabilities	Directional Count, Speed, Classification, Gaps	Bi-directional Count, Speed, Classification, Occupancy, Headways, Gaps (all by lane)	Turning Movement Count, Classification
Crew Size Recommended to Install	2	2	2
Portability/Storage	ATDR extremely lightweight and self-contained w/handle (road tubes must be regularly checked and maintained)	Separate power supply cabinet very heavy, otherwise lightweight assembly (extension ladder required for mounting)	Self-contained VCU w/handle, lightweight pole-mount assembly, 6-foot expandable (to 25 feet) camera mast
Ease of Set-Up[1]	60-75 min. (exposed to traffic)	45-50 min. (no exposure to traffic)	10-15 min. (no exposure to traffic)
Max. Record Time[2]	30 days (solar re-charge)	10 days (10-12 hrs for re-charge)	24 hrs (4-5 hrs for re-charge)
Data Acquisition	Download to separate licensed software on laptop (immediate processing)	Download to separate licensed software on laptop (immediate processing)	VCU memory card to proprietary Internet-based video uploading, analysis and storage (48 hrs. min. turnaround)
Total Equipment Cost per Location[3]	~$2,600	~$6,700	~$3,700

[1] Time shown includes 2-person set-up per location.
[2] Determined by life of road tube for JAMAR, and battery and/or storage disk capacity for Wavetronix and Miovision.
[3] Includes all basic unit accessories, software, power supply, cabling, etc. and two JAMAR ATDRs. Site defined as bi-directional installation for segment counts and one Miovision VCU per intersection.

Accuracy Methodology

Tests were established to determine the accuracy of both approach counts and turning movement counts. The first test examined in this paper is the segment counts.

Segment Count Accuracy Testing

The segment count accuracy testing was completed in conjunction with a data collection project in Sarasota, Florida, where three (3) mid-block locations were selected for both weekday and weekend data acquisition in March 2009.

The three test locations represent divided arterial roadway cross-sections of either four or six lanes, with both raised and painted medians. The basic accuracy test was to compare tube data to Wavetronix data with tube data being the control volume. This was conducted over a five day continuous period. The Figure 1 illustrates the results of two site comparisons, the remaining site yielded similar results.

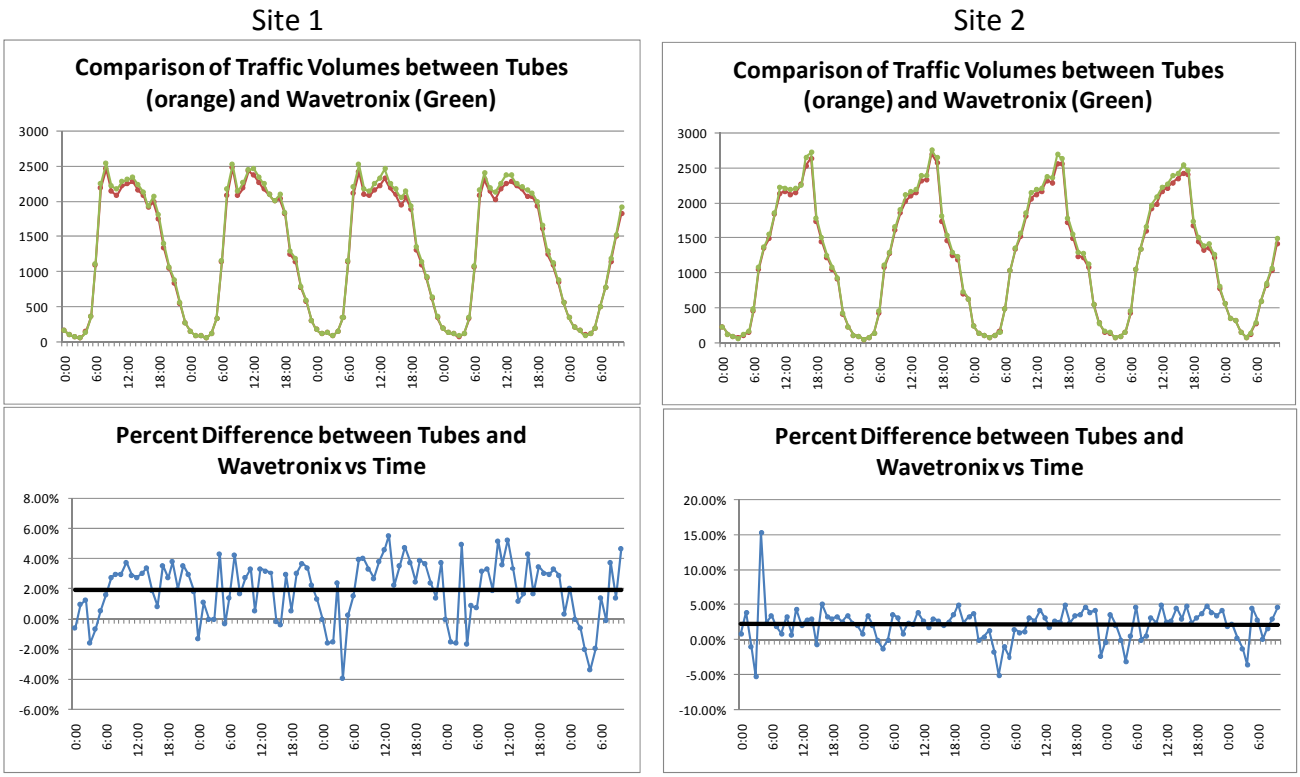

Figure 1, Temporal Comparisons between tube data and Wavetronix data (raw count and percent)

The results indicated Wavetronix and tube data track closely, with Wavetronix consistently returning high volume counts during periods of heaviest traffic. It also seems the same level of accuracy is consistent over time, as indicated by the black line illustrating average percent error.

To provide a robust accuracy evaluation Miovision VCUs were also set up at the same locations as tubes and Wavetronix. This provided the opportunity to compare directional segment counts across a control volume (via manual counting in the office off of the Miovision video), Wavetronix, and tubes. Two hours were selected for this comparative accuracy test representing the beginning and end of the data collection time frame.

The two, non-intrusive technologies (Wavetronix and Miovision) were both mounted on the same roadside light pole at each of the three test sites. The road tubes (one for each direction) from the JAMAR ATDRs were placed at the same pole, or as close to each of the same roadside light poles as possible, in order to capture identical volumes. Table 2 summarizes the results.

Overall, both tubes and Wavetronix performed well compared to the control volume with overall error of less than 4 percent. Given the reduced risk exposure to personnel, the flexible installation options and the high degree of accuracy Wavetronix units provide a viable alternative to road tube installations. Like most decisions in traffic engineering, good engineering judgment should be applied when deciding between non-intrusive and intrusive data collection platforms.

Table 2, Segment Count Accuracy Comparisons

Segment Count Accuracy Results		Control Volume	Wavetronix	% delta	JAMAR	% delta
March 24, 2009 (noon-1pm)						
Site 1	NB	2,274	2,314	1.8%	2,252	-1.0%
	SB	2,317	2,211	-4.6%	2,166	-6.5%
Site 2	NB	1,533	1,418	-7.5%	1,478	-3.6%
	SB	1,488	1,490	0.1%	1,424	-4.3%
Site 3	NB	1,259	1,260	0.1%	1,249	-0.8%
	SB	1,451	1,382	-4.8%	1,402	-3.4%
March 28, 2009 (10-11am)						
Site 1	NB	1,911	1,914	0.2%	1,828	-4.3%
	SB	1,511	1,488	-1.5%	1,422	-5.9%
Site 2	NB	1,226	1,182	-3.6%	1,196	-2.4%
	SB	1,239	1,248	0.7%	1,196	-3.5%
Site 3	NB	1,073	1,052	-2.0%	1,025	-4.5%
	SB	1,221	1,126	-7.8%	1,158	-5.2%
	Total Count	18,503	18,085	-2.3%	17,796	-3.8%

Turning Movement Count Accuracy Testing

The initial turning movement count accuracy testing was completed in conjunction with a data collection effort in Melbourne, Florida, in September of 2008. A single intersection was counted by traditional methods using two personnel with electronic count boards. The Miovision VCU was also set up to capture video during the same period. The control volumes were established for each turning movement by having personnel view the captured video in and office setting. A follow-up test was completed in Virginia Beach, Virginia during May of 2009.

Once the control volumes were established, the basic comparisons were between manual counts in the field and Miovision automated counts. Tables 3 and 4 summarize the results of Test Cases 1 and 2 respectively.

Table 3, Turning Movement Count Accuracy Comparisons (Test Case 1)

Babcock Street and Eber Road		SBL	SBT	SBR	WBL	WBT	WBR	NBL	NBT	NBR	EBL	EBT	EBR	Total Entering Volume
1000-1300	Control	248	2043	484	183	345	180	327	2180	195	522	387	270	7364
	Manual	254	2070	487	170	349	180	333	2182	187	537	384	296	7429
		2.4%	1.3%	0.6%	-7.1%	1.2%	0.0%	1.8%	0.1%	-4.1%	2.9%	-0.8%	9.6%	0.9%
	Miovision	225	1996	484	177	330	185	298	2091	185	531	375	280	7157
		-9.3%	-2.3%	0.0%	-3.3%	-4.3%	2.8%	-8.9%	-4.1%	-5.1%	1.7%	-3.1%	3.7%	-2.8%

Table 4, Turning Movement Count Accuracy Comparisons (Test Case 2)

Lynnhaven Pkwy and Cherie Dr		SBL	SBT	SBR	WBL	WBT	WBR	NBL	NBT	NBR	EBL	EBT	EBR	Total Entering Volume
1100-1300	Control	63	1198	112	23	53	75	596	1596	18	167	40	474	4412
	Manual	63	1186	110	24	57	67	590	1584	15	170	44	466	4376
		0.0%	-1.0%	-1.8%	4.3%	7.5%	-10.7%	-1.0%	-0.8%	-16.7%	1.8%	10.0%	-1.7%	-0.8%
	Miovision	62	1285	111	22	53	84	593	1686	17	168	27	482	4590
		-1.6%	7.3%	-0.9%	-4.3%	0.0%	12.0%	-0.5%	5.6%	-5.6%	0.6%	-32.5%	1.7%	4.0%

The results indicate Miovision accuracy was between 96.4% and 95.0% when total error volumes are considered. Miovision has reported independent testing by Montana DOT agrees with our internal tests presented within this paper, with a reported accuracy of 97.4%.

Camera placement and viewing angle will have significant impact on data accuracy. Proper unit configuration and setup are imperative to ensure the highest degree of count accuracy.

Overall, we are pleased with the level of count accuracy especially when one considers that the accuracy is likely steady over the study period versus the anticipated fatigue of a manual count, eliminates our need to maintain temporary employees (and the resulting high turnover rate), and provides an audit trail via the captured video.

Miovision Equipment Discussion

Miovision fielded their pole mount configuration (versus the original tri-pod) in late 2008 coupled with a miniaturized VCU. There were hardware and firmware issues with the initial units that have been addressed. Miovision continues to take user feedback to address equipment serviceability and functionally improvements. Overall, we have been very impressed with Miovision's customer support and willingness to make configuration changes. The video upload process is dependent on the available bandwidth and the volume of users attempting to upload videos at the same time. This results in long upload times and intermittent upload failures.

Miovision's innovation continues in the data collection industry with new products. Their latest efforts have been focused on providing a VCU with extended battery and memory capability in an effort to compete with long term counts, such as segment counts. During our segment count accuracy comparisons we focused on tubes versus Wavetronix, with the control volume being established via Miovision collected video. Since the data was available we compared Miovision counts versus control counts for the segment tests. The results were within a few vehicles when comparing total volume collected (18,503 for the control count versus 18,509 for the Miovision count). This finding certainly supports Miovision's efforts to compete with current segment count technology.

Summary/Findings

Traffic operations engineers require accurate data for all activities, this includes directional segment counts and intersection turning movement counts. Albeck Gerken, Inc. engineers are heavily invested in traffic count technologies and conducted accuracy testing across several platforms; JAMAR road tubes versus Wavetronix for segment counts; and manual methods using JAMAR electronic count boards versus Miovision for turning movement counts. This white paper documents the testing procedure and results obtained. In no way were the tests rigorous nor intended to sufficiently stand up to statistical standards. However, the internal testing was non-biased and intended to help us make investment decisions on the latest technologies, develop appropriate risk management decision thresholds, and at its core determine for ourselves the level of accuracy we can expect.

The following summarizes our findings:

- Non-intrusive data collection techniques offer significant reduction in risk exposure over traditional segment count methods and moderate reductions in risk exposure for traditional turning count methods.
- The Wavetronix HD performed well when compared to road tube volume accuracy, and may have provided better results under heavier volume conditions. The ease of installation and additional data metrics by lane provided (speed, classification, occupancy, etc.); make Wavetronix a viable alternative to road tubes.
- Miovision Video Collection Units offer an accurate alternative to traditional manual turning movement count techniques. The additional benefits of easy deployment, reduced requirements for trained staff, and the unique aspect of an audit trail make Miovision a viable alternative to traditional manual turning movement counting. The issue of counting served traffic versus demand traffic is not solved by using Miovision, nor any known technology available. Engineering judgment still pertains to data collection.

It's worth noting that no vendor sponsored these tests, they were completely funded and analyzed by Albeck Gerken, Inc. engineers for internal use. This white paper has been provided as a simple means to exchange important industry information.

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