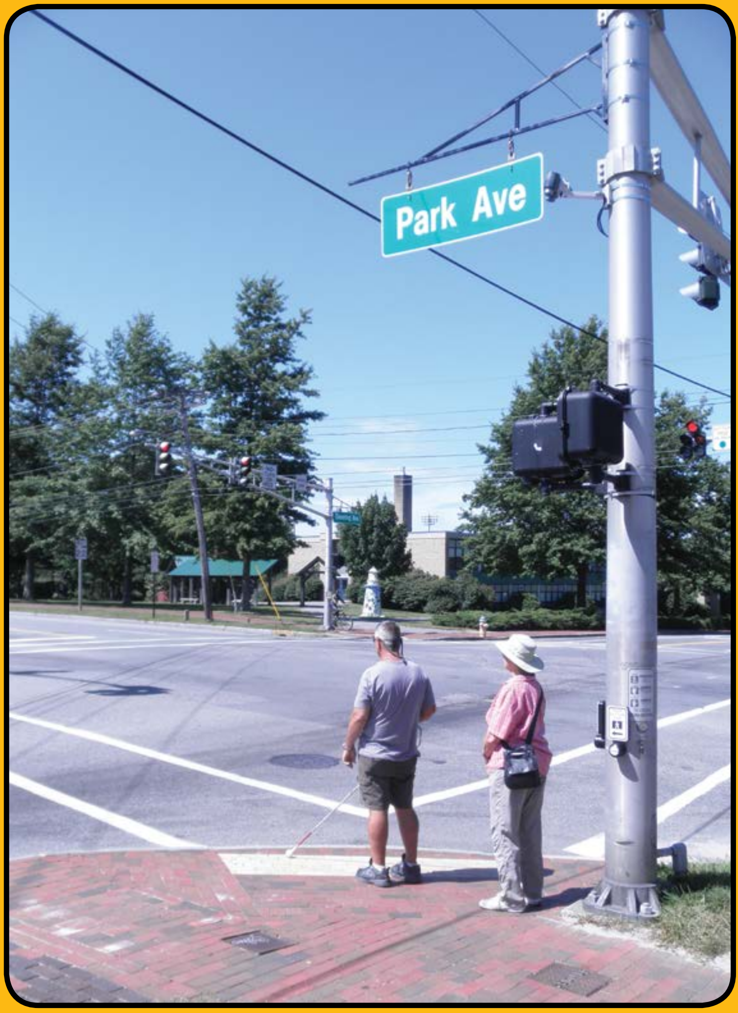
Large Field Test of New Stereo Detection System for the Pedestrian Signal Phase for the Visually Impaired

PUBLICATION NO. FHWA-HRT-12-074

SEPTEMBER 2012



U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
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McLean, VA 22101-2296

FOREWORD

The objective of this report is to validate a new tool to assist the physically and visually impaired in safely crossing streets. This was accomplished by conducting a large field test in four cities in four States. These study results will help officials determine whether pedestrian detection systems can be operated safely without interfering with other traffic control tools. Proposed configurations may extend the pedestrian signal timing phase or omit a pedestrian phase when no pedestrians are present. The final system configuration results indicate that the stereo pedestrian system works without interfering with other systems. This report provides details and raw data for the tests so that decisionmakers may make their own evaluations.

Joseph I. Peters
Director, Office of Operations
Research and Development

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA-HRT-12-074	2. Government Accession No.	3. Recipient's Catalog No.

4. Title and Subtitle Large Field Test of New Stereo Detection System for the Pedestrian Signal Phase for the Visually Impaired	5. Report Date September 2012 6. Performing Organization Code:
7. Author(s) Bo Ling, David Gibson, Billie Louise Bentzen, Paul Burton, Neil Boudreau, Mike Bobinsky, and Jim Hoben	8. Performing Organization Report No.
9. Performing Organization Name and Address Migma Systems 1600 Providence Highway Walpole, MA 02081	10. Work Unit No. 11. Contract or Grant No. DTRT5706C10030
12. Sponsoring Agency Name and Address Research and Special Programs Administration Federal Highway Administration 6300 Georgetown Pike McLean, VA 22101-2296	13. Type of Report and Period Covered Field Test Report 14. Sponsoring Agency Code HRDO-04 and RVA-21

15. Supplementary Notes
The FHWA Contracting Officer's Technical Representative (COTR) was David Gibson, P.E, HRDO-10.

16. Abstract
In March 2010, a large field test study was conducted on a stereo pedestrian detection system in four cities in four States under the Federal Highway Administration's Small Business Innovative Research program. The objective was to prove that the stereo vision would reliably detect pedestrians in real-world environments under all weather conditions (e.g., sunny, cloudy, foggy, rainy, and snowy) and extreme temperatures (e.g., very high temperatures in the southern part of the country and very low temperature in the northern part of the country) and determine that the system effectively actuates pedestrian calls and locator tones on accessible pedestrian signals (APSs).

The study was conducted in Tucson, AZ; Somerville, MA; Portland, ME; and Manchester, NH. The stereo pedestrian detection systems were installed to evaluate their performance in complex real-world pedestrian/traffic environments under all weather conditions and extreme temperatures. A total of 17 systems, consisting of one computer and two cameras per crossing, were installed at 9 geographically disparate test sites. These were installed at both midblock crossings and at intersections. When pedestrians were detected at crosswalk ramps, the system automatically actuated both regular and APS pushbuttons to make the service request on behalf of the pedestrians. System performances were evaluated using images saved in external hard disks. Results from the testing showed that the overall positive detection rate for the automated APS actuation zones in all four cities was close to 98 percent, with the average number of false calls per day less than three. This excellent performance was confirmed through the real operations of systems installed at the test sites. Currently, all of the systems are operational 24 h a day, 7 days a week. Comments from the general public, including the blind and visually impaired community, were all positive.

This system provides automated actuation of pushbuttons based on the presence of pedestrians. This provides the protection of pedestrian phases, thereby reducing the possibility of collisions between vehicles and pedestrians, preventing unnecessary fatalities, and automatically extending the walk time for seniors and wheelchair pedestrians without slowing down the traffic flow.

17. Key Words Field test, Pedestrian detection, Pedestrian phase, Pedestrian actuation, Pedestrian crossing, Snow, Rain, Partly sunny, Sunny, Weather	18. Distribution Statement No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 151	22. Price N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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EXECUTIVE SUMMARY

In March 2010, a large field test was conducted of a stereo pedestrian detection system in four cities in four States under the Federal Highway Administration's (FHWA) Small Business Innovative Research (SBIR) program. The objective was to prove that the stereo vision would reliably detect pedestrians in real-world environments under all weather conditions (e.g., sunny, cloudy, foggy, rainy, and snowy) and extreme temperatures (e.g., very high temperatures in the southern part of the country and very cold temperatures in the northern part of the country) and to determine whether the system effectively actuates pedestrian calls and the locator tones on accessible pedestrian signals (APSs).

The study was conducted in Tucson, AZ (five test sites, one signalized intersection, and four signalized midblock crossings, including two walk time extensions); Somerville, MA (one signalized intersection adjacent to a recreation center); Portland, ME (two signalized intersections, with one being near an education and rehabilitation center for people who are blind or who have low vision); and Manchester, NH (one signalized intersection adjacent to a medical center). The field test equipment was first certified by an independent lab test company to meet standards established in the *Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests*.(1) The lab performed a series of tests that included high/low temperature, humidity, rain, icing, vibration, and Federal Communications Commission (FCC) 15 Subpart B (unintentional radiators) testing for electromagnetic interference.(2) The units passed Class A digital devices for higher, less strict limits and Class B digital devices for lower, more strict limits.

The stereo pedestrian detection systems were installed to evaluate their performance in complex real-world pedestrian/traffic environments under all weather conditions and extreme temperatures. In the four cities, a total of 17 systems, consisting of one computer and two cameras per crossing, were installed at 9 geographically disparate test sites. These were installed at both midblock crossings and at intersections. When pedestrians were detected at crosswalk ramps, the system automatically actuated both regular and APS pushbuttons to make a service request on behalf of the pedestrians. System performances were evaluated using images saved in external universal serial bus (USB) hard disks.

Results from the testing showed that the overall positive detection rate for the automated APS actuation zone was close to 98 percent, with the average number of false calls less than three per day. This excellent performance was confirmed through the real operations of systems installed at the test sites. Out of the total count evaluation days, the systems detected 308 of 310 pedestrians (99 percent) on 6 rainy days and 244 of 248 pedestrians (98 percent) on 4 snowy days. Currently, all of the systems are operational 24 h a day, 7 days a week (24/7). Comments from the general public, including the blind and visually impaired community, were all positive.

The automated actuation of pushbuttons based on the stereo detection of the presence of pedestrians was demonstrated to reliably and accurately call and/or omit pedestrian phases and thus potentially reduce the possibility of collisions between vehicles and pedestrians. The units automatically extended the walk time for seniors and wheelchair pedestrians successfully without slowing down the traffic flow.

INTRODUCTION

While studying pedestrian operations and safety, research and development engineers have observed an aging population with many slow-moving elderly, impaired, and visually disabled pedestrians. Michael F. Trentacoste, Director of the Turner-Fairbank Highway Research Center, stated, "According to the 2000 census, Americans aged 65 and older make up 12.4 percent of the U.S. population." Additionally, "By the year 2030, one in five Americans will be over 65."[(3)] As a result, detecting and tracking systems for these aging pedestrians are necessary to support collision warning systems, intersection traffic control operations, and safety for visually impaired pedestrians. A pedestrian detection system using stereo imaging and artificial intelligence algorithms for pulling out and tracking pedestrians from the stream of moving objects at intersections was determined to be a potential way to address these issues and show the utility of such systems. Since the goal was to put the candidate system into use as an exemplar, the SBIR program was chosen as the research vehicle.

BACKGROUND OF SBIR PROGRAM

The SBIR program is divided into two major phases. During phase I, researchers developed and demonstrated the prototype software and hardware that embodied a simplified version of the system. The software was run on top of a real-time operating system to demonstrate the capabilities. The algorithms and software were prototyped and validated using the software program Mathcad. Several unique features identifiable by stereo imaging were validated and utilized to enhance the separate detection of pedestrians from the presence of other moving objects such as cars, motorcycles, branches, dogs, birds, and shadows. A commercial stereo camera (not environmentally hardened) was utilized to develop the concepts and algorithms (see figure 1).

Figure 1. Photo. Commercial stereo camera used for phase I algorithm research.

During phase II of the SBIR program, researchers enhanced the system algorithms and performed preliminary interfacing to a real-time traffic signal controller emulating a pedestrian pushbutton. Phase II addressed issues related to making the system minimally functional during rain and snow. The project required working with experts in traffic engineering, real-time control, video sensing, and pedestrian detection to make it work. Phase II demonstrated the basic practicality of the concept and its hardware and software at a crosswalk at a midblock crossing at Phillips Academy in Andover, MA.

Phase II was used to conduct a large-scale field test of the equipment and software to demonstrate its safety under real-world traffic operations conditions. This report documents those tests. The objective of the large-scale field test was to prove to traffic engineers that it is operationally safe to install pedestrian sensors to decrease problems and enhance pedestrian crossing safety.

In March 2010, a large-scale field test was conducted of a stereo pedestrian detection system in four cities in four States under FHWA's SBIR program. The objective was to prove that stereo vision would reliably detect pedestrians in real-world environments under all weather conditions (e.g., sunny, cloudy, foggy, rainy, and snowy) and extreme temperatures (e.g., very high temperatures in the southern part of the country and very cold temperatures in the northern part of the country). Determining whether the system effectively actuates pedestrian calls and the locator tones on APSs is critical to convincing engineers that it is safe to use these systems to improve pedestrian crossings.

Test sites were selected on the basis of the number of pedestrian fatalities that occurred in the past few years and the number of pedestrians and/or the number of visually impaired pedestrians using the sites daily. These criteria address the pedestrian safety concerns at intersections and midblock crosswalks. For example, many pedestrians simply walk into an intersection without pushing the pushbutton and then rush through the crosswalk when there are oncoming vehicles, which could potentially cause fatalities.

Visually impaired pedestrians can easily recognize that they are at an intersection with an actuated pedestrian signal when they hear the locator tone of an APS. The locator tone helps them find the pushbutton, and then they must push the button (the same button used by all pedestrians) to request a pedestrian phase. The locator tone does not indicate the location of the crosswalk at many intersections because pushbuttons have not been required to be in a specific location in relation to the crosswalk. In the absence of an APS locator tone, it can be challenging for pedestrians who are visually impaired to locate pushbuttons, and most of them will not attempt to locate and use pushbuttons unless they know a crossing has a pushbutton and they know the location of that pushbutton.

According to the *Manual of Uniform Traffic Control Devices* (MUTCD), APS locator tones are required to operate 24/7.[4] In order to evaluate the effect of stereo pedestrian detection and consequent actuation of the locator tone and/or the pedestrian call on street crossings by pedestrians with visual impairments, all stereo detection units installed in this field test were capable of actuating APS pushbuttons based on detection of pedestrians at curb ramps. The APS pushbutton helps visually impaired and blind pedestrians quickly locate the pushbutton through the audible locator tone. Since locator tones could be too loud and cause concerns for nearby residents, they should only be turned on when pedestrians are within 12 ft (3.66 m) of the pushbutton, as defined by the MUTCD.[4]

This large-scale field test was conducted in two stages. In stage I, all system units installed at the test sites were standalone and not interfaced with the traffic signal system; they merely detected pedestrians. Researchers recorded the results in an offline analysis. Local transportation department traffic engineers participated in the test and mailed their results to the researchers. The results were manually scanned, and the saved images were sorted into two categories:

regular images saved every second and pedestrian detection images saved whenever pedestrians were detected. Both pedestrian detection rate and the number of false calls were subsequently estimated for the system performance evaluation.

When performance at all field test sites was consistently satisfactory, the test entered stage II. The system units were connected directly to the APS pushbuttons and interacted with the traffic signal system to place a service call on behalf of pedestrians detected as they waited to cross the intersection. False calls also placed service calls and potentially delayed the traffic flow, which was undesirable. APS locator tones performed in typical fashion, sounding once per second during the do not walk and flashing do not walk intervals. All systems were in operation 24/7, and local transportation department personnel carefully monitored the system performance and gathered comments from the general public.

Local engineers in all four cities were satisfied with the system performance at the test sites, and no traffic interruption was reported. In a follow-up stage III in Portland, ME, visually impaired pedestrians without the aid of the stereo pedestrian detection system and with and without the pedestrian detection system assisting the APS system were tested, and the system was found to be effective for them.

OBJECTIVE

The field test measurements were conducted to achieve the following primary objectives:

- Evaluate detection capabilities under key visibility altering weather conditions (e.g., sunny, cloudy, foggy, rainy, and snowy weather). Verify that the performance of the unit under long-term field conditions is not adversely affected by rain, snow, and road dust.
- Measure detection accuracy under a variety of adverse temperature conditions known to impair electronics equipment (e.g., extreme temperatures in different geographical areas).
- Evaluate detection accuracy for activating the APS tones for visually impaired pedestrians for the number of pedestrians detected and for the number of false calls.
- Evaluate detection accuracy for activating the pedestrian phase for the number of pedestrians detected to call the phase correctly and for the number of false calls that delay traffic unnecessarily.
- Evaluate the ability of the electronics to function correctly under adverse environmental conditions in an environmental testing laboratory according to Department of Defense (DoD) standards (e.g., high/low temperatures, humidity, rain, icing, and vibration).[(1)] (See the appendix for additional details.)
- Evaluate the ability of the electronics to reliably call the pedestrian phase when a pedestrian is detected by the sensor.
- Evaluate the ability of the electronics to reliably extend the pedestrian phase when a pedestrian remains in the crosswalk. (This testing required the presence of a traffic signal controller that has an option for extending the pedestrian phase when requested by a pedestrian sensor.)

Data collected at the field test sites in 2011 and 2012 indicated that the units performed well under a variety of environmental conditions. Laboratory testing demonstrated that harsh environmental conditions, particularly high levels of moisture and rain, did not adversely affect the electronics.

BACKGROUND—STEREO DETECTION SYSTEM

This section provides a brief description of stereo detection technology and its linkage to visually impaired pedestrian assistance (APS pushbuttons) and the traffic control hardware.

The system used in this large-scale field test consists of a stereo camera, an industrial-graded single-board computer (SBC), and video cables. Both camera lenses are equipped with 24 infrared (IR) light-emitting diodes (LEDs) for low-light operation. With the IR LEDs, pedestrians are detected up to 80 ft (24.4 m) away from the camera in dark areas without streetlights.

Stereo cameras take two images of the same scene from slightly different viewing angles. Algorithms form a disparity map from the images to extract human body three-dimensional features. Stereo imaging achieves a higher detection rate (> 98 percent) and a lower number of false calls (< five per day). The disparity map filters out problems from changing illumination, background, and shading.

To detect pedestrians waiting at an intersection, the stereo camera must be mounted nearby (approximately 15 ft (4.58 m) above the ground) with a view of the pedestrian(s) in the middle of the stereo images. Figure 2 shows a stereo camera, which is circled in red, mounted to a signal pole.

Figure 2. Photo. Stereo camera mounted on a pole above a pedestrian walk signal.

For the field test, project engineers worked with the local traffic engineers to place the SBC sensor processors in the traffic controller cabinet. Stereo camera images were transmitted to the SBC through video cables and processed for the detection of pedestrians. Each SBC can process images from two stereo cameras. The SBC has an Intel® atom processor for lower power consumption and uses Microsoft XP Embedded® as the real-time operating system. Separate relay cables were wired between the APS pushbuttons and the SBC for visually impaired pedestrians. All cables were pulled through an underground conduit. Figure 3 shows SBCs, marked by a red circle, placed inside a cabinet. For a typical intersection, there are four SBCs and eight stereo cameras to cover the eight approaches to the four crosswalks.

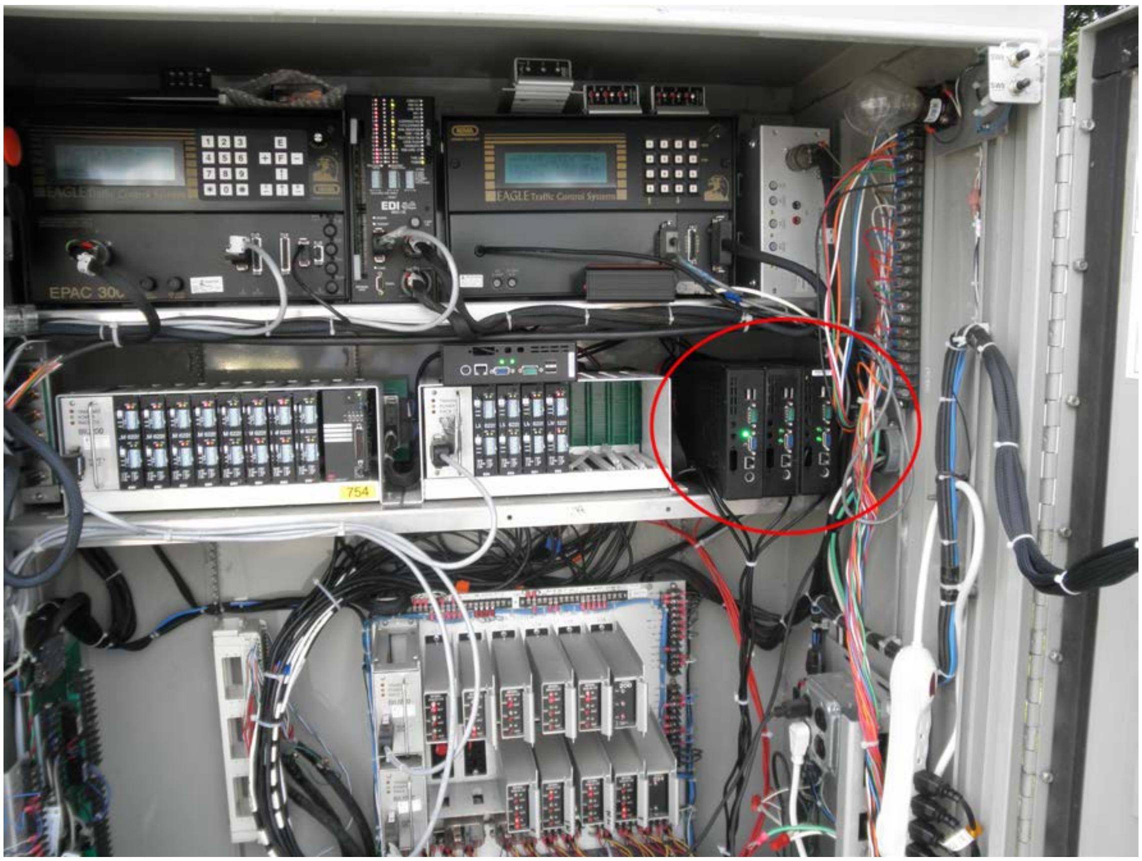

Figure 3. Photo. Four SBCs in a traffic control cabinet.

In this study, there were 17 SBCs and 34 stereo cameras installed at locations in four cities: 8 systems in Tucson, AZ; 4 systems in Somerville, MA; 5 systems in Portland, ME; and 2 systems in Manchester, NH.

The stereo pedestrian detection systems automatically actuated the APS pushbutton and triggered its locator tone based on the presence of pedestrians. There are two detection zones, and each of them has different functionalities. These two zones are described in the following sections.

AUTOMATED APS PUSHBUTTON LOCATOR TONE-TRIGGERING ZONE

The automated APS pushbutton locator tone-triggering zone is outlined in red in figure 4. In this zone, pedestrian detection turns on the APS locator tone. Since the detection in this zone is almost instantaneous, there could be some false calls. However, it is not critical to have false calls in this zone because the locator tone is turned on for only 30 s (configurable), and no service call is placed. This zone is larger than the actuation zone because it must alert approaching pedestrians about the pedestrian crossing.

AUTOMATED APS PUSHBUTTON ACTUATION ZONE

The automated APS pushbutton actuation zone is outlined in yellow in figure 4. If a pedestrian is detected in this zone, a service call is automatically placed. To be detected, the pedestrian must wait in this zone for 4 to 5 s (configurable). Since a service call is automatically made by the system, the pedestrian does not need to press the pushbutton. However, if desired, the pedestrian can still press the button and hear the APS information message identifying the intersection and the street that is controlled by the pushbutton. False calls in this zone stop and delay traffic. As a result, the number of false calls per day must be very low.

Figure 4. Photo. Two-zone detection architecture for locator triggering and pushbutton actuation.

PREPARATION FOR LARGE-SCALE FIELD TEST

At the start of this large-scale field test, test units were manufactured and tested for stereo alignment. Algorithms were installed in each unit. All stereo cameras and electronics went through rigorous tests at the laboratory field test site outside an office entrance before being placed in the field. Figure 5 shows this test site, which simulates a typical intersection corner. The laboratory site accommodated varying distances between the stereo camera and the ramp. Detection results were evaluated to ensure the quality of the systems for the field test.

Figure 5. Photo. Simulated pedestrian waiting area test site.

All systems installed at the test sites recorded detection images (i.e., those with pedestrians detected) and regular images (i.e., those recorded every second). These images were saved in the external USB hard disks. When pedestrians were detected, 15 consecutive images were recorded continuously, starting from the moment when the detection was made. Regular images were recorded by one of two lenses of the stereo camera every second.

Since one SBC can process two stereo cameras installed at both sides of the crosswalk, “system 1” and “system 2” were created to differentiate between them. The data were saved in separate folders each day. The folder structure was identical for both systems. When the system was up and running, it initially stored the current date. Then, a check for the time change was performed in every loop of execution. In this checking function, the new date was acquired from the system and compared with the initially stored date. If there was a change in the year, month, or day, a new “year,” “month,” or “day” folder was created.

After the folders were created, the images were saved within the folders. In order to differentiate them, images were saved in the format of *year_month_day_hour_minute_second.bmp*. These images were stored in a folder labeled “Monitor.” Whenever there was pedestrian detection, 15 consecutive images were saved in a folder labeled “Detection.” These detection images were saved in the format of *year_month_day_hour_minute_second_milliseconds.bmp*. The bmp image format rather than the jpeg format was chosen because it takes longer to convert an image to the jpeg format.

TEST SITE SELECTION

The primary criteria for selecting test sites were the number of pedestrian accidents that had occurred in the past few years and pedestrian daily volume at the sites. Based on the selection criteria, each participating local transportation department initially recommended a number of sites for consideration. A site visit was then scheduled, and researchers met local transportation department personnel to inspect each test site to ensure the success of installation. Once the test sites were selected, subsequent field installations were scheduled. Figure 6 through figure 14 show the layout of each of the test sites.

There were five test sites in Tucson, AZ: one signalized intersection and four signalized midblock crossings. Figure 6 through figure 10 show aerial views. Systems for pedestrian walk time extension were installed at midblock crossings at East Broadway Boulevard (Fellowship Square) and West Kelso Street/North Oracle Road. Both crosswalks are over 160 ft (48.8 m) long. Instead of extending the pedestrian crossing time permanently, the systems installed at these two sites can extend walk time based on the presence of pedestrians in the crosswalk.

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Figure 6. Photo. East Roger Road at North 1st Avenue test site in Tucson, AZ.[(5)]

Imagery ©2012 Google, Map data ©2012 Google

Figure 7. Photo. North Campbell Avenue at East Blacklidge Drive test site in Tucson, AZ.[(6)]

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Figure 8. Photo. East Grant Road at North Palo Verde Boulevard test site in Tucson, AZ.[(7)]

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Figure 9. Photo. East Broadway Boulevard at Fellowship Square test site in Tucson, AZ.[(8)]

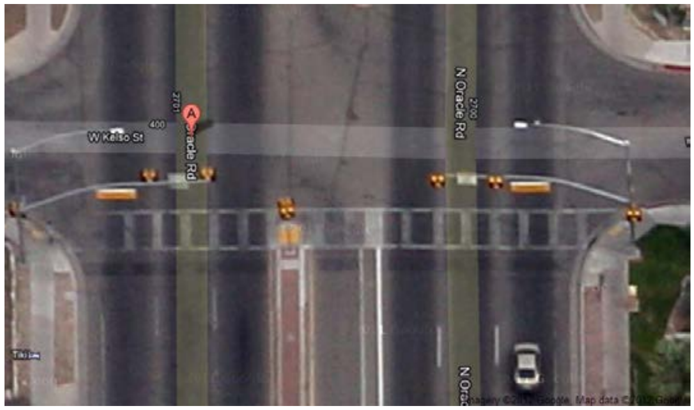

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Figure 10. Photo. West Kelso Street/North Oracle Road test site in Tucson, AZ.[(9)]

Figure 11 shows a signalized intersection that was selected in Somerville, MA. It is one of the largest intersections in Massachusetts. This intersection is next to a recreational park and residential buildings. Pedestrian volume is high during the daytime and at night.

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Figure 11. Photo. Intersection at McGrath Highway and Broadway in Somerville, MA.[(10)]

The Maine Department of Transportation (MaineDOT) in Portland, ME, recommended a number of test sites. During the site visit, it was found that some sites were not suitable for the system installation due to aged conduits. Two signalized intersections were selected, one at Deering Avenue and Park Avenue and the other at Commercial Street and Franklin Street. The intersection at Deering Avenue and Park Avenue is within walking distance to an education and rehabilitation center for people who are blind or who have low vision. The intersection at Commercial Street and Franklin Street is next to a ferry terminal, and pedestrian volume is high. Figure 12 and figure 13 show these two test sites.

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Figure 12. Photo. Deering Avenue/Park Avenue test site in Portland, ME.[(11)]

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Figure 13. Photo. Commercial Street/Franklin Street test site in Portland, ME.(12)

The test site in Manchester, NH, is located at the Catholic Medical Center (see figure 14). Since this intersection is primarily used by hospital visitors, the pedestrian volume is extremely high. It is also used by pedestrians who have vision and mobility impairments.

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Figure 14. Photo. Aerial view of Medical Center test site at McGregor Street and Foundry Street in Manchester, NH.(13)

STANDARD LAB TESTS FOR HARDWARE COMPONENTS

For the field installation, both stereo camera and SBC went through the standard tests performed by a leading international provider of independent inspection, testing, and certification services including product conformity testing and certification, electromagnetic compatibility testing, performance testing, and other quality assessment services. The testing standards and procedures were based on DoD test standards (see the appendix for details of the test results).(1) (Note that even though all tests in the appendices were performed in metric units only per the DoD test standards, the results are shown in this report in English units with the specified metric units in parentheses to conform to Government Printing Office publication standards.)

An independent lab test company performed a series of tests that include high/low temperature, humidity, rain, icing, vibration, and FCC. These tests were recommended by the Massachusetts Department of Transportation (MassDOT) as essential for any traffic equipment to be deployed in the field. Both stereo camera and SBC were subjected to three cycles of high/low temperature (24 h each). The purpose of this test was to obtain data to help evaluate effects of high/low temperature conditions on materiel safety, integrity, and performance. This temperature test confirms that the hardware for this large-scale field test meets the temperature requirement of -23.8 to 158 °F (-31 to 70 °C). The humidity test was used to determine the resistance of materiel to the effects of a warm, humid atmosphere. The test was performed for 11 days with a total of five cycles. Each test cycle lasted 48 h. The temperature varied between 77 °F (25 °C) ±72 °F (22.2 °C) at 95 percent humidity. The stereo pedestrian sensor hardware passed this test, as well.

The rain test procedure follows Method 506.4 of the DoD standards.(1) The purpose of this test is to help determine the following with respect to rain, water spray, or dripping water:

- Effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel.
- Capability of the materiel to satisfy its performance requirements during and after exposure to water.
- Any physical deterioration of the materiel caused by the rain.
- Effectiveness of any water removal system.
- Effectiveness of protection offered to a packaged materiel.

The test procedure uses nozzles that produce a square spray pattern or other overlapping pattern and with a droplet size predominantly in the 0.019- to 0.176-inch (0.5- to 4.5-mm) range at approximately 38.72 psi (267 kPa). The stereo camera passed this test.

The icing or freezing rain procedure follows Method 521.2 of the DoD standards.(1) The purpose of this test is to evaluate the effect of icing on the operational capability of materiel. The testing is designed to determine if materiel can operate after ice accumulation from rain, drizzle, fog, splash, or other sources. Ice formation can impede materiel operation and survival and affect the safety of the operating system. This method also provides tests for evaluating the effectiveness of de-icing equipment and techniques. The stereo camera passed this test.

Vibration tests are described in Method 514.5 of the DoD standards.[(1)] The test verifies that materiel will function in and withstand the vibration exposures of a life cycle, including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. There are different vibration procedures such as general vibration, loose cargo transportation, large assembly transportation, assembled aircraft store captive carriage, and free flight. The systems used at field tests were subject to operational service where they were configured for service use. The system was secured to the test fixture at the mounting points. The same type of mounting hardware used for traffic equipment operational service was used during the test. The stereo pedestrian sensor system hardware also passed this test.

The system was subject to FCC 15 Subpart B (unintentional radiators) testing for electromagnetic interference.[(2)] The category of unintentional radiators includes a variety of devices that contain clocks or oscillators and logic circuitry but that do not deliberately generate radio frequency emissions. Among the common unintentional radiators are personal computers, peripherals, receivers, radios, TVs, and cable TV home terminals. Two levels of radiation and conducted emissions limits for unintentional radiators are specified in FCC Part 15 Subpart B.[(2)] The two levels are Class A digital devices (higher, less strict limits) and Class B digital devices (lower, more strict limits). The stereo pedestrian sensor system hardware passed both Class A and Class B tests.

PERFORMANCE RESULTS BASED ON FULL-DAY SCAN

During the field test, both regular images and detection images were stored in external USB hard disks. The data were used for offline performance analysis. The regular images were saved at a rate of 1 Hz and were mainly used for identifying the ground truths. A person manually scanned all of the regular images to determine when pedestrian(s) were crossing the street. These ground truths were then cross checked with the detection images to determine whether or not the same pedestrians identified in the regular images were actually detected by the system. The detection images could also be used to evaluate the number of false calls per day.

One major issue related to manual scanning is the amount of images that need to be scanned. It was estimated that one SBC that can process two stereo cameras will accumulate 15,552,000 images in 3 months. Since there were 17 SBCs installed during the field test, in 3 months, there will be over 260 million images that need to be manually scanned.

To obtain an accurate estimation of system performance, two scanning methods have been used: full-day scan and random sampling-based scan. The full-day scan is recommended to understand the true performance of a system. However, it is impossible to scan all of the data within a limited time and budget. The performance results from a full-day scan provide the system performance in a snapshot. The random sampling approach is found in the section entitled "Performance Results Based on Statistical Sampling."

A total of 28 days were manually scanned for the performance evaluation, covering all four cities and a variety of weather conditions (i.e., snowy, raining, sunny, and cloudy). The following evaluation criteria were used for the system performance estimation, and they have been used by researchers for pedestrian detection performance evaluation:

- Overall Error Rate (%) = ((Total Detection Count) − (Ground Truth Count))/(Ground Truth Count).
- Missed Detection Error Rate (%) = (Missed Detection Count)/(Ground Truth Count).
- False Detection Error Rate (%) = (False Detection Count)/(Ground Truth Count).

In addition, another criterion was added, which is related to the average number of false detection counts (false calls) per day (24-h period). This performance is easy to understand and has a direct impact on the traffic flow when the pedestrian detection system is connected to the traffic signal system. For each city, the results that were manually scanned were listed, and the performance data were calculated.

Table 1 lists the scanning results for the test site in Somerville, MA, over 9 days. The table covers all weather conditions such as snowy, rainy, cloudy, and sunny.

Table 1. Test Site data for Somerville, MA.

Date and Day	Weather	No. of Missed Pedestrians in Automated APS Actuation Zone	No. of Missed Pedestrians in APS Locator Tone Triggering Zone	No. of False Calls in Automated APS Actuation Zone	No. of False Calls in APS Locator Tone Triggering Zone
3/9/2011 (Wed.)	Cloudy	0 (detected 32 out of 32 pedestrians)	0 (detected 75 out of 75 pedestrians)	0	0
3/19/2011 (Sat.)	Cloudy/ sunny	0 (detected 19 out of 19 pedestrians)	7 (detected 40 out of 47 pedestrians)	11	19
3/24/2011 (Thur.)	Cloudy/ rainy	1 (detected 23 out of 24 pedestrians)	1 (detected 48 out of 49 pedestrians)	10	17
3/28/2011 (Mon.)	Sunny	0 (detected 32 out of 32 pedestrians)	0 (detected 51 out of 51 pedestrians)	0	8
4/1/2011 (Fri.)	Snow	0 (detected 53 out of 53 pedestrians)	0 (detected 89 out of 89 pedestrians)	0	0
4/2/2011 (Sat.)	Cloudy/ rainy	0 (detected 69 out of 69 pedestrians)	0 (detected 109 out of 109 pedestrians)	1	3
4/5/2011 (Tue.)	Rainy	0 (detected 71 out of 71 pedestrians)	0 (Detected 163 out of 163 pedestrians)	1	1
6/1/2011 (Wed.)	Cloudy/ rainy	1 (detected 64 out of 65 pedestrians)	3 (detected 186 out of 189 pedestrians)	0	0
6/3/2011 (Fri.)	Cloudy/ sunny	0 (detected 42 out of 42 pedestrians)	1 (detected 65 out of 66 pedestrians)	17	36

The performance evaluation data for the test site in Somerville, MA, are listed in table 2. The overall positive detection rate for the detection in automated APS pushbutton actuation zone was over 99 percent, and the average number of false calls per day was about four. For the APS locator tone triggering zone, the positive detection rate was over 98 percent, and the average number of false calls per day was about 15.

Table 2. Performance evaluation results for Somerville, MA.

Performance Criterion	Automated APS Actuation Zone	APS Locator Tone Triggering Zone
Ground truth count	407	878
Total detection count	445	997
Missed detection count	2	12
False detection count	40	131
Overall error rate	38/407 = 9.3 percent	119/878 = 13.6 percent
Missed detection error rate	2/407 = 0.5 percent	12/878 = 1.4 percent
False detection error rate	40/407 = 9.8 percent	131/878 = 14.9 percent
Positive detection rate	1 – 0.5 percent = 99.5 percent	1 – 1.4 percent = 98.5 percent
Average false count per day	40/9 = 4.4/day	131/9 = 14.6/day

In total, 9 days of data were manually scanned for the two test sites in Portland, ME (see table 3). The data also cover the weather conditions such as snowy, rainy, cloudy, and sunny.

Table 3. Test data for the two test sites in Portland, ME.

Date and Day	Weather	No. of Missed Pedestrians in Automated APS Actuation Zone	No. of Missed Pedestrians in APS Locator Tone Triggering Zone	No. of False Calls in Automated APS Actuation Zone	No. of False Calls in APS Locator Tone Triggering Zone
3/8/2011 (Tue.)	Cloudy/ snowy	2 (detected 80 out of 82 pedestrians)	0 (detected 137 out of 137 pedestrians)	0	10
3/9/2011 (Wed.)	Sunny	0 (detected 89 out of 89 pedestrians)	0 (detected 157 out of 157 pedestrians)	3	9
3/10/2011 (Thur.)	Rainy	0 (detected 34 out of 34 pedestrians)	0 (detected 73 out of 73 pedestrians)	4	25
3/14/2011 (Mon.)	Partially sunny	0 (detected 73 out of 73 pedestrians)	0 (detected 162 out of 162 pedestrians)	13	36
3/21/2011 (Mon.)	Snow	0 (detected 31 out of 31 pedestrians)	0 (detected 103 out of 103 pedestrians)	2	4
3/25/2011 (Fri.)	Cloudy/ snowy	2 (detected 80 out of 82 pedestrians)	0 (detected 163 out of 163 pedestrians)	4	30
3/26/2011 (Sat.)	Cloudy	0 (detected 63 out of 63 pedestrians)	0 (detected 172 out of 172 pedestrians)	0	2
6/1/2011 (Wed.)	Mostly cloudy	0 (detected 84 out of 84 pedestrians)	0 (detected 179 out of 179 pedestrians)	2	5
6/4/2011 (Sat.)	Sunny	0 (detected 86 out of 86 pedestrians)	0 (detected 212 out of 212 pedestrians)	4	30

The performance evaluation data for the test sites in Portland, ME, are listed in table 4. The overall positive detection rate for the detection in automated APS button actuation zone was over 99.7 percent, and average number of false calls per day was about four. For the APS locator tone triggering zone, the positive detection rate was 100 percent, and average number of false calls per day was about 17.

Table 4. Performance evaluation results for Portland, ME.

Performance Criterion	Automated APS Actuation Zone	APS Locator Tone Triggering Zone
Ground truth count	624	1,358
Total detection count	654	1,509
Missed detection count	2	0
False detection count	32	151
Overall error rate	30/624 = 4.8 percent	143/878 = 11.1 percent
Missed detection error rate	2/624 = 0.3 percent	0/1358 = 0 percent
False detection error rate	32/624 = 5.1 percent	151/1358 = 11.1 percent
Positive detection rate	1 – 0.3 percent = 99.7 percent	1 – 0 percent = 100 percent
Average false count per day	32/9 = 3.6/day	151/9 = 16.8/day

Table 5 lists the scanning data for the test sites in Manchester, NH, over 5 days. The data cover weather conditions such as rainy, cloudy, and sunny.

Table 5. Test data for the two test sites in Manchester, NH.

Date and Day	Weather	No. of Missed Pedestrians in Automated APS Actuation Zone	No. of Missed Pedestrians in APS Locator Tone Triggering Zone	No. of False Calls in Automated APS Actuation Zone	No. of False Calls in APS Locator Tone Triggering Zone
4/19/2011 (Tue.)	Rain	0 (detected 47 out of 47 pedestrians)	0 (detected 156 out of 156 pedestrians)	0	0
5/1/2011 (Sun.)	Sunny	0 (detected 89 out of 89 pedestrians)	0 (detected 103 out of 103 pedestrians)	0	11
5/6/2011 (Sat.)	Cloudy	1 (detected 47 out of 48 pedestrians)	1 (detected 170 out of 171 pedestrians)	5	47
5/12/2011 (Thur.)	Sunny	0 (detected 73 out of 73 pedestrians)	0 (detected 204 out of 204 pedestrians)	0	11
6/3/2011 (Fri.)	Sunny	3 (detected 143 out of 146 pedestrians)	2 (detected 339 out of 341 pedestrians)	0	4

The performance evaluation data for the test sites in Manchester, NH, are listed in table 6. The overall positive detection rate for the detection in automated APS button actuation zone was over 99 percent, and average number of false calls per day was about one. For the APS locator tone triggering zone, the positive detection rate was 99.7 percent, and average number of false calls per day was about 15.

Table 6. Performance evaluation results for Manchester, NH.

Performance Criterion	Automated APS Actuation Zone	APS Locator Tone Triggering Zone
Ground truth count	403	975
Total detection count	404	1,045
Missed detection count	4	3
False detection count	5	73
Overall error rate	1/403 = 0.02 percent	70/975 = 7.2 percent
Missed detection error rate	4/403 = 0.1 percent	3/975 = 0.3 percent
False detection error rate	5/403 = 5.1 percent	73/975 = 7.5 percent
Positive detection rate	1 – 0.1 percent = 99 percent	1 – 0.3 percent = 99.7 percent
Average false count per day	4/5 = 0.8/day	73/5 = 14.6/day

Table 7 lists the scanning results for the test sites in Tucson, AZ, over 5 days. The weather during these 4 days was always sunny.

Table 7. Test data for two test sites in Tucson, AZ.

Date and Day	Weather	No. of Missed Pedestrians in Automated APS Actuation Zone	No. of Missed Pedestrians in APS Locator Tone Triggering Zone	No. of False Calls in Automated APS Actuation Zone	No. of False Calls in APS Locator Tone Triggering Zone
5/6/2011 (Fri.)	Sunny	1 (detected 7 out of 8 pedestrians)	0 (detected 8 out of 8 pedestrians)	0	0
5/13/2011 (Fri.)	Sunny	1 (detected 5 out of 6 pedestrians)	0 (detected 6 out of 6 pedestrians)	1	0
5/17/2011 (Tue.)	Mostly Clear	1 (detected 125 out of 126 pedestrians)	0 (detected 126 out of 126 pedestrians)	4	0
7/1/2011 (Fri.)	Sunny	2 (detected 24 out of 26 pedestrians)	0 (detected 41 out of 41 pedestrians)	3	13

The performance evaluation data for the test sites in Tucson, AZ, are listed in table 8. The overall positive detection rate for the detection in automated APS button actuation zone was over 95.9 percent, and the average number of false calls per day was about two. For the APS locator tone triggering zone, the positive detection rate was 100 percent, and the average number of false calls per day was about three.

Table 8. Performance evaluation results for Tucson, AZ.

Performance Criterion	Automated APS Actuation Zone	APS Locator Tone Triggering Zone
Ground truth count	191	226
Total detection count	192	240
Missed detection count	8	0
False detection count	9	14
Overall error rate	1/191 = 0.05 percent	14/226 = 6.2 percent
Missed detection error rate	8/191 = 4.1 percent	0/226 = 0 percent
False detection error rate	9/191 = 4.7 percent	14/226 = 6.2 percent
Positive detection rate	1 – 4.1 percent = 95.9 percent	1 – 0 percent = 100 percent
Average false count per day	9/5 = 1.8/day	14/5 = 2.8/day

Compared to the positive detection rate in other cities, it seems that the rate for Tucson, AZ, was relatively low. This is because the evaluation data of the first 3 days in table 7 are from two test sites where the walk time extension application was installed for the first time. The parameters and zone configuration were not finalized during that time.

In summary, the overall positive detection rate for the automated APS actuation zone at all four cities was 98.5 percent, and the average number of false calls per day was 2.7. This performance is extremely good, and it implies that the stereo pedestrian detection system installed at the street intersections detected almost every pedestrian waiting to cross the street while causing almost no delay to the traffic flow. This performance has also been confirmed during stage II of this large-scale field test. By May 2012, seven systems were operational 24/7 for over 6 months. Currently, all of the systems are operational.

PERFORMANCE RESULTS BASED ON STATISTICAL SAMPLING

Since it is impractical to manually scan all of the images saved for performance evaluation, the statistical sampling theory was applied to reduce the number of images (samples) to be scanned. This approach is similar to the opinion poll where a small number of people are surveyed over a large population. One widely used sampling formula is as follows:

$$ME = z\sqrt{\frac{p(1-p)}{N}}$$

Figure 15. Equation. Margin of error.

Where *ME* represents the margin of error, *z* is the Z-score, *p* is the probability of an image containing a pedestrian, and *N* is the sample size. The Z-score is associated with the confidence interval (i.e., 90, 95, or 99 percent). Since there is not any knowledge about *p*, a value of 0.5 is used, which also gives the largest *ME* with a fixed Z-score and population size *N*. The margin of error is usually chosen as 3, 2, and 1 percent. For the confidence interval of 90, 95, and 99 percent, the Z-score is 1.645, 1.96, and 2.58, respectively.

Figure 15 is often applied when the simple random sample principle is used. In statistics, a simple random sample is a subset of samples chosen from a larger population. Each sample is chosen randomly and entirely by chance such that each individual has the same probability of being chosen at any stage during the sampling process. This formula for the margin of error assumes that there is an infinitely large population and thus does not depend on the size of the population of interest. According to the sampling theory, this assumption is valid as long as the sampling fraction is less than 5 percent.

Suppose the confidence interval is chosen as 95 percent. In this case, $z = 1.96$. It can be derived that for a margin of error of 3 percent, the sample size is 1,067. In other words, if one scans 1,067 images out of 21,340 (i.e., 1,067/0.05) images, the results will have a margin of error of 3 percent with 95 percent confidence. However, each of these 21,340 images must have at least 1 pedestrian, which requires a manual scan as well.

In this approach, all of the images were divided into temporal categories as follows:

- One entire year is divided into the following four seasons:
  - Winter (December, January, and February).
  - Spring (March, April, and May).
  - Summer (June, July, and August).
  - Fall (September, October, and November).
- One entire day is divided into the following three subcategories:
  - Morning (6 a.m.–12 p.m.).

- Afternoon (12 p.m.–6 p.m.).
- Night (6 p.m.–6 a.m.).

- Each subcategory (morning, afternoon, or night) is divided into 5-min intervals.

A large number of images was randomly sampled from each category and then combined to form a large pool of images. Although not all of these sampled images had pedestrians, there were at least more than 21,340 images that had pedestrians. From these sampled images, 1,090 images were manually and randomly selected, and each of them had at least 1 pedestrian. These images were then manually evaluated by staff personnel. The performance evaluation results are given in table 9.

Table 9. Performance evaluation results based on random sampling.

Type of Detection Zone	Total Number of Pedestrians	Number of Pedestrians Detected	Number of Pedestrians Missed	Positive Detection Rate (Percent)
Automated APS actuation zone	553	538	15	97.3
APS locator tone triggering zone	930	910	20	97.8

The positive detection rates are within the margin of error of 3 percent with 95 percent confidence, which are similar to what was estimated from the full-day scanning. The number of false calls from random sampling was not estimated because it is impossible to know how many false calls are made in 1 day.

The overall quality of performance can be summed up by an observation by one of the city traffic engineers who helped in the evaluation process. Richard B. Nassi, P.E., Ph.D. stated in a personal communication to one of the authors that, "Tucson is experiencing wonderful results with the equipment and automated pedestrian detection has made our PUFFIN operations very effective."

INTEGRATION WITH TRAFFIC SIGNAL CONTROL SYSTEM

During stage II of this large-scale field test, stereo pedestrian detections systems were enabled to interact with the traffic signal system through APS pushbuttons. When pedestrians were detected in the automated APS actuation zone, a service request was made on behalf of the pedestrians. However, an APS locator is currently left on all the time. At the intersection of Commercial Street and Franklin Street in Portland, ME, APS buttons were not installed due to irregular distances between signal poles and ramps. Instead, the audible confirmation devices were installed. This inexpensive device informs pedestrians that they have been detected and that a service request has been automatically made for them.

Figure 16 through figure 29 shows site photos; the stereo cameras are encircled in red.

Figure 16. Photo. Operational stereo pedestrian detection system on East Broadway at Fellowship Square in Tucson, AZ.

Figure 17. Photo. Operational stereo pedestrian detection system on southeast corner of North Campbell Avenue and East Blacklidge Drive in Tucson, AZ.

Figure 18. Photo. Operational stereo pedestrian detection system at the intersection of West Kelso Street and North Oracle Road in Tucson, AZ.

Figure 19. Photo. Operational stereo pedestrian detection system on the west side of the intersection at East Grant Road and North Palo Verde Boulevard in Tucson, AZ.

Figure 20. Photo. Operational stereo pedestrian detection system at the intersection of McGrath Highway and Broadway in Somerville, MA.

Figure 21. Photo. Operational stereo pedestrian detection system at the north crosswalk across McGrath Highway parallel to Broadway in Somerville, MA.

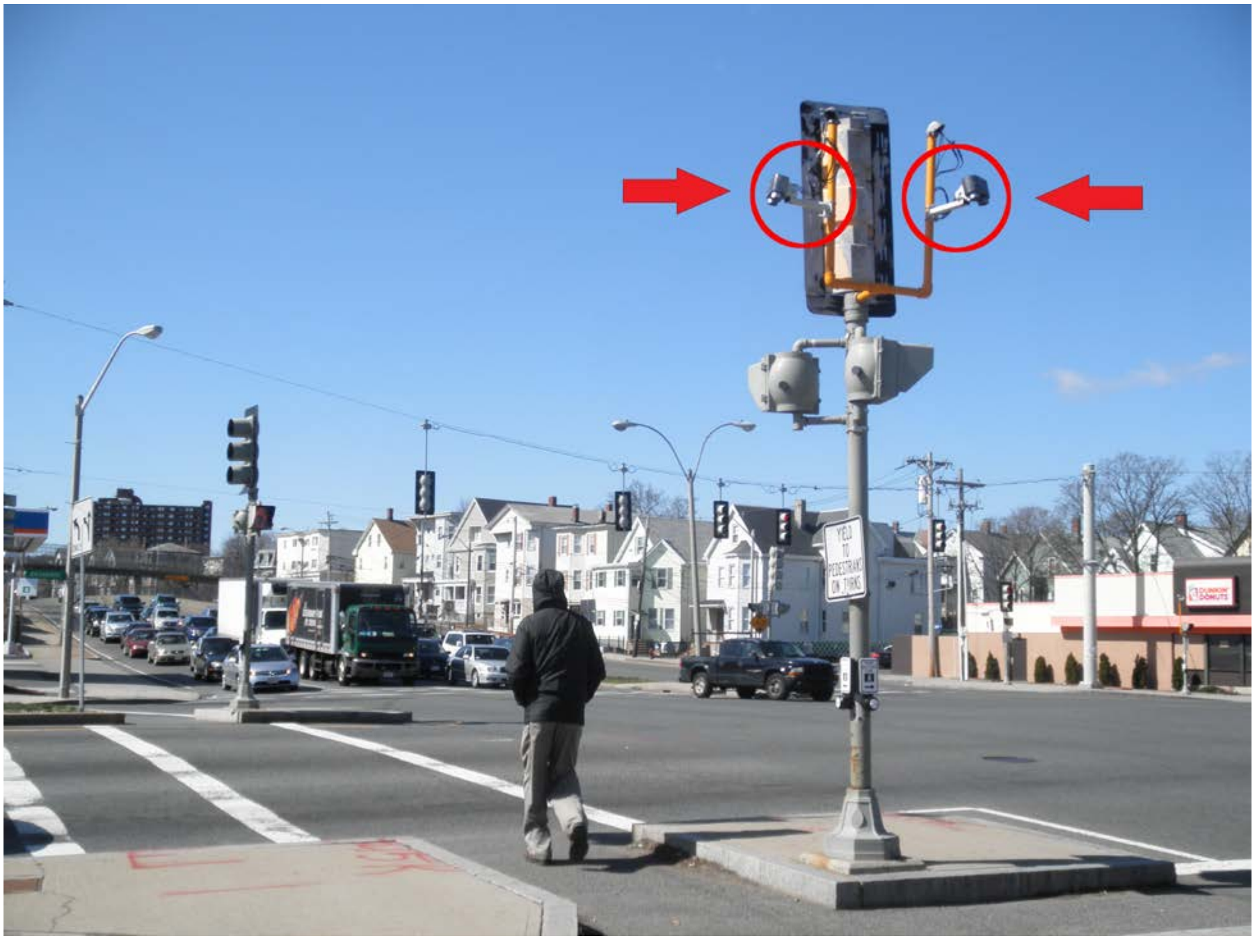


Figure 22. Photo. Two operational stereo pedestrian detection systems on the east side of McGrath Highway parallel to Broadway in Somerville, MA.

Figure 23. Photo. Operational stereo pedestrian detection system on the south side of Broadway and the west side of McGrath Highway in Somerville, MA.

Figure 24. Photo. Operational stereo pedestrian detection system on the northeast corner of Deering Avenue and Park Avenue in Portland, ME.

Figure 25. Photo. Operational stereo pedestrian detection system at Deering Avenue and Park Avenue in Portland, ME.

Figure 26. Photo. Operational stereo pedestrian detection system at Franklin Street and Commercial Street in Portland, ME.

Figure 27. Photo. Operational stereo pedestrian detection system on southeast corner of McGregor Street and Foundry Street in Manchester, NH.

Figure 28. Photo. Operational stereo pedestrian detection system along McGregor Street at Foundry Street in front of Catholic Medical Center in Manchester, NH.

Figure 29. Photo. Operational stereo pedestrian detection system at the west side of McGregor Street at Foundry Street at the Catholic Medical Center in Manchester, NH.

Since this research was conducted as part of FHWA's SBIR, efforts are being made by the researchers to bring this product to the market in a timely fashion. Researchers have established a network of distributors in the traffic industry. They are also in the process of getting the stereo pedestrian detection products approved by States. A supply chain has been established for product manufacturing in quantity.

SUMMARY

Large-scale testing has been performed to measure the performance of stereo vision technology for pedestrian sensing using statistical sampling relative to criteria established in cooperation with practicing traffic engineers of the jurisdictions hosting the tests. Testing was conducted by taking benchmark sample pictures using the same equipment used to sense the pedestrians and evaluating them. Measurements were made using a standardized test procedure. Results show that the systems reliably detected pedestrians with a minimal number of false alarms. Interestingly, the number of missed detections was not higher under rainy or snowy conditions.

In March 2010, under FHWA's SBIR program, researchers conducted a large-scale field test project in Tucson, AZ; Somerville, MA; Portland, ME; and Manchester, NH. The stereo pedestrian detection systems were installed to evaluate their performance in the real-world environment under all weather conditions and extreme temperatures. In total, 17 systems were installed at both midblock crossings and intersections in those four cities. When pedestrians were detected at crosswalk ramps, the system automatically actuated both regular and APS pushbuttons to make the service request on behalf of the pedestrians. System performances were evaluated using images saved in external USB hard disks. The overall positive detection rate for the automated APS actuation zone at all four cities was close to 98 percent, and the average number of false calls per day was less than three. This excellent performance has also been confirmed through the real operations of systems installed at the test sites. Currently, all of the systems are operational 24/7. Comments from the general public, including the blind and visually impaired community, are all positive. The impact of the system on street crossings by pedestrians who have little or no vision is being evaluated.

This successful project has demonstrated that the advanced image processing technologies using stereo cameras can be used to reliably detect pedestrians in a complex outdoor environment. Through automated actuation of pushbuttons based on the presence of pedestrians, this system can reduce the number of collisions between vehicles and pedestrians, help prevent unnecessary fatalities, and automatically extend the walk time for seniors and pedestrians in wheelchairs without slowing down the traffic flow.

RECOMMENDATIONS

Pedestrian interactions have critical implications for a variety of important traffic control and evaluation applications. As a result, enhancing the reliability and safety of operational use of pedestrian sensing technologies has been an area of interest to the Pedestrian Research Subcommittee and the Traffic Signal Systems Research Subcommittee of the Transportation Research Board and of the FHWA Offices of Research, Development and Technology.

Stereo vision technology for sensing pedestrians was characterized in this study via standardized statistical sampling methods relative to standard statistical tests. This technology has been demonstrated to be an effective tool for evaluating the presence or absence of pedestrians as well as interacting with the pedestrian phases of traffic signal control applications. The results from the testing show that this technology may be effectively used to assist pedestrians who cannot or do not press the pedestrian pushbutton. The technology has a high level of reliability suitable for assisting visually disabled pedestrians. This study was conducted under SBIR 040-FH3 and therefore is limited to assessing the technology developed under that study. It did not address other pedestrian sensing technologies such as radar, light detection and ranging, and IR sensing technologies.

This study provides baseline information on how to conduct pedestrian sensing research. Further research into how to document the reliability and effectiveness of sensors for use with pedestrians is recommended.

APPENDIX—CERTIFIED LABORATORY TEST REPORTS

METHOD 501.4. HIGH-TEMPERATURE TEST[(1)]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

Test Report

Company	Migma Systems, Inc.
Address	1600 Providence Highway Walpole, MA 02081
Contact	Uma Venkataraman
Product Name	Midblock
Serial Number(s)	1 & 2
Project Number	G100146942
Test Performed	Method 501.4 High Temperature
Standard	MIL-STD-810F
Test Engineer	Albert Noyes
Date Tested (Start, Stop)	July 13 through July 16, 2010
Test Room/Area	AMAP Lab
Photo	Yes
Test Level(s)	See Table 1.3-1
Deviation from Test Method	None
Product Modification	None
EUT Results	Pass
Posted Filename	G100146942BOX-003
Prepared by; Albert E. Noyes	
Reviewed by; Mike Koffink Operations Manager	
Report Date	July 31, 2010

Table of Contents

REVISION SUMMARY – The following changes have been made to this Report:

Date	Project No.	Project Handler	Pages(s)	***Description of Change***
7/31/10	G100146942	Albert Noyes	-	Initial Release

List of Tables and Figures

1. Executive Summary

1.1 Scope

This report describes Method 501.4 High Temperature testing performed on July 13 through July 16, 2010 on the Migma Midblock Cameras submitted by Migma Systems, Inc.. Testing was performed pursuant to MIL-STD-810F, Method 501.4 High Temperature.

Technical descriptions of the equipment under test, support equipment, test equipment, test procedures and results are presented in the following sections.

1.2 Purpose

MIL-STD-810F, Method 501.4 High Temperature Test is for evaluating a products ability to operate properly in a high temperature environment.

1.3 Conclusions

The Migma Midblock, P/N Migma Midblock was tested to the MIL-STD-810F, Method 501.4 High Temperature performance requirements in it's as received condition. See Table 1.3-1 for a summary of the test results

Table 1.3-1: Summary of Test Requirements and Results

Environmental Conditions During Testing:		Ambient (□C):	Per 507.4	Method	Per 501.4	Pressure (hPa):	N/A
Pretest Verification Performed		Yes		Equipment under Test:		Migma Midblock	
Test Engineer(s):	Albert Noyes			EUT Serial Number(s):		1 & 2	
Engineer's Initials:		Date Test Performed:	7/13 – 7/16	Reviewer's Initials:		Date Reviewed:	

Requirements	Results
MIL-STD-810F Method 501.4 High Temperature. 3 cycles as	Pass

1.4 Performance Criteria

Pass/Fail Criteria: The EUT will continue to operate as intended during a prolonged exposure to a MIL-STD-810F, Method 501.4 High Temperature

2. Test Environment

2.1 EUT Description

The equipment under test (EUT) is: Migma Midblock

**EUT
Configuration**

Description	Manufacturer	Part Number	Serial Number
Traffic Camera system	Migma Systems, Inc.	Migma Midblock	1 & 2

Power supply upgraded with military temperature grade FET.

2.1.1 Support Equipment:

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	Remote PC - single board	Migma Systems	MM0510	64496SB0211	N/A
	PC Power supply	FSP Group Inc	9NA0840302	H00000059	N/A
	Camera Power supplies	-	LD12125A	-	N/A

Cables:

Quantity	Description
1	PC Power Cord

2.2 Test Facility Description

The test facility is located on the premises of Intertek at 70 Codman Hill Road, Boxborough, MA, 01719. Testing is performed in one or more of the following chambers: A

(A) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(B) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(C) Environmental Chamber Tenney 3ft wide x 3ft high x 3ft deep
(D) Environmental Agree Chamber CSZ 53in wide x 37in high x 53in deep
(E) Thermal Shock Chamber, Cincinnati Sub-Zero 16cu ft

2.3 Test Equipment

Table 2.3-1: Test Equipment

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
148-012	Environmental Chamber	Envirotronics	SH27C	08015563-11264	8/27/10

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

2.4 Product Disposition

All items received for testing undergo an inspection to ensure proper working condition upon receipt and before return shipment. The Migma Midblock, P/N Migma Midblock passed the incoming inspection when received for testing July 19, through July 20, 2010. The Migma Midblock camera system was returned to Migma Systems, Inc. after completion of testing.

3. Test Descriptions and Results

3.1 METHOD 501.4 HIGH TEMPERATURE

3.1.1 Object

The objective of this test is to determine the ability of an electronic device to properly operate during a prolonged exposure to a Method 501.4 High Temperature environment.

3.1.2 Procedure

1. Sample was examined visually for any defects prior to the start of testing and a pre-test functional check was performed.
2. Sample is placed into an environmental chamber and connected to the support equipment. The sample is then put into an operational state.

The environmental chamber is then programmed to run profile 5014 and the test is started. This profile is setup to run this 24hr sequence 3 times.

TABLE 501.4-II. High temperature cycles, climatic category - Hot.[1/]

Time of Day	Ambient Air Conditions		Induced Conditions	
	Temperature[3/] °C (°F)	Humidity[2/] % RH	Temperature[3/] °C (°F)	Humidity[2/] % RH
0100	35 (95)	6	35 (95)	6
0200	34 (94)	7	34 (94)	7
0300	34 (93)	7	34 (94)	7
0400	33 (92)	8	33 (92)	7
0500	33 (91)	8	33 (92)	7
0600	32 (90)	8	33 (91)	7
0700	33 (91)	8	36 (97)	5
0800	35 (95)	6	40 (104)	4
0900	38 (101)	6	44 (111)	4
1000	41 (106)	5	51 (124)	3
1100	43 (110)	4	56 (133)	2
1200	44 (112)	4	63 (145)	2
1300	47 (116)	3	69 (156)	1
1400	48 (118)	3	70 (158)	1
1500	48 (119)	3	71 (160)	1
1600	49 (120)	3	70 (158)	1
1700	48 (119)	3	67 (153)	1
1800	48 (118)	3	63 (145)	2
1900	46 (114)	3	55 (131)	2
2000	42 (108)	4	48 (118)	3
2100	41 (105)	5	41 (105)	5
2200	39 (102)	6	39 (103)	6
2300	38 (100)	6	37 (99)	6
2400	37 (98)	6	35 (95)	6

[1/] These cycles were derived from AR 70-38, 1 August 1979, and essentially conform to those in MIL-HDBK-310 and NATO STANAG 2895. These values represent typical conditions throughout a typical day in this climatic category. "Induced Conditions" are air temperature levels to which materiel may be exposed during storage or transit situations that are aggravated by solar loading.
[2/] Humidity control during high temperature testing is generally not necessary. Use these values only in special cases.
[3/] Data were originally recorded in °F and converted to °C. Hence, table data conversion may not be consistent.

3. Proper operation of the sample is monitored daily throughout the duration of the test. Any change in operation is noted and included in this report.
4. After Testing allow the sample is allowed to stabilize at room ambient temp for 24hours.
5. Upon completion of the test the sample will be returned to Migma Systems, Inc. for complete evaluation.

Testing of the EUT was performed in AMAP Lab (see Section 2.2 or Table 2.3-1).

3.1.3 Test Equipment

The following test equipment was used for this test: Refer to Table 2.3-1.

3.1.4 Climatic Conditions

The climatic conditions must comply with certain requirements during testing as called out in MIL- STD-810F. These conditions were monitored throughout testing.

3.1.5 Confidence of Results and Deviations from Test Method

Confidence of results is obtained by continuously monitoring the temperature and operational condition of the samples during testing.

3.1.6 Results

The Migma Midblock was tested to and passes the requirements for MIL-STD-810F. The specific test is, Method 501.4 High Temperature. Table 1.3-1 for a summary of the test results

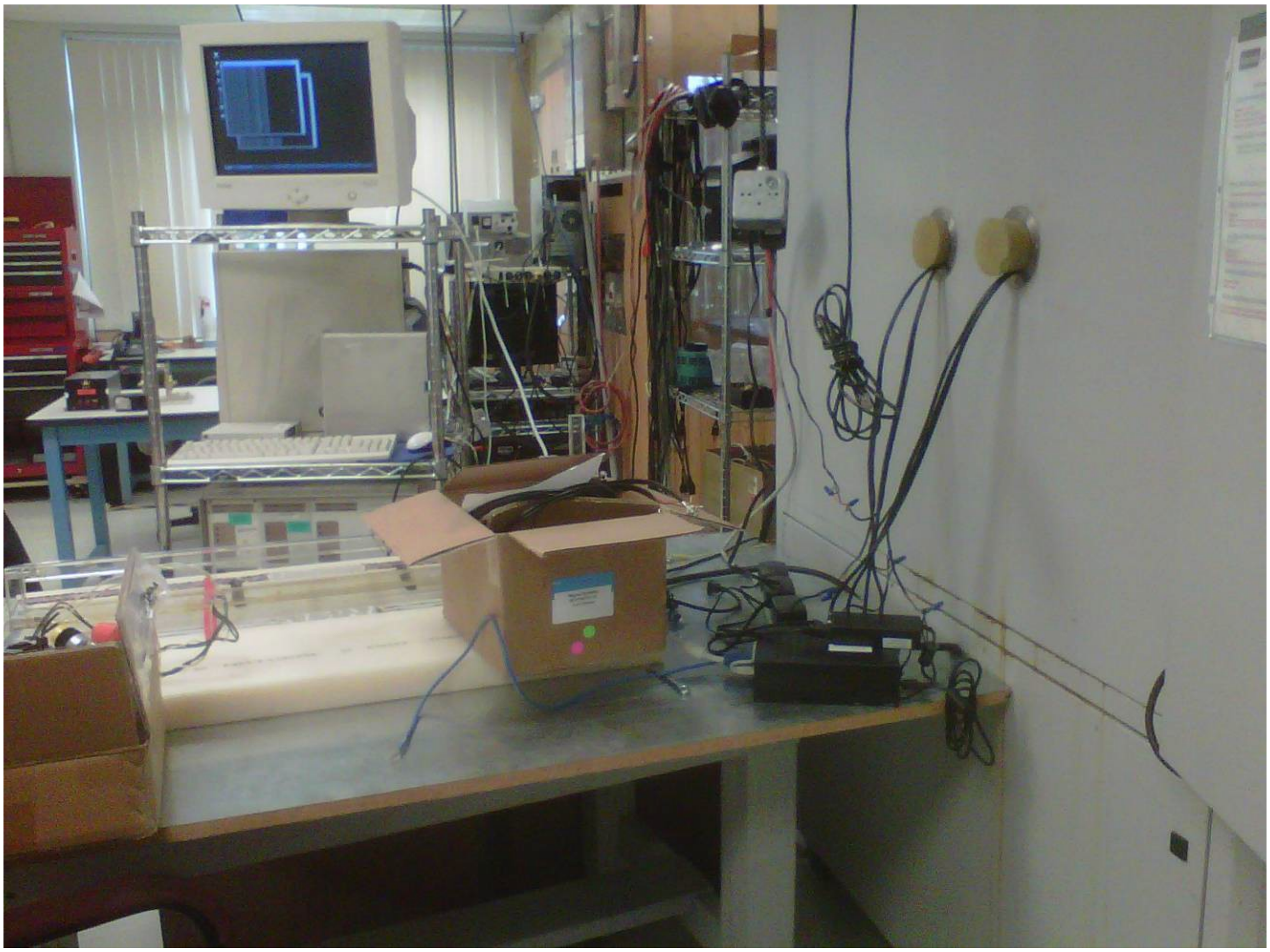
The above results pertain only to the specific item submitted for testing, identified by the product's model and serial numbers.

Configuration Photos

Comark
Migma Midblock

Standard: MIL-STD-810F
Test: 501.4 High Temperature
Photo: MidBlock Cameras in chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 501.4 High Temperature
Photo: Support Equipment
Test Engineer: Albert Noyes

METHOD 502.4. LOW-TEMPERATURE TEST[1]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

Test Report

Company	Migma Systems, Inc.
Address	1600 Providence Highway Walpole, MA 02081
Contact	Uma Venkataraman
Product Name	Midblock
Serial Number(s)	1 & 2
Project Number	G100146942
Test Performed	Method 502.4 Low Temperature
Standard	MIL-STD-810F
Test Engineer	Albert Noyes
Date Tested (Start, Stop)	July 19 through July 20, 2010
Test Room/Area	AMAP Lab
Photo	Yes
Test Level(s)	See Table 1.3-1
Deviation from Test Method	None
Product Modification	None
EUT Results	Pass
Posted Filename	G100146942BOX-002
Prepared by; Albert E. Noyes	
Reviewed by; Mike Koffink Operations Manager	
Report Date	July 31, 2010

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REVISION SUMMARY – The following changes have been made to this Report:

Date	Project No.	Project Handler	Pages(s)	***Description of Change***
7/31/10	G100146942	Albert Noyes	-	Initial Release

List of Tables and Figures

1. Executive Summary

1.1 Scope

This report describes Method 502.4 Low Temperature testing performed on July 19 through July 20, 2010 on the Migma Midblock Cameras submitted by Migma Systems, Inc.. Testing was performed pursuant to MIL-STD-810F, Method 502.4 Low Temperature.

Technical descriptions of the equipment under test, support equipment, test equipment, test procedures and results are presented in the following sections.

1.2 Purpose

MIL-STD-810F, Method 502.4 Low Temperature Test is for evaluating a products ability to operate properly in a Low temperature environment.

1.3 Conclusions

The Migma Midblock, P/N Migma Midblock was tested to the MIL-STD-810F, Method 502.4 Low Temperature performance requirements in it’s as received condition. See Table 1.3-1 for a summary of the test results.

Table 1.3-1: Summary of Test Requirements and Results

Environmental Conditions During Testing:		Ambient (□C):	Per 507.4	Method	Per 502.4	Pressure (hPa):	N/A
Pretest Verification Performed		Yes		Equipment under Test:		Migma Midblock	
Test Engineer(s):	Albert Noyes			EUT Serial Number(s):		1 & 2	
Engineer's Initials:		Date Test Performed:	7/19 – 7/20	Reviewer's Initials:		Date Reviewed:	

Requirements	Results
MIL-STD-810F Method 502.4 Low Temperature.	Pass

1.4 Performance Criteria

Pass/Fail Criteria: The EUT will continue to operate as intended during a prolonged exposure to a MIL-STD-810F, Method 502.4 Low Temperature.

2. Test Environment

2.1 EUT Description

The equipment under test (EUT) is: Migma Midblock

EUT Configuration

Description	Manufacturer	Part Number	Serial Number
Traffic Camera system	Migma Systems, Inc.	Migma Midblock	1 & 2

Power supply upgraded with military temperature grade FET.

2.1.1 Support Equipment:

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	Remote PC - single board	Migma Systems	MM0510	64496SB0211	N/A
	PC Power supply	FSP Group Inc	9NA0840302	H00000059	N/A
	Camera Power supplies	-	LD12125A	-	N/A

Cables:

Quantity	Description
1	PC Power Cord

2.2 Test Facility Description

The test facility is located on the premises of Intertek at 70 Codman Hill Road, Boxborough, MA, 01719. Testing is performed in one or more of the following chambers: A

(A) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(B) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(C) Environmental Chamber Tenney 3ft wide x 3ft high x 3ft deep
(D) Environmental Agree Chamber CSZ 53in wide x 37in high x 53in deep
(E) Thermal Shock Chamber, Cincinnati Sub-Zero 16cu ft

2.3 Test Equipment

Table 2.3-1: Test Equipment

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
148-012	Environmental Chamber	Envirotronics	SH27C	08015563-11264	8/27/10

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

2.4 Product Disposition

All items received for testing undergo an inspection to ensure proper working condition upon receipt and before return shipment. The Migma Midblock, P/N Migma Midblock passed the incoming inspection when received for testing July 19, through July 20, 2010. The Migma Midblock camera system was returned to Migma Systems, Inc. after completion of testing.

3. Test Descriptions and Results

3.1 METHOD 502.4 LOW TEMPERATURE

3.1.1 Object

The objective of this test is to determine the ability of an electronic device to properly operate during a prolonged exposure to a Method 502.4 Low Temperature environment.

3.1.2 Procedure

1. Sample was examined visually for any defects prior to the start of testing and a pre-test functional check was performed.
2. Sample is placed into an environmental chamber and connected to the support equipment. The sample is then put into an operational state.

   The environmental chamber is then programmed to run at -31˚C and the test is started. This test is setup to run this as follows.

4.5.3 Procedure II - Operation.

Step 1. With the test item in the test chamber, adjust the chamber air temperature to the low operating temperature of the test item as specified in the test plan. Maintain at least two hours following temperature stabilization of the test item.

Step 2. Conduct as complete a visual examination of the test item as chamber access limitations will allow.
Step 3. Document the results.
Step 4. Conduct an operational checkout of the test item as in paragraph 4.5.1.2, Step 6.
Step 5. Document the results.
Step 6. If manipulation of the test item is required at low temperature, proceed to Step 4 of paragraph 4.4.4. If not, proceed to step 7 of this procedure.
Step 7. Adjust the chamber air temperature to standard ambient and maintain until temperature stabilization of the test item has been achieved.
Step 8. Conduct a complete visual examination of the test item.
Step 9. Document the results.
Step 10. If appropriate, conduct an operational checkout and record results for comparison with data obtained in paragraph 4.5.1.2, Step 6.

3. Proper operation of the sample is monitored daily throughout the duration of the test. Any change in operation is noted and included in this report.
4. After Testing allow the sample is allowed to stabilize at room ambient temp for 24hours.
5. Upon completion of the test the sample will be returned to Migma Systems, Inc. for complete evaluation.

Testing of the EUT was performed in AMAP Lab (see Section 2.2 or Table 2.3-1).

3.1.3 Test Equipment

The following test equipment was used for this test: Refer to Table 2.3-1.

3.1.4 Climatic Conditions

The climatic conditions must comply with certain requirements during testing as called out in MIL- STD-810F. These conditions were monitored throughout testing.

3.1.5 Confidence of Results and Deviations from Test Method

Confidence of results is obtained by continuously monitoring the temperature and operational condition of the samples during testing.

3.1.6 Results

The Migma Midblock was tested to and passes the requirements for MIL-STD-810F. The specific test is, Method 502.4 Low Temperature. Table 1.3-1 for a summary of the test results

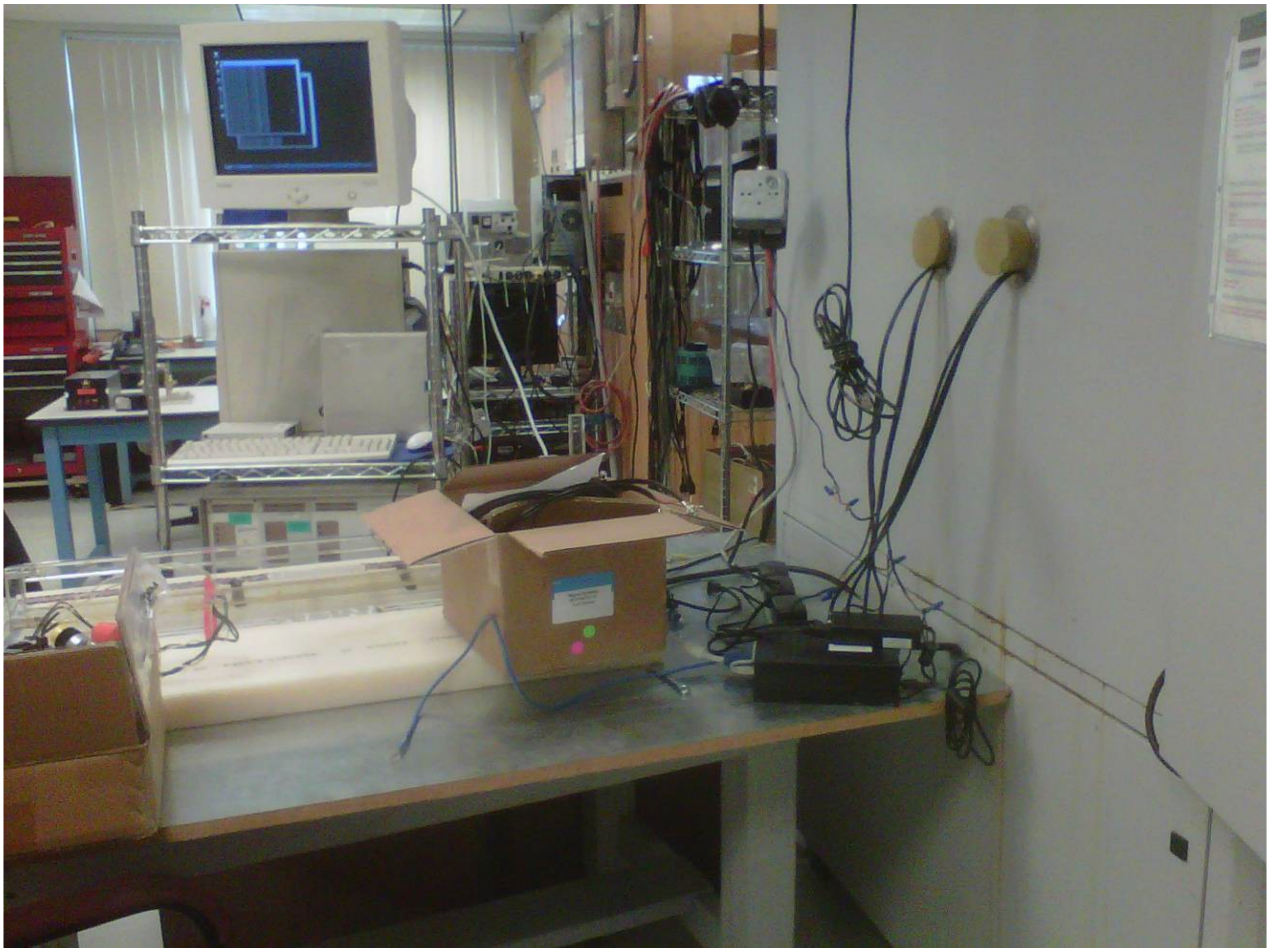
The above results pertain only to the specific item submitted for testing, identified by the product's model and serial numbers.

Configuration Photos

Comark
Migma Midblock

Standard: MIL-STD-810F
Test: 502.4 Low Temperature
Photo: MidBlock Cameras in chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 502.4 High Temperature
Photo: Support Equipment
Test Engineer: Albert Noyes

METHOD 507.4. HUMIDITY TEST[1]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

Test Report

Company	Migma Systems, Inc.
Address	1600 Providence Highway Walpole, MA 02081
Contact	Uma Venkataraman
Product Name	Midblock
Serial Number(s)	1 & 2
Project Number	G100146942
Test Performed	Method 507.4 Humidity
Standard	MIL-STD-810F
Test Engineer	Albert Noyes
Date Tested (Start, Stop)	July 21 through August 5, 2010
Test Room/Area	AMAP Lab
Photo	Yes
Test Level(s)	See Table 1.3-1
Deviation from Test Method	None
Product Modification	None
EUT Results	Pass
Posted Filename	G100146942BOX-003
Prepared by; Albert E. Noyes	
Reviewed by; Mike Koffink Operations Manager	
Report Date	August 31, 2010

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REVISION SUMMARY – The following changes have been made to this Report:

Date	Project No.	Project Handler	Pages(s)	***Description of Change***
8/31/10	G100146942	Albert Noyes	-	Initial Release

List of Tables and Figures

1. Executive Summary

1.1 Scope

This report describes Method 507.4 Humidity testing performed on July 21 through August 5, 2010 on the Migma Midblock Cameras submitted by Migma Systems, Inc.. Testing was performed pursuant to MIL-STD-810F, Method 507.4 Humidity.

Technical descriptions of the equipment under test, support equipment, test equipment, test procedures and results are presented in the following sections.

1.2 Purpose

MIL-STD-810F, Method 507.4 Humidity Test is for evaluating a products ability to operate properly in a high humidity environment.

1.3 Conclusions

The Migma Midblock, P/N Migma Midblock was tested to the MIL-STD-810F, Method 507.4 Humidity performance requirements in it's as received condition. See Table 1.3-1 for a summary of the test results.

Table 1.3-1: Summary of Test Requirements and Results

Environmental Conditions During Testing:		Ambient (°C):	Per 507.4	Method 507.4 Humidity (%):	Per 507.4	Pressure (hPa):	N/A
Pretest Verification Performed		Yes		Equipment under Test:		Migma Midblock	
Test Engineer(s):	Albert Noyes			EUT Serial Number(s):		1 & 2	
Engineer's Initials:		Date Test Performed:	7/21/10 – 8/5/10	Reviewer's Initials:		Date Reviewed:	

Requirements	Results
MIL-STD-810F METHOD 507.4 HUMIDITY INCLUDING 24HR PRECONDITIONING SOAK AND 5CYLES AS DEFINED IN FIGURE 507.4-1 OF MIL-STD-810F	Pass

1.4 Performance Criteria

Pass/Fail Criteria: The EUT will continue to operate as intended during a prolonged exposure to a MIL-STD-810F, Method 507.4 Humidity environment.

2. Test Environment

2.1 EUT Description

The equipment under test (EUT) is: Migma Midblock

EUT Configuration

Description	Manufacturer	Part Number	Serial Number
Traffic Camera system	Migma Systems, Inc.	Migma Midblock	1 & 2

Power supply upgraded with military temperature grade FET.

2.1.1 Support Equipment:

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	Remote PC - single board	Migma Systems	MM0510	64496SB0211	N/A
	PC Power supply	FSP Group Inc	9NA0840302	H00000059	N/A
	Camera Power supplies	-	LD12125A	-	N/A

Cables:

Quantity	Description
1	PC Power Cord

2.2 Test Facility Description

The test facility is located on the premises of Intertek at 70 Codman Hill Road, Boxborough, MA, 01719. Testing is performed in one or more of the following chambers: A

(A) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(B) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(C) Environmental Chamber Tenney 3ft wide x 3ft high x 3ft deep
(D) Environmental Agree Chamber CSZ 53in wide x 37in high x 53in deep
(E) Thermal Shock Chamber, Cincinnati Sub-Zero 16cu ft

2.3 Test Equipment

Table 2.3-1: Test Equipment

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
148-012	Environmental Chamber	Envirotronics	SH27C	08015563-11264	8/27/10

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

2.4 Product Disposition

All items received for testing undergo an inspection to ensure proper working condition upon receipt and before return shipment. The Migma Midblock, P/N Migma Midblock passed the incoming inspection when received for testing July 21 through August 5, 2010. The Migma Midblock camera system was returned to Migma Systems, Inc. after completion of testing.

3. Test Descriptions and Results

3.1 METHOD 507.4 HUMIDITY

3.1.1 Object

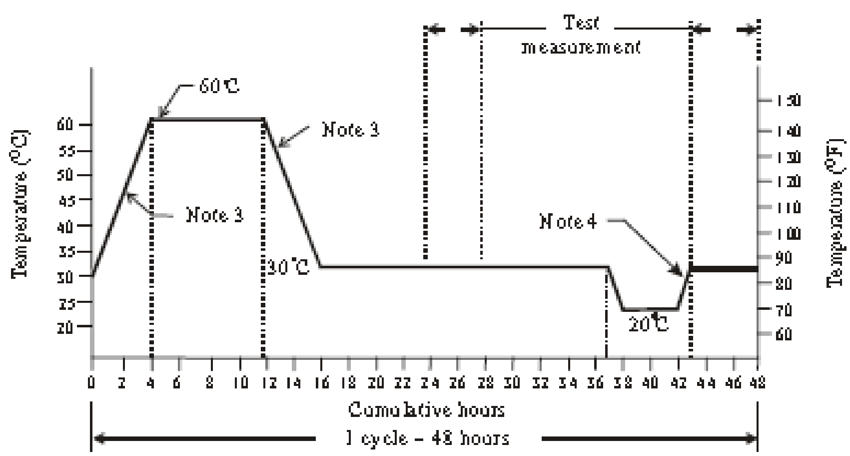
The objective of this test is to determine the ability of an electronic device to properly operate during a prolonged exposure to a Method 507.4 Humidity environment.

3.1.2 Procedure

1. Sample was examined visually for any defects prior to the start of testing and a pre-test functional check was performed.
2. Sample is placed into an environmental chamber and connected to the support equipment. The sample is then put into an operational state.
3. The environmental chamber is then programmed to run profile 5074 and the test started. Profile 5074 starts with a 24hr preconditioning soak of 23°C @ 50%RH after which the following cycle described below is followed. This 48hr cycle is repeated for a total of 5 complete cycles. Max temp is programmed to +40˚C for this product.

4.5.3 Procedure II - Operation.

Step 1. With the test item in the test chamber, adjust the chamber air temperature to the low operating temperature of the test item as specified in the test plan. Maintain at least two hours following temperature stabilization of the test item.



NOTES:

1. During temperature change, use a tolerance of not greater than 3°C (5°F).
2. Maintain the relative humidity at 95 ±4% at all times except that during the descending temperature periods the relative humidity may drop to as low as 85%.
3. Use a rate of temperature change between 30 and 60°C of not less than 8°C per hour.
4. Do not use a temperature increase in this portion of the curve that is less than 10°C per hour.

FIGURE 507.4-1. Aggravated temperature-humidity cycle.

4. Proper operation of the sample is monitored daily throughout the duration of the test. Any change in operation is noted and included in this report.
5. After Testing allow the sample is allowed to stabilize at room ambient temp for 24hours.
6. Upon completion of the test the sample will be returned to Migma Systems, Inc. for complete evaluation.

Testing of the EUT was performed in AMAP Lab (see Section 2.2 or Table 2.3-1).

3.1.3 Test Equipment

The following test equipment was used for this test: Refer to Table 2.3-1.

3.1.4 Climatic Conditions

The climatic conditions must comply with certain requirements during testing as called out in MIL- STD-810F. These conditions were monitored throughout testing.

3.1.5 Confidence of Results and Deviations from Test Method

Confidence of results is obtained by continuously monitoring the temperature and operational condition of the samples during testing.

3.1.6 Results

The Migma Midblock was tested to and passes the requirements for MIL-STD-810F. The specific test is, Method 507.4 Humidity. Table 1.3-1 for a summary of the test results

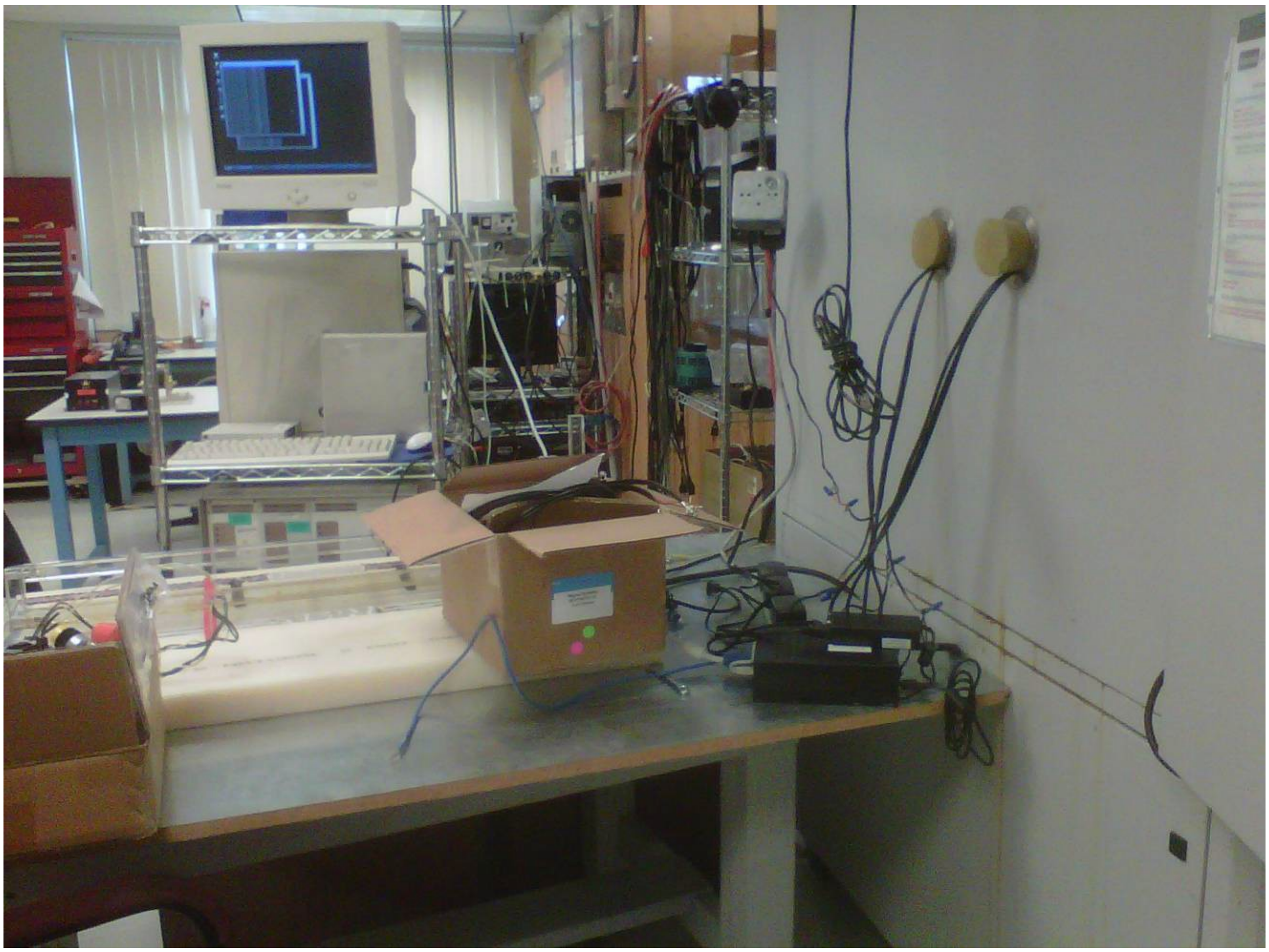
The above results pertain only to the specific item submitted for testing, identified by the product's model and serial numbers.

Configuration Photos

Comark
Migma Midblock

Standard: MIL-STD-810F
Test: 507.4 Humidity
Photo: MidBlock Cameras in chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 507.4 Humidity
Photo: Support Equipment
Test Engineer: Albert Noyes

METHOD 506.4. RAIN TEST[1]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

Test Report

Company	Migma Systems, Inc.
Address	1600 Providence Highway Walpole, MA 02081
Contact	Uma Venkataraman
Product Name	Midblock
Serial Number(s)	1 & 2
Project Number	G100146942
Test Performed	Method 506.4 Rain
Standard	MIL-STD-810F
Test Engineer	Albert Noyes
Date Tested (Start, Stop)	October 25, 2010
Test Room/Area	AMAP Lab
Photo	Yes
Test Level(s)	See Table 1.3-1
Deviation from Test Method	None
Product Modification	None
EUT Results	Pass
Posted Filename	G100146942BOX-004
Prepared by; Albert E. Noyes	
Reviewed by; Mike Koffink Operations Manager	
Report Date	August 31, 2010

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REVISION SUMMARY – The following changes have been made to this Report:

Date	Project No.	Project Handler	Pages(s)	***Description of Change***
10/29/10	G100146942	Albert Noyes	-	Initial Release

List of Tables and Figures

1. Executive Summary

1.1 Scope

This report describes Method 506.4 Rain testing performed on October 25, 2010 on the Migma Midblock Cameras submitted by Migma Systems, Inc. Testing was performed pursuant to MIL- STD-810F, Method 506.4 Rain.

Technical descriptions of the equipment under test, support equipment, test equipment, test procedures and results are presented in the following sections.

1.2 Purpose

MIL-STD-810F, Method 506.4 Rain Test is for evaluating a products ability to operate properly in an outdoor rain/wet environment.

1.3 Conclusions

The Migma Midblock was tested to the MIL-STD-810F, Method 506.4 Rain performance requirements in it’s as received condition. See Table 1.3-1 for a summary of the test results.

Table 1.3-1: Summary of Test Requirements and Results

<table>
<tr><td colspan="2">Environmental Conditions During Testing:</td><td>Ambient (°C):</td><td>Per 506.4</td><td>Method 506.4 Rain (%):</td><td>Per 506.4</td><td>Pressure (hPa):</td><td>N/A</td></tr>
<tr><td colspan="2">Pretest Verification Performed</td><td colspan="2">Yes</td><td colspan="2">Equipment under Test:</td><td colspan="2">Migma Midblock</td></tr>
<tr><td>Test Engineer(s):</td><td colspan="3">Albert Noyes</td><td colspan="2">EUT Serial Number(s):</td><td colspan="2">1 & 2</td></tr>
<tr><td>Engineer’s Initials:</td><td></td><td>Date Test Performed:</td><td>10/25/10</td><td>Reviewer’s Initials:</td><td></td><td>Date Reviewed:</td><td></td></tr>
</table>

Requirements	Results
MIL-STD-810F METHOD 506.4 RAIN, PROCEDURE III DRIP	Pass

1.4 Performance Criteria

Pass/Fail Criteria: The EUT will continue to operate as intended during a prolonged exposure to a MIL-STD-810F, Method 506.4 Rain environment.

2. Test Environment

2.1 EUT Description

The equipment under test (EUT) is: Migma Midblock

EUT Configuratio n

Description	Manufacturer	Part Number	Serial Number
Traffic Camera system	Migma Systems, Inc.	Migma Midblock	1 & 2

Power supply upgraded with military temperature grade FET.

2.1.1 Support Equipment:

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	Remote PC - single board	Migma Systems	MM0510	64496SB0211	N/A
	PC Power supply	FSP Group Inc	9NA0840302	H00000059	N/A
	Camera Power supplies	-	LD12125A	-	N/A

Cables:

Quantity	Description
1	PC Power Cord

2.2 Test Facility Description

The test facility is located on the premises of Intertek at 70 Codman Hill Road, Boxborough, MA, 01719. Testing is performed in one or more of the following chambers: A

(A) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(B) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(C) Environmental Chamber Tenney 3ft wide x 3ft high x 3ft deep
(D) Environmental Agree Chamber CSZ 53in wide x 37in high x 53in deep
(E) Thermal Shock Chamber, Cincinnati Sub-Zero 16cu ft
(F) Rain/SPX tester, Intertek

2.3 Test Equipment

Table 2.3-1: Test Equipment

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	SPX/RAIN tester	Intertek	SPX	-	11/13/10
SAF186	Clock/Timer	Fisher Scientific	870A	20398073	8/11/11
SAF262	Flow Valve	ED&D	-	5011510	11/13/10

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

2.4 Product Disposition

All items received for testing undergo an inspection to ensure proper working condition upon receipt and before return shipment. The Migma Midblock, P/N Migma Midblock passed the incoming inspection when received for testing October 25, 2010. The Migma Midblock camera system was returned to Migma Systems, Inc. after completion of testing.

3. Test Descriptions and Results

3.1 METHOD 506.4 RAIN

3.1.1 Object

The objective of this test is to determine the ability of an electronic device to properly operate during a prolonged exposure to a Method 506.4 Rain environment.

3.1.2 Procedure

1. Sample was examined visually for any defects prior to the start of testing and a pre-test functional check was performed.
2. Sample is placed into the rain chamber and connected to the support equipment. The sample is then put into an operational state.
3. The rain chamber is then set to run drip test at a flow rate of 1.7mm/minute with the samples at a distance of 48cm from the drip head and then the test is started. This flow rate is maintained for a period of 15 minutes while continually monitoring the samples for any change in operating condition.
4. Any change in operation is noted and included in this report.
5. After Testing allow the sample is allowed to stabilize at room ambient temp for 24hours.
6. Upon completion of the test the sample will be returned to Migma Systems, Inc. for complete evaluation.

Testing of the EUT was performed in Safety Lab (see Section 2.2 or Table 2.3-1).

3.1.3 Test Equipment

The following test equipment was used for this test: Refer to Table 2.3-1.

3.1.4 Climatic Conditions

The climatic conditions must comply with certain requirements during testing as called out in MIL- STD-810F. These conditions were monitored throughout testing.

3.1.5 Confidence of Results and Deviations from Test Method

Confidence of results is obtained by continuously monitoring the temperature and operational condition of the samples during testing.

3.1.6 Results

The Migma Midblock was tested to and passes the requirements for MIL-STD-810F. The specific test is, Method 506.4 Rain. Table 1.3-1 for a summary of the test results

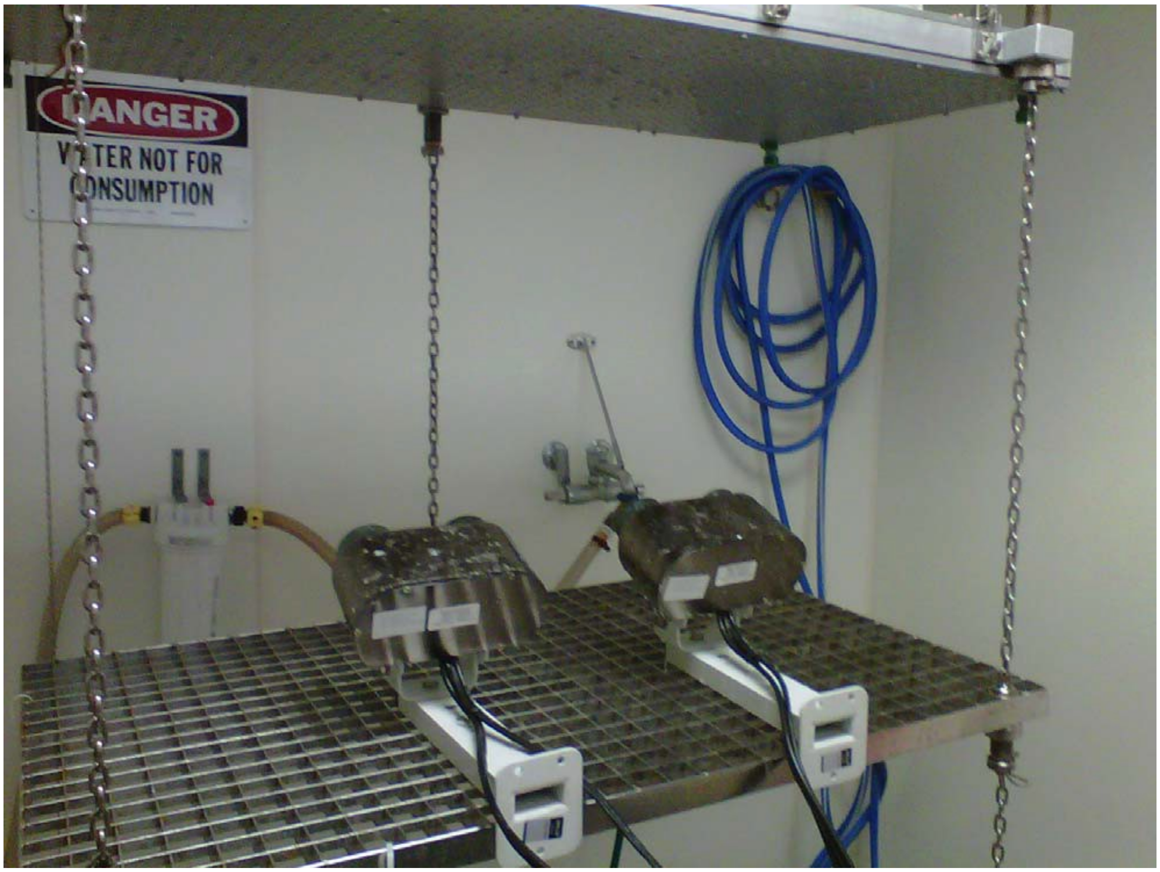
The above results pertain only to the specific item submitted for testing, identified by the product's model and serial numbers.

Configuration Photos

Comark
Migma Midblock

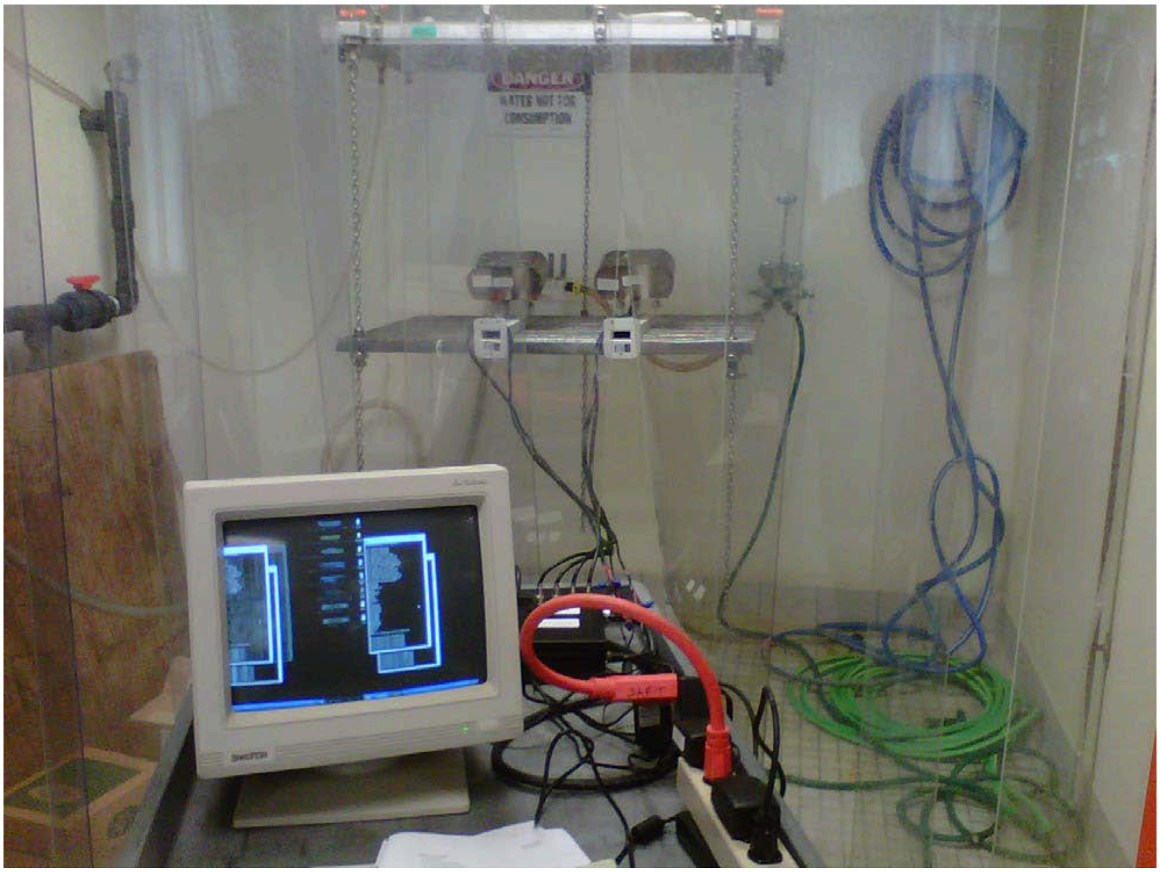
Standard: MIL-STD-810F
Test: 506.4 Rain
Photo: MidBlock Cameras in Rain/SPX chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 506.4 Rain
Photo: MidBlock Cameras in Rain/SPX chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 506.4 Rain
Photo: Support Equipment
Test Engineer: Albert Noyes

METHOD 521.2. ICING TEST[1]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

Test Report

Company	Migma Systems, Inc.
Address	1600 Providence Highway Walpole, MA 02081
Contact	Uma Venkataraman
Product Name	Midblock
Serial Number(s)	1 & 2
Project Number	G100146942
Test Performed	Method 521.2 Icing
Standard	MIL-STD-810F
Test Engineer	Albert Noyes
Date Tested (Start, Stop)	August 25 through August 26, 2010
Test Room/Area	AMAP Lab
Photo	Yes
Test Level(s)	See Table 1.3-1
Deviation from Test Method	None
Product Modification	None
EUT Results	Pass
Posted Filename	G100146942BOX-005
Prepared by; Albert E. Noyes	
Reviewed by; Mike Koffink Operations Manager	
Report Date	August 31, 2010

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REVISION SUMMARY – The following changes have been made to this Report:

Date	Project No.	Project Handler	Pages(s)	***Description of Change***
8/31/10	G100146942	Albert Noyes	-	Initial Release

List of Tables and Figures

1. Executive Summary

1.1 Scope

This report describes Method 521.2 Icing testing performed on August 25 through August 26, 2010 on the Migma Midblock Cameras submitted by Migma Systems, Inc.. Testing was performed pursuant to MIL-STD-810F, Method 521.2 Icing.

Technical descriptions of the equipment under test, support equipment, test equipment, test procedures and results are presented in the following sections.

1.2 Purpose

MIL-STD-810F, Method 521.2 Icing Test is for evaluating a products ability to operate properly in an icing environment.

1.3 Conclusions

The Migma Midblock, P/N Migma Midblock was tested to the MIL-STD-810F, Method 521.2 Icing performance requirements in it’s as received condition. See Table 1.3-1 for a summary of the test results.

Table 1.3-1: Summary of Test Requirements and Results

<table>
<tr><td colspan="2">Environmental Conditions During Testing:</td><td>Ambient (□C):</td><td>Per 507.4</td><td>Method</td><td>Per 521.2</td><td>Pressure (hPa):</td><td>N/A</td></tr>
<tr><td colspan="2">Pretest Verification Performed</td><td colspan="2">Yes</td><td colspan="2">Equipment under Test:</td><td colspan="2">Migma Midblock</td></tr>
<tr><td>Test Engineer(s):</td><td colspan="3">Albert Noyes</td><td colspan="2">EUT Serial Number(s):</td><td colspan="2">1 & 2</td></tr>
<tr><td>Engineer’s Initials:</td><td></td><td>Date Test Performed:</td><td>8/25/10 – 8/26/10</td><td>Reviewer’s Initials:</td><td></td><td>Date Reviewed:</td><td></td></tr>
</table>

Requirements	Results
MIL-STD-810F Method 521.2 AS DEFINED IN PROCEDURE 1 “GLAZE ICE” .	Pass. Occasional loss of signal was detected during application of spray. The unit did self recover quickly.

1.4 Performance Criteria

Pass/Fail Criteria: The EUT will continue to operate as intended allowing for temporary disturbances with self recovery during a prolonged exposure to a MIL-STD-810F, Method 521.2 Icing environment.

2. Test Environment

2.1 EUT Description

The equipment under test (EUT) is: Migma Midblock

EUT Configuration

Description	Manufacturer	Part Number	Serial Number
Traffic Camera system	Migma Systems, Inc.	Migma Midblock	1 & 2

Power supply upgraded with military temperature grade FET.

2.1.1 Support Equipment:

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
-	Remote PC - single board	Migma Systems	MM0510	64496SB0211	N/A
	PC Power supply	FSP Group Inc	9NA0840302	H00000059	N/A
	Camera Power supplies	-	LD12125A	-	N/A

Cables:

Quantity	Description
1	PC Power Cord

2.2 Test Facility Description

The test facility is located on the premises of Intertek at 70 Codman Hill Road, Boxborough, MA, 01719. Testing is performed in one or more of the following chambers: A

(A) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(B) Environmental Chamber Envirotronics 3ft wide x 3ft high x 3ft deep
(C) Environmental Chamber Tenney 3ft wide x 3ft high x 3ft deep
(D) Environmental Agree Chamber CSZ 53in wide x 37in high x 53in deep
(E) Thermal Shock Chamber, Cincinnati Sub-Zero 16cu ft

2.3 Test Equipment

Table 2.3-1: Test Equipment

Asset Number	Equipment Description	Manufacturer	Model Number	Serial Number	Calibration Due Date
148-012	Environmental Chamber	Envirotronics	SH27C	08015563-11264	8/27/10

All equipment used for testing has been calibrated according to methods and procedures defined by the National Institute of Standards and Technology (NIST).

2.4 Product Disposition

All items received for testing undergo an inspection to ensure proper working condition upon receipt and before return shipment. The Migma Midblock, P/N Migma Midblock passed the incoming inspection when received for testing July 21 through August 5, 2010. The Migma Midblock camera system was returned to Migma Systems, Inc. after completion of testing.

3. Test Descriptions and Results

3.1 METHOD 521.2 ICING

3.1.1 Object

The objective of this test is to determine the ability of an electronic device to properly operate during a prolonged exposure to a Method 521.2 Icing environment.

3.1.2 Procedure

1. Sample was examined visually for any defects prior to the start of testing and a pre-test functional check was performed.
2. Sample is placed into an environmental chamber and connected to the support equipment. The sample is then put into an operational state.
3. The environmental chamber is then programmed to run 0˚C and the test is started. The sequence followed is according to Procedure 1 below from method 521.2.

4.5.1.2 Pretest standard ambient checkout.

All items require a pretest standard ambient checkout to provide baseline data. Conduct the checkout as follows:

Step 1. Install temperature sensors in, on, or around the test item as described in the test plan.

Step 2. Install the test item in the chamber (Part One, paragraph 5.8.1) in the required configuration and orientation, and at standard ambient conditions (Part One, paragraph 5.1).

Step 3. Conduct a visual examination of the test item with special attention to stress areas such as corners of molded cases, and document the results.

Step 4. Conduct an operational checkout (Part One, paragraph 5.8.2) as described in the plan to obtain baseline data, and record the results.

Step 5. If the test item operates satisfactorily, proceed to paragraph 4.5.2. If not, resolve the problems and repeat Step 4 above.

4.5.2 Procedure I - Glaze ice.

Step 1. Stabilize the test item temperature at 0°C (-0/+2°C).

Step 2. Deliver a uniform, precooled water spray for 1 hour to allow water penetration into the test item crevices/openings (although a water temperature of 0 - 3°C is ideal, a water temperature of 5°C and a water delivery rate of 25 mm/h has proven satisfactory).

Step 3. Adjust the chamber air temperature to -10°C or as specified and maintain the waterspray rate until the required thickness of ice has accumulated on the appropriate surfaces. Wind or a side spray may be used to assist accumulation of ice on the sides of the test item.

NOTE: If it is difficult to produce a satisfactory layer of glaze ice, vary one or more of the parameters as necessary, i.e., water or test item temperature, spray rate, distance between the nozzles and the test item, etc.

NOTE: It may be easier to stop spraying during the temperature reduction to facilitate temperature adjustment and to minimize frosting of test chamber refrigeration coils.

Step 4. Maintain the chamber air temperature for a minimum of 4 hours to allow the ice to harden. Examine for safety hazards and, if appropriate, attempt to operate the test item. Document the results (with photographs if necessary).

Step 5. If step 4 has resulted in failure or if the specification allows ice removal, remove the ice. Limit the method of ice removal to that determined in 3.1b, e.g., built-in ice removal systems, plus expedient means which could be expected to be employed in the field. Note the effectiveness of ice removal techniques used.

Step 6. Examine for safety hazards and, if appropriate (and possible), attempt to operate the test item at the specified low operating temperature of the materiel.

Step 7. If required, repeat steps 3 through 6 to produce other required thicknesses of ice.

Step 8. Stabilize the test item at standard ambient conditions and perform a post-test operational check.

4. Proper operation of the sample is monitored throughout the duration of the test. Any change in operation is noted and included in this report.
5. After Testing allow the sample is allowed to stabilize at room ambient temp for 24hours.
6. Upon completion of the test the sample will be returned to Migma Systems, Inc. for complete evaluation.

Testing of the EUT was performed in AMAP Lab (see Section 2.2 or Table 2.3-1).

3.1.3 Test Equipment

The following test equipment was used for this test: Refer to Table 2.3-1.

3.1.4 Climatic Conditions

The climatic conditions must comply with certain requirements during testing as called out in MIL- STD-810F. These conditions were monitored throughout testing.

3.1.5 Confidence of Results and Deviations from Test Method

Confidence of results is obtained by continuously monitoring the temperature and operational condition of the samples during testing.

3.1.6 Results

The Migma Midblock was tested to and passes the requirements for MIL-STD-810F. The specific test is, Method 507.4 Humidity. Table 1.3-1 for a summary of the test results

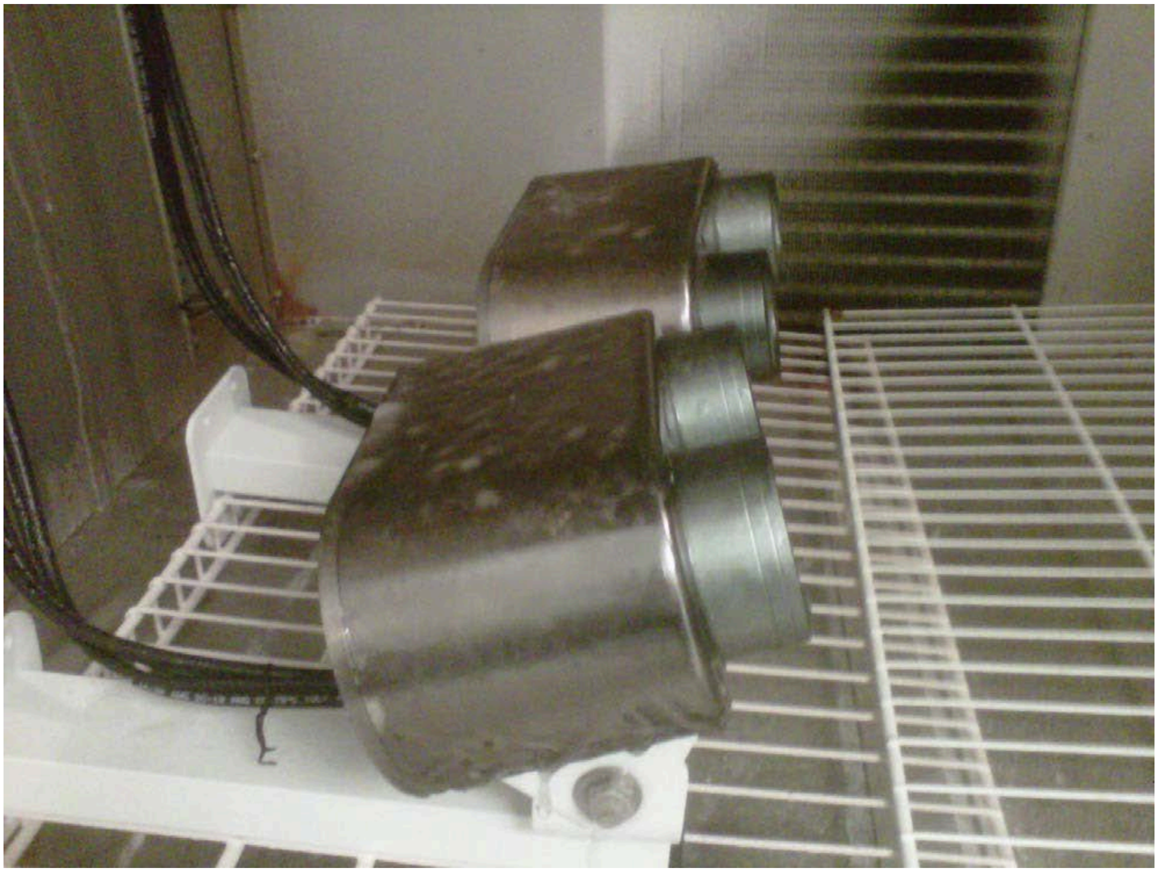
The above results pertain only to the specific item submitted for testing, identified by the product's model and serial numbers.

Configuration Photos

Comark
Migma Midblock

Standard: MIL-STD-810F
Test: 521.2 Icing
Photo: MidBlock Cameras in chamber
Test Engineer: Albert Noyes

Comark
Migma Midblock



Standard: MIL-STD-810F
Test: 521.2 Icing
Photo: Cameras in Chamber
Test Engineer: Albert Noyes

METHOD 514.5. VIBRATION TEST[1]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

13200 Levan Road
Livonia, MI 48150

Telephone: 734-591-9161
Facsimile: 734-432-0555
www.intertek.com

Test Report for:

MIGMA SYSTEMS, INC.
Attn: Ms. Tia Maria Silva

VIBRATION TEST
Two (2) Migma Mid-Block Cameras

Client PO No.: 105

Don Hartwick Project Manager
Project Manager

Michael Wells
Department Manager

October 27, 2010
Report No.: G100146942DET-006

Attn: Ms. Tia Maria Silva
Migma Systems
1600 Providence Hwy
Walpole, MA 02081
Phone: (508) 660-0328
Fax: (508) 660-0288
Email Address: tsilva@migmasys.com

DATE RECEIVED: 10/22/2010
DATES TESTED: 10/23/2010 through 10/26/2010

WORK REQUESTED / APPLICABLE DOCUMENTS:

Per the client's request and in accordance with MIL-STD-810F issued 2001/11/01 along with our quotation number 500235542 dated 05/26/2010; perform Vibration Test.

DESCRIPTION OF TEST SAMPLES:

Two (2) Migma Mid-Block Cameras, sample numbers DET1010221054-001 and

DET1010221054-002. Condition of Samples: Production

EQUIPMENT LIST:

Asset	Descr	Manufacturer	M	Ser
161130	VIBRATION CONTROLLER	VIBRATION	8500	0e0634
161130.	COMPUTER	HP	COMPAQ dc 5000	MXL4490JVV
161236	ACCELEROMETER	PCB	J353B15	96157
161233	ACCELEROMETER	PCB	J353B15	87860
160063	SHAKER, 4000 FORCE	UNHOLTZ-DICKIE	TC 208	427
160064	POWER AMPLIFIER	UNHOLTZ-DICKIE	TA115	none

VIBRATION TEST

Date Received: 10/22/2010
Date(s) Tested: 10/23/2010 through 10/26/2010

Description of Samples:
Two (2) Migma Mid-Block Cameras, sample numbers DET1010221054-001 and DET1010221054-002.

Test Procedure:
The test samples were secured to a vibration shaker utilizing attached mounting brackets. The test samples were subjected to a random vibration for one (1) hour from 20 to 2000G's in each of the three mutually perpendicular axes in accordance with Figure 514.5C-17 of the specification and as described below:

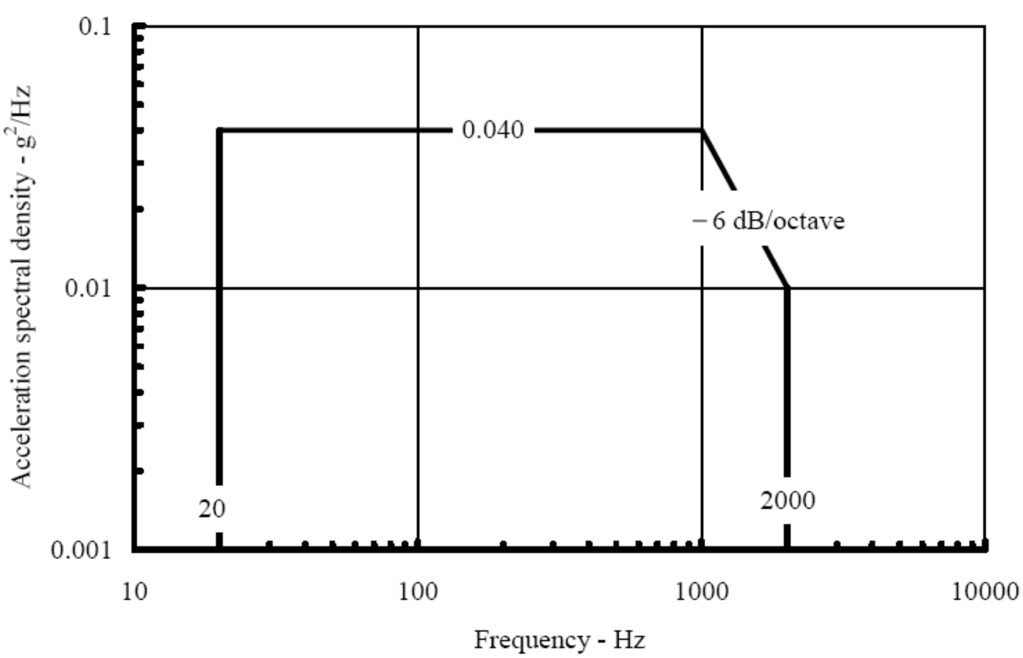


FIGURE 514.5C-17. General minimum integrity exposure.

20 to 1000 Hz.	0.040 g^2/Hz.
1000 to 2000 Hz.	-6 d/B/octave

During testing the test samples were powered to verify operation.

VIBRATION TEST (cont'd)

Acceptance Criteria: None stated.

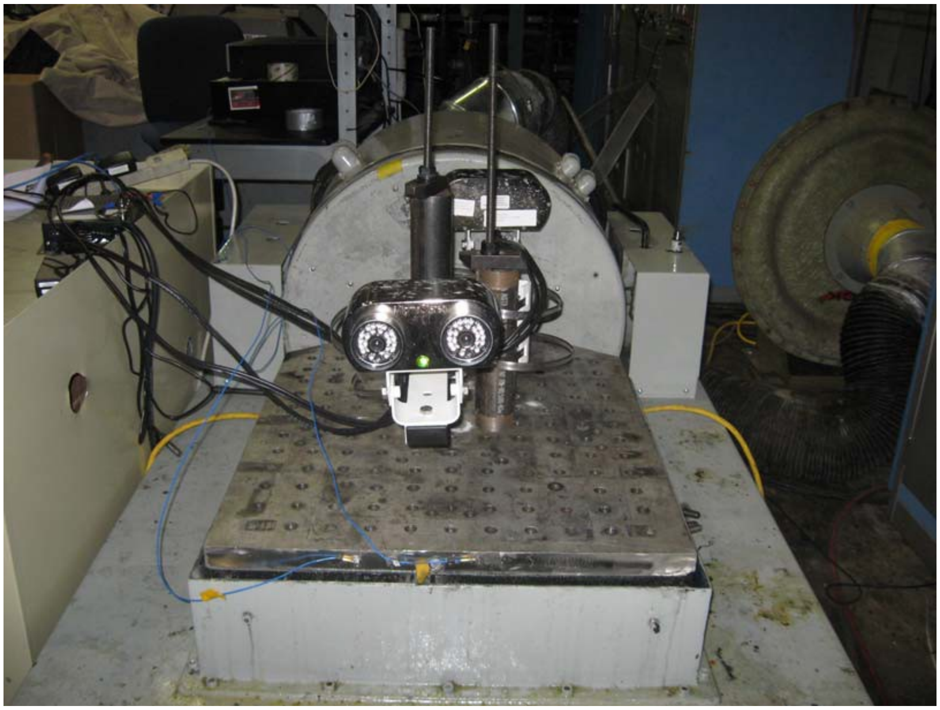
Results:
At the completion of testing the test samples showed no signs of visible damage and were operational. The test samples were returned to the Boston facility for additional testing and final evaluation.

Observation:
At the completion of the Vertical Axis, a lens on sample number DET1010221054-001 was noted to be loose.

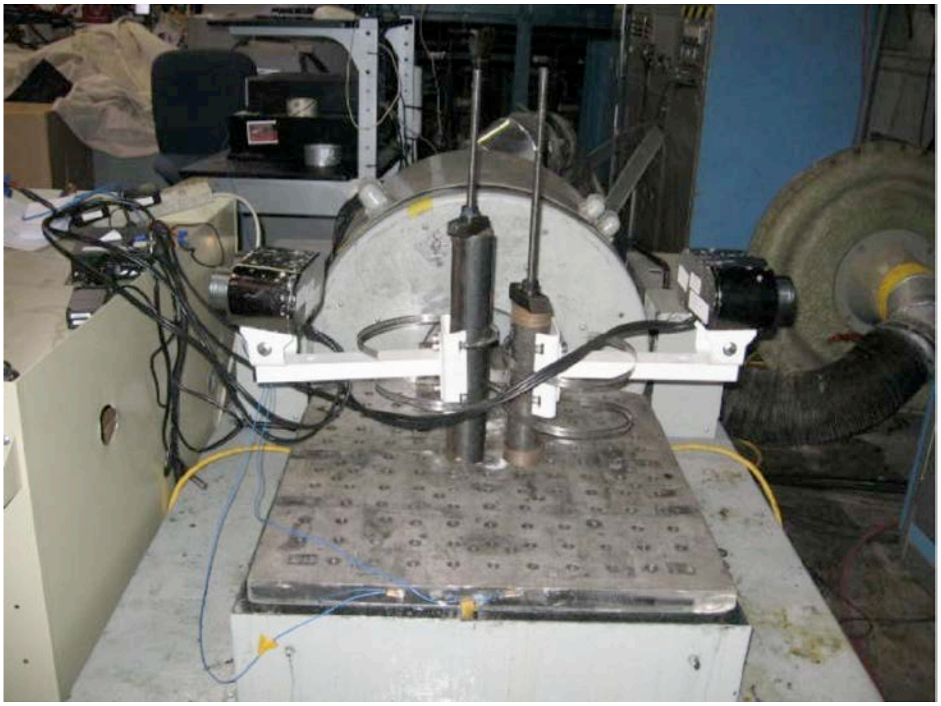
Appendix:
Appendix A – Photographs
Appendix B – Vibration Plots

Disposition of Test Samples:
At the completion of testing, the samples were returned to the client.

APPENDIX A – PHOTOGRAPHS



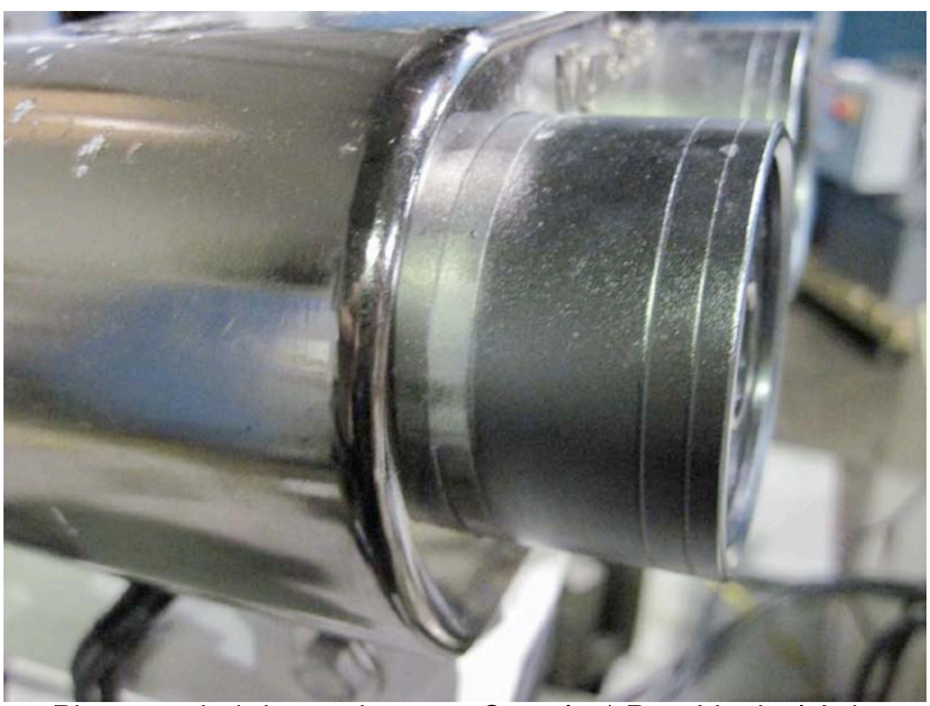
Photograph 1: Test Set Up Fore-Aft Direction



Photograph 2: Test Set Up Lateral Direction

APPENDIX A – PHOTOGRAPHS (cont'd)

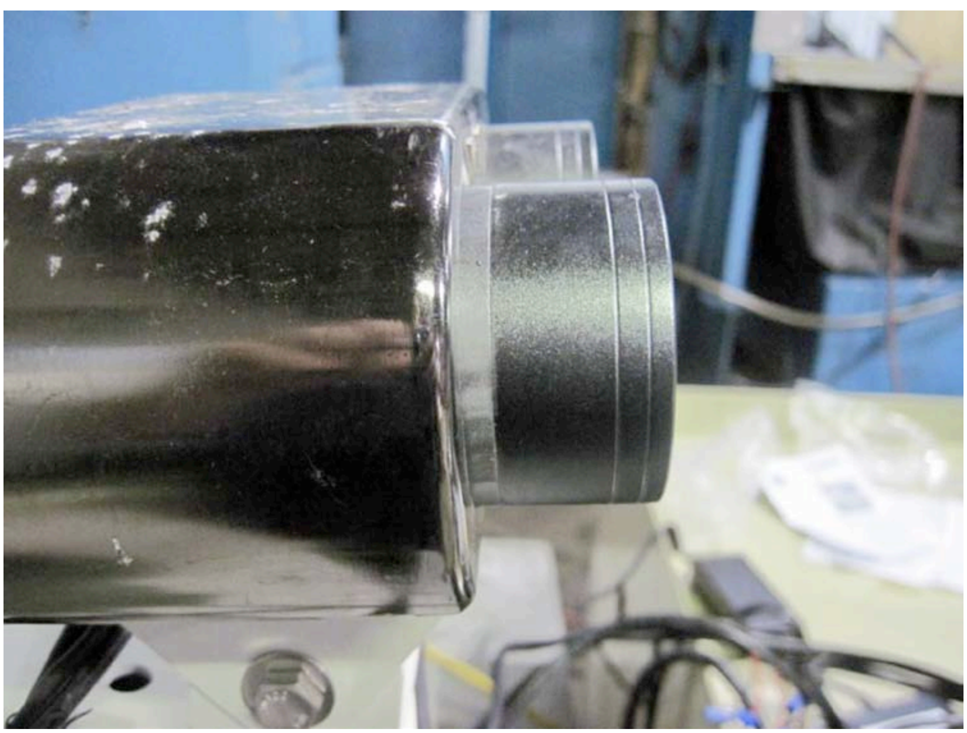
Photograph 3: Test Set Up Vertical Direction



Photograph 4: Loose Lens on Sample 1 Post Vertical Axis

APPENDIX A – PHOTOGRAPHS (cont'd)


Photograph 5: Loose Lens on Sample 1 Post Vertical Axis


Photograph 4: Loose Lens on Sample 1 Post Vertical Axis

APPENDIX B – VIBRATION PLOTS

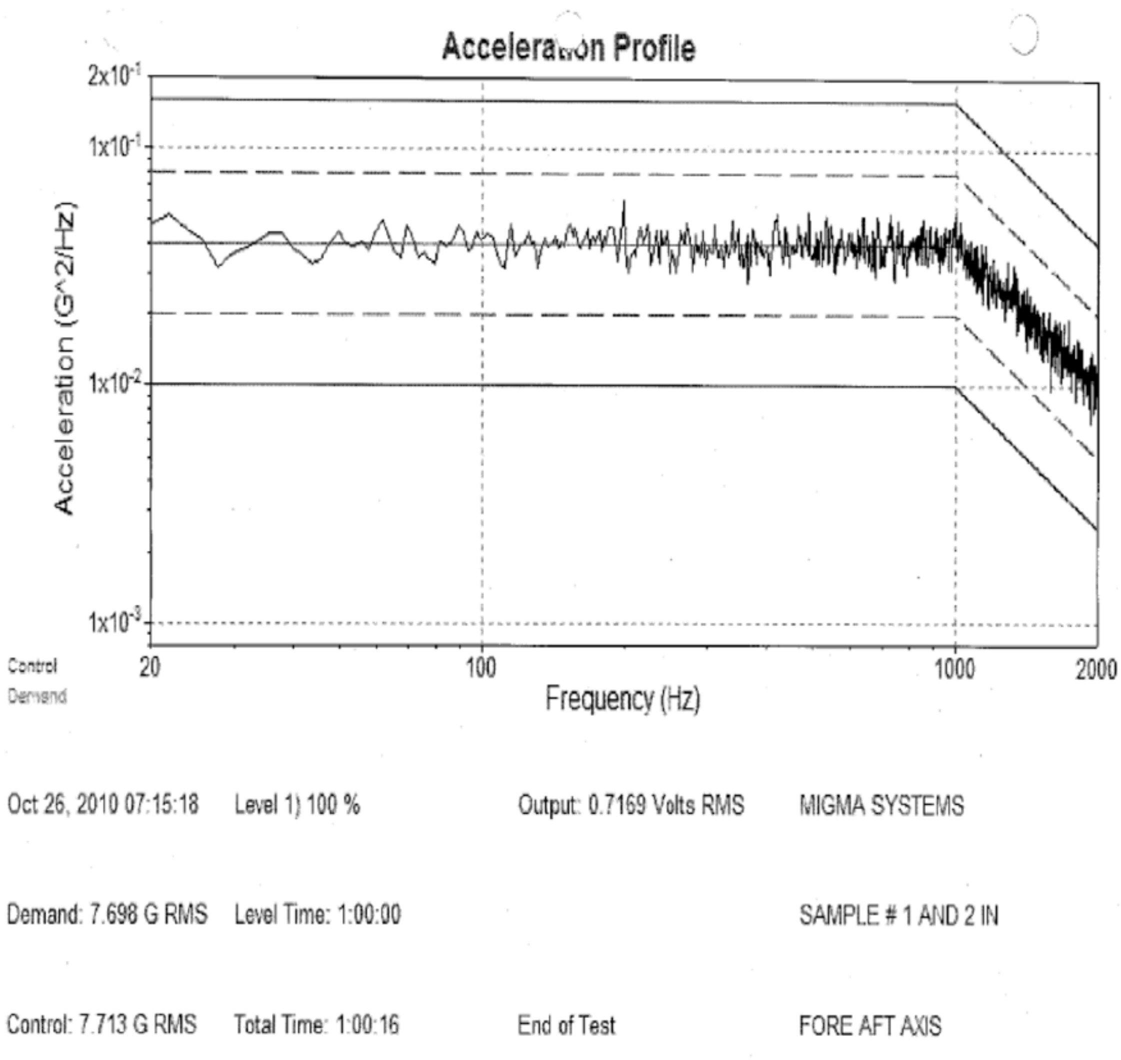


Figure 1: Vibration Plot, Fore- Axis Direction

APPENDIX B – VIBRATION PLOTS (cont'd)

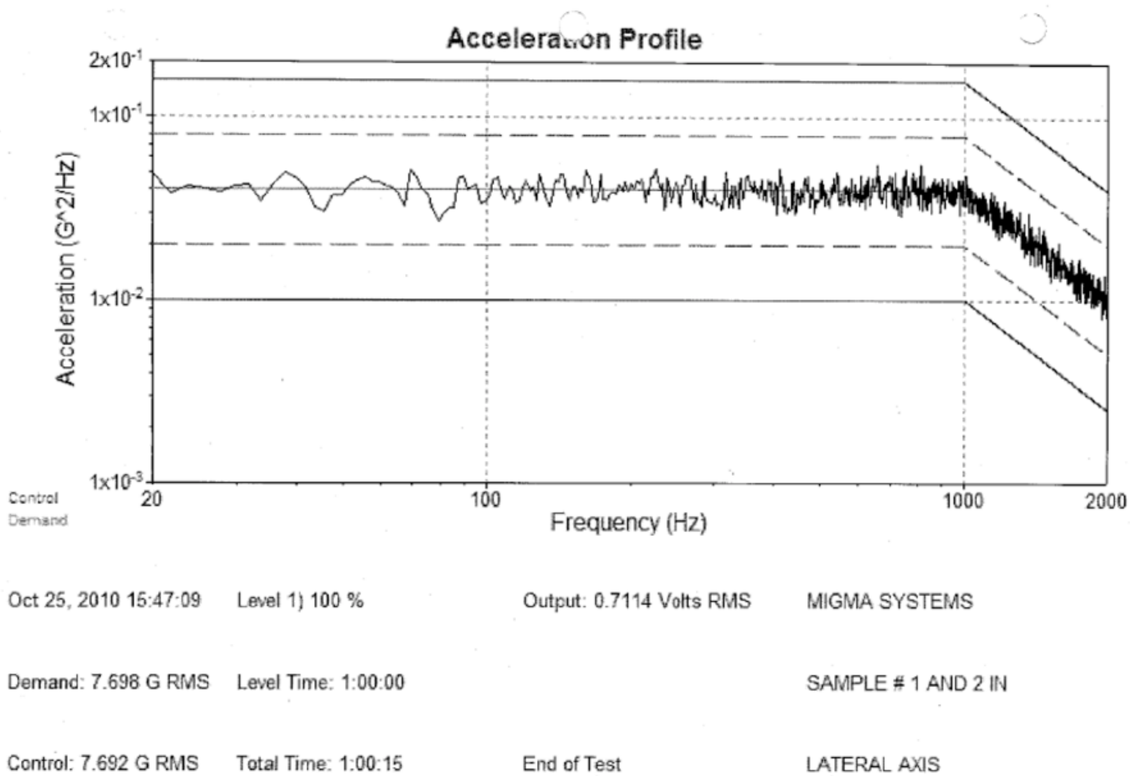
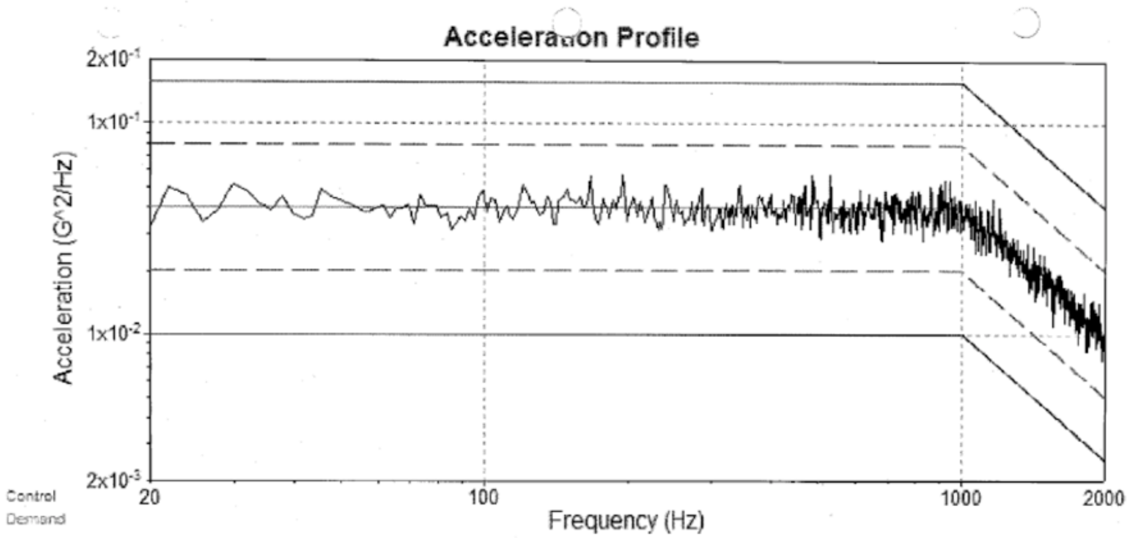


Figure 2: Vibration Plot, Lateral Direction

APPENDIX B – VIBRATION PLOTS (cont'd)



Oct 23, 2010 07:55:56	Level 1) 100 %	Output: 0.6179 Volts RMS	MIGMA SYSTEMS
Demand: 7.698 G RMS	Level Time: 1:00:00		SAMPLE # 1 AND 2 IN
Control: 7.658 G RMS	Total Time: 1:00:16	End of Test	VERTICAL AXIS

Figure 3: Vibration Plot, Vertical Direction

TERMS AND CONDITIONS

1.0 INTRODUCTION

These Terms and Conditions are incorporated into the Intertek proposal made and submitted to you. The party executing this document ("Client") indicates acceptance of this proposal and that it is agreed that a resulting contract exists between Client and Intertek which governs the performance of the stated services and the rights and obligations of the parties and that Intertek may proceed with the work.

2.0 PROPOSAL TERM

Unless otherwise stated in the proposal, this offer shall remain valid until accepted, but in no event for a period longer than thirty days from the date of the proposal.

3.0 CLIENT INFORMATION

Client represents that the information supplied by it or its agents to Intertek is accurate and complete and samples are representative, and Client has informed Intertek concerning any dangerous or potentially dangerous characteristics of such samples which could cause injury during the performance of the work or in the transporting of such samples and Client also acknowledges that Intertek is relying upon such information and samples or data in the preparation of this proposal without further verification by Intertek as to its accuracy or completeness. The Client agrees to hold Intertek harmless and indemnify Intertek from any liability of whatever kind or nature, including but not limited to court costs and reasonable attorneys fees if information provided by the Client is inaccurate or incomplete or samples are not representative. Intertek agrees that information received from the Client shall remain the property of the Client and will be returned to the Client upon demand, except for that which is necessary as a basis for the Intertek Reports. Client may designate in writing any information provided by Client to Intertek as confidential and proprietary. If Client has done so, Intertek will not release to third parties any such information without the prior written consent of the Client or only in response to a proper court order or process. As to that information, Intertek may make and retain copies. Client shall designate in writing to Intertek if it does not wish to have Intertek transmit any information, including test data and Reports, via fax or electronic means.

4.0 PROPOSAL, PRICE AND SCHEDULE

Intertek will work diligently to provide the services according to the costs and schedule stated in the referenced proposal. Client recognizes and agrees that the proposal is a good faith estimate of the costs for the services to be provided and times of completion, but such estimate is not a guarantee of the total costs or time that may be involved in completing the proposal. Intertek will not exceed the authorized estimate of costs without written authorization of Client. Samples will be shipped by Client to Intertek prepaid and will be returned collect or disposed of at Client's expense within thirty (30) days after testing is completed, unless alternative arrangements are made by Client. Additional fees will be charged for unanticipated assembly or preparation of samples. Test services will not be initiated until satisfactory credit has been established with Intertek's accounting department.

5.0 INVOICING

Invoices will generally be issued upon project completion. In certain instances, interim invoices may be issued. Invoices are due and payable to Intertek at its offices, within thirty (30) calendar days after receipt of invoice, and client agrees to pay reasonable collection costs if necessary in the event of non-payment.

6.0 INSURANCE

Intertek declares that it maintains workers' compensation and employer's liability insurance on Intertek employees in a form and amount as required by applicable laws. This insurance does not cover any employees of Client or third parties who may be involved with the work to be performed, whether on property of Intertek, Client or third parties.

7.0 REPORTS

The Client agrees to waive any claim against Intertek and defend, indemnify, and hold Intertek harmless from any and all causes of action, lawsuit, proceedings or claims, including legal fees and expenses incurred by Intertek, allegedly arising as a result of unauthorized use of Intertek's Reports. The Reports include all reports, laboratory test data, calculations, estimates, notes and other documents prepared by Intertek in the course of providing services to the Client. Reports will be made utilizing Intertek's standard format unless otherwise agreed to in writing. The Client agrees to indemnify Intertek for any breach by the Client arising out of clause 3.0 (Client Information) above requiring accurate and complete information and representative samples. Intertek retains any and all rights of ownership of Intertek's concepts, ideas, inventions, patents or copyrights used by Intertek in preparing Intertek's Reports and the provision of services to the Client. Only the client is authorized to copy or distribute this report and then only in its entirety, and the Client shall not use the Reports in a misleading manner. Client further agrees and understands that reliance upon the Reports is limited to the representations made therein. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. If Intertek becomes directly or indirectly involved in litigation as a result of misuse of its Reports, the Client agrees to compensate Intertek for its fees and expenses, including legal costs, in accordance with Intertek's prevailing fee schedule and expense reimbursement policy.

8.0 LIMITED WARRANTY

Intertek warrants that if any of its completed services fail to conform to professional standard, Intertek will, at its own expense, perform corrective services of the type originally performed as may be reasonably required to correct such defects, of which Intertek is notified in writing within six months of the completion of services. No other representation, express or implied, and no warranty or guarantee is included or intended in this Agreement, or in any report, opinion, document or otherwise.

9.0 LIMITS OF LIABILITY

Intertek's liability is limited as follows:

9.1 The Client agrees to limit Intertek's liability arising from Intertek's professional activity, errors, or omissions, such that the total aggregate liability of Intertek shall not exceed Intertek's total fee for the services rendered on the project in question, except in the case of a finding of gross negligence or willful misconduct on the part of Intertek by a court of competent jurisdiction.

9.2 Intertek shall be discharged from all liability to the Client for all claims for loss, damage or expense unless a claim is made within three (3) months of the date at which the damage, defect or alleged non-performance became apparent to the Client, and the process of law served no later than two (2) years from the provision of services by Intertek.

9.3 Intertek shall not be liable to the Client for any consequential damages incurred by Client due to the fault of Intertek, regardless of the nature of this fault, whether it was committed by Intertek, its employees, agents or subcontractors. Consequential damages include, but are not limited to, loss of use and loss of profit.

9.4 The Client agrees to extend any and all limitations, indemnifications, and waivers provided by the Client to Intertek to those individuals and organizations Intertek retains for proper execution of the work. These shall be deemed to include but are not necessarily limited to Intertek's officers and employees and their heirs and assigns, as well as Intertek's agents, subcontractors and their officers, employees, heirs and assigns.

9.5 Client acknowledges that testing, including sample preparation and transportation, may damage or destroy Client's product. Client agrees to hold Intertek harmless from any and all responsibility for such alteration.

9.6 The Client agrees Intertek shall not be responsible for any injuries to the Client's representatives while attending to or observing testing at Intertek's facility. If testing takes place at the Client's facility, Client agrees that Intertek will not operate and shall not be responsible for any of Client's equipment and that although Intertek agrees to abide by Client's safety procedures, Intertek shall not be responsible for injury to any of Client's personnel.

10.0 GOVERNING LAW

This proposal, and any work performed pursuant to this proposal, shall be governed by the laws of the jurisdiction within which the Intertek facility making the proposal is located. Any action brought hereon shall be venued in said jurisdiction.

11.0 SEVERABILITY

Any provision of this proposal that may be held invalid, void or unenforceable for any reason, shall not affect any other term or condition of this proposal, and such term or condition shall be replaced or interpreted to accomplish the intent of the parties.

12.0 MODIFICATIONS

No modification, waiver or amendment of any of these terms and conditions shall be binding upon Intertek unless identified in writing as to modification, waiver or amendment of such terms and conditions, and such writing is signed by an agent of Intertek acknowledging the modification, waiver or amendment.

CFR47 FCC PART15, SUBPART B: 2009 EMISSIONS TESTS[2]

The following certified laboratory test report contains supporting documentation and results of the testing performed for the research initiative in this report. The authors of this current study have not edited or changed the test report in this appendix except to remove more than one instance of the company logo within the document and to format the report.

13200 Levan Road
Livonia, MI 48150

Telephone: 734-591-9161
Facsimile: 734-432-0555
www.intertek.com

EMC TEST REPORT

Report Number: 100146942BOX-001
Project Number: G100146942

Report Issue Date: July 26, 2010

Product Designation: MigmaMidblock

Standards: CFR47 FCC Part15, Subpart B:2009

Tested by:	Client:
Intertek Testing Services NA, Inc.	Migma Systems
70 Codman Hill Road	1600 Providence Highway
Boxborough, MA 01719	Walpole, MA 02081

Report prepared by	Report reviewed by
Xavier Zambrano	Michael Murphy

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 3.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested complies with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

2 Test Summary

2 Test Summary

Section	Test Full Name	Result
3	Client Information	
4	Description of Equipment Under Test	
5	System Setup and Method	
6	Radiated Emissions (CFR47 FCC Part15, Subpart B: 2009)	Pass
7	AC Mains Conducted Emissions (CFR47 FCC Part15, Subpart B: 2009	
8	Revision History	

3 Client Information

Client Information

3 Client Information

Company: Migma Systems
1600 Providence Highway
Walpole, MA 02081

Contact: Mrs. Uma Venkataraman

Telephone: (508) 660-0328

Fax:

Email: uma@migmasys.com

4 Description of Equipment Under Test

Equipment Under Test			
Video System	Migma Systems	MigmaMidblock	1 & 2

Receive Date:	07/01/201
Received Condition:	Good
Type:	Production

Description of Equipment under test Under Test

The equipment under test is a video system

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
120VAC	1.2A	60Hz	Single

Operating modes of the EUT

No.	Descriptions of EUT Exercising
1	Unit
2	

Issued: 07/26/2010

System Setup and Method

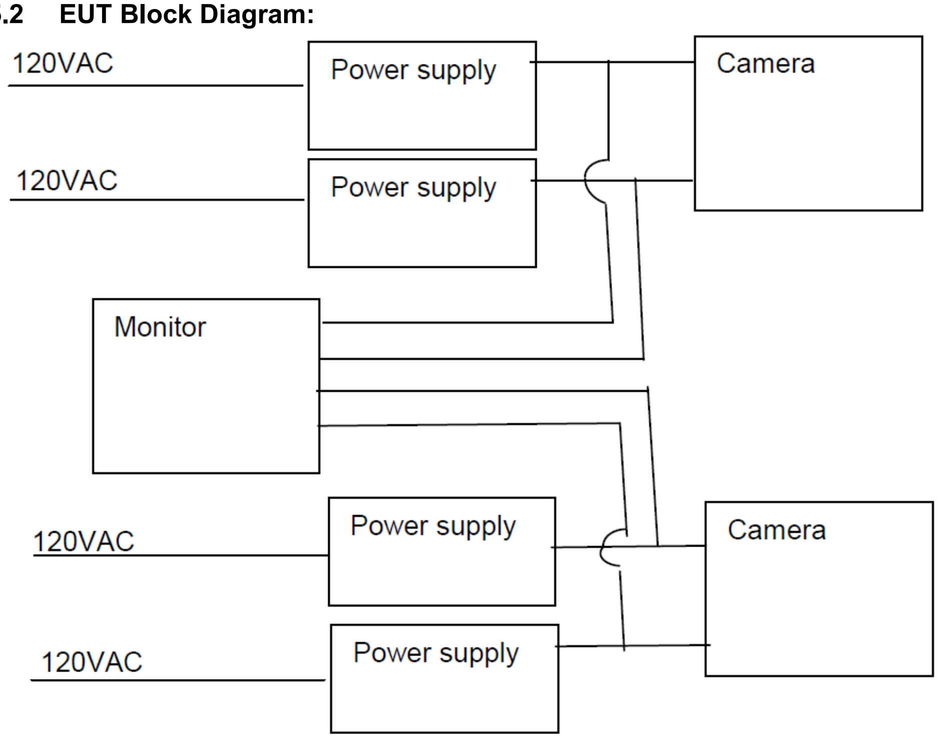
Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	AC Mains	2	None	None	Plastic
2	(2x) BMC/Twisted Pair	2	None	None	Metallic

Support			
Description	Manufacturer	Model Number	Serial Number
Monitor (PAN1)	Panasonic	WV-BM80	49W10776

5.1 Method:

Part 15 B of FCC CFR 47. ANSI C63.4

5.2 EUT Block Diagram:



6 Radiated Emissions

6.1 Method

Tests are performed in accordance with CFR47 FCC Part15, Subpart B:2009

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A wooden table 80 cm high is used for table-top equipment.

Measurement Uncertainty
For radiated emissions, U_{lab} (3.5 dB at 3m and 3.5 dB at 10m below 1 GHz, and 4.2 dB at 3m above 1 GHz) < U_{CISPR} (5.2 dB), which is the reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Issued: 07/26/2010

Sample Calculations

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – AG
Where FS = Field Strength in dB V/m
RA = Receiver Amplitude (including preamplifier) in dB V
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dB V is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dB V/m. This value in dB V/m was converted to its corresponding level in V/m.

RA = 52.0 dB V AF = 7.4 dB/m CF = 1.6 dB
AG = 29.0 dB
FS = 32 dB V/m
To convert from dB V to V or mV the following was used:

UF = $10^{(NF / 20)}$ where UF = Net Reading in V
NF = Net Reading in dB V

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
UF = $10^{(32 \text{ dB V} / 20)}$ = 39.8 V/m

Issued: 07/26/2010

6.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
ROS002	9kHz to 3GHz EMI Test Receiver	Rohde & Schwartz	ESCI 1166.5950 K03	100067	03/26/2010	03/26/2011
145003	Preamplifier (150 KHz to 1.3 GHz)	Hewlett Packard	8447D	2443A04077	09/16/2009	09/16/2010
145106	Bilog Antenna (30MHz - 5GHz)	Sunol Sciences	JB5	A111003	06/01/2009	09/01/2010
DAV003	Weather Station	Davis Instruments	7400	PE80529A39A	06/11/2010	06/11/2011
145400	Cable	Huber and Suhner	Sucoflex 106	233089004	05/01/2009	07/31/2010
145406	Cable	Huber and Suhner	Sucoflex 106	233096002	05/01/2009	07/31/2010
145407	Cable	Huber and Suhner	Sucoflex 106	233089001	05/01/2009	07/31/2010
145414	Cable	Huber and Suhner	Sucoflex 106	233089002	05/01/2009	07/31/2010

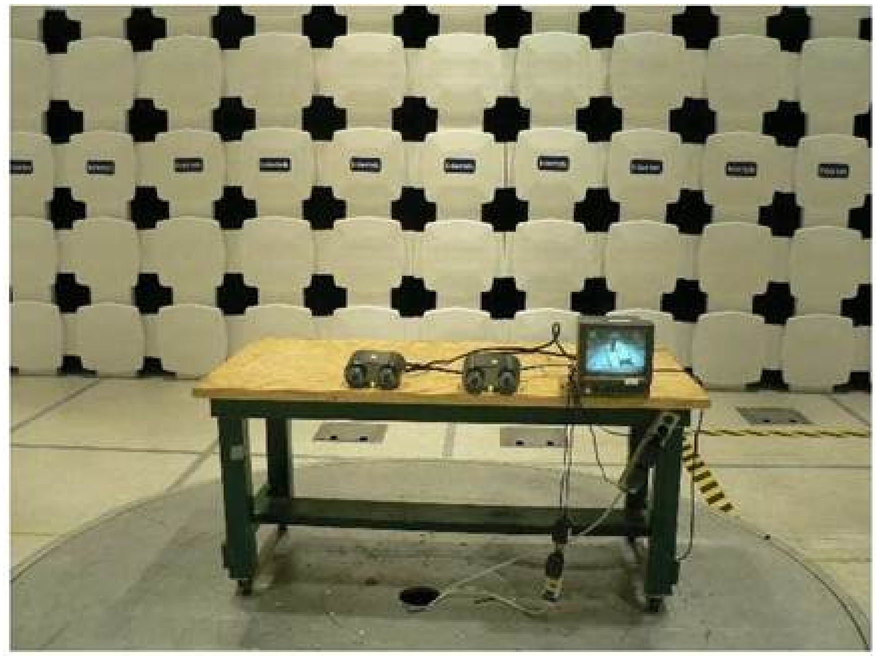
Software Utilized:

Name	Manufacturer	Version
Excel 2003	Microsoft	(11.8231.8221) SP3
EMI Boxborough.xls	Intertek	4/17/09

6.3 Results

The sample tested was found to Comply.

6.4 Setup Photographs:



6.5 Test Data:

Radiated Emissions

Company: MigmaMidblock Systems
Model #: MigmaMidblock
Serial #: 1&2
Engineers: Xavier Zambrano Location: Client's
Project # G100086017 Date(s): 07/13/10
Standard: FCC Part 15/Cispr22 Class A
Receiver: ROS002 Limit Distance (m): 10:
PreAmp: preamplifier 145-003.txt Test Distance (m) 10:

Antenna & Cables :N Bands: N, LF, HP, SHF
Antenna: 145-106 10M Ver.txt 145-106 10M HOR.txt
Cable(s) 10 M TrackA Cables.txt NONE
Barometer: DAV003 Filter: NONE
Temp/Humidity/Pressure: 24 46% 999

Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW

Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dB(uV/m)	Limit dB(uV/m)	Margin dB	Bandwidth
QP	V	57.273	51.03	7.25	1.27	27.31	0.00	32.24	40.00	-7.76	120/300 kHz
QP	V	71.587	20.61	7.90	1.40	27.30	0.00	2.61	40.00	-37.39	120/300 kHz
QP	V	143.179	20.00	13.17	1.86	26.94	0.00	8.09	40.00	-31.91	120/300 kHz
QP	V	186.1286	33.46	11.57	2.04	26.68	0.00	20.39	40.00	-19.61	120/300 kHz
QP	V	200.449	47.37	12.96	2.10	26.60	0.00	35.82	40.00	-4.18	120/300 kHz
QP	V	229.078	44.21	11.51	2.22	26.80	0.00	31.13	40.00	-8.87	120/300 kHz
QP	H	57.27	38.57	7.13	1.27	27.31	0.00	19.66	40.00	-20.34	120/300 kHz
QP	H	171.809	41.75	11.73	1.99	26.77	0.00	28.70	40.00	-11.30	120/300 kHz
QP	H	186.128	28.90	11.25	2.04	26.68	0.00	15.51	40.00	-24.49	120/300 kHz
QP	H	200.447	46.48	12.64	2.10	26.60	0.00	34.62	40.00	-5.38	120/300 kHz
QP	H	229.081	53.37	11.20	2.22	26.80	0.00	39.98	40.00	-0.02	120/300 kHz
QP	H	401.903	44.79	15.68	2.81	28.01	0.00	35.27	47.00	-11.73	120/300 kHz

Test Personnel: Xavier Zambrano
Product Standard: FCC subpart 15
Input Voltage: 120VAC
Pretest Verification
w/ BB Source: **No**

Test Date: 7/13/2010
Test Levels: Class A
Ambient Temperature: 24 ºC
Relative Humidity: 46 %
Atmospheric Pressure: 999 mbars

Deviations, Additions, or Exclusions: None

7 AC Mains Conducted Emissions

7.1 Method:

Tests are performed in accordance with CFR47 FCC Part15, Subpart B:2009

TEST SITE:

The EMC Lab has two Semi-anechoic Chambers and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

Measurement Uncertainty

For conducted emissions, U_{lab} (3.2 dB in worst case) < U_{CISPR} (3.6 dB), which is the reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample Calculations

The following is how net line-conducted readings were determined:

NF = RF + LF + CF + AF
Where NF = Net Reading in dB V
RF = Reading from receiver in dB V
LF = LISN Correction Factor in dB
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB AG = Amplifier Gain in dB

To convert from dB V to V or mV the following was used:

UF = $10^{(49.1 \text{ dB V} / 20)}$ = 285.1 V/m

Example:
NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 dB V
UF = $10^{(49.1 \text{ dB V} / 20)}$ = 285.1 V/m

7.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
147149	Spectrum Analyzer	Hewlett Packard	8591E	3346A02258	03/11/2010	03/11/2011
145005	Conducted Cable Site 1	Hutton	RG58/U	none	11/01/2006	11/01/2007
145005	LISN: 50 Ohm/50 microHenry	Solar Electronics	9252-50-R-24-BNC	941725	01/27/2010	01/27/2011
DS22A	Attenuator, 20dB	Mini Circuits	20dB, 50 ohm	DS22A	09/17/2009	09/17/2010
Dav001	Weather Station	Davis Instruments	7400	PE80519A61	06/11/2010	06/11/2011

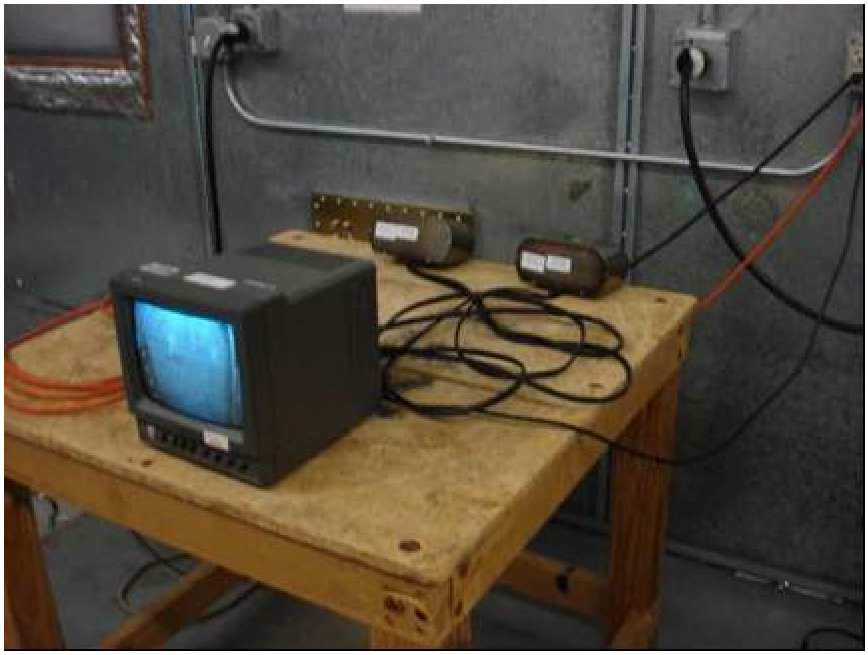
Software Utilized:

Name	Manufacturer	Version
Excel 2003	Microsoft	(11.8231.8221) SP3
EMI Boxborough.xls	Intertek	4/17/09

7.3 Results:

The sample tested was found to Comply.

7.4 Setup Photographs:



7.5 Data:

Conducted Emissions

Company: MigmaMidblock Systems
Model #: MigmaMidblock
Serial #: 1&2
Engineers: Xavier Zambrano
Project # G100086017 Date(s): 07/13/10
Standard: FCC Part 15 Subpart B Class B
Barometer DAV001 Temp/Humidity/Pressure: 22 54% 998

Receiver: 147149
Cable: CBLBNC51_1-5-2011.txt
LISN 1: LISN145005_[1]_1-27-2011.txt
Location: EMC LISN 2: LISN145005[L2]1-16-10.txt
LISN 3: NONE.
LISN 4: NONE.
Attenuator: DS22A 09-17-2010.txt

Voltage/Frequency: 120VAC/60Hz Frequency Range: 0.150 - 30MHz
Net is the sum of worst-case lisn, cable, & attenuator losses, and initial reading, factors are not shown
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor; Bandwidth denoted as RBW/VBW

Detector Type	Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Line 4 dB(uV)	Net dB(uV)	QP Limit dB(uV)	Margin dB	Bandwidth
QP	0.151	32.98	28.20			53.10	65.94	-12.84	9/30 kHz
QP	0.272	26.21	15.95			46.29	61.06	-14.77	9/30 kHz
QP	0.363	14.00	14.94			34.95	58.66	-23.71	9/30 kHz
QP	0.870	11.48	14.45			34.55	56.00	-21.45	9/30 kHz
QP	1.014	11.40	13.05			33.16	56.00	-22.84	9/30 kHz
QP	14.317	9.75	16.24			36.93	60.00	-23.07	9/30 kHz
QP	28.635	26.11	27.34			48.39	60.00	-11.61	9/30 kHz

Detector Type	Frequency MHz	Reading Line 1 dB(uV)	Reading Line 2 dB(uV)	Reading Line 3 dB(uV)	Reading Line 4 dB(uV)	Net dB(uV)	Average Limit dB(uV)	Margin dB	Bandwidth
AVG	0.151	9.54	13.25			33.37	55.94	-22.58	9/30 kHz
AVG	0.272	11.45	7.71			31.53	51.06	-19.53	9/30 kHz
AVG	0.363	3.37	5.52			25.53	48.66	-23.13	9/30 kHz
AVG	0.870	1.98	4.57			24.67	46.00	-21.33	9/30 kHz
AVG	1.014	1.14	2.24			22.35	46.00	-23.65	9/30 kHz
AVG	14.317	4.10	5.85			26.54	50.00	-23.46	9/30 kHz
AVG	28.635	16.12	20.54			41.59	50.00	-8.41	9/30 kHz

Test Personnel: Xavier Zambrano
Product Standard: FCC subpart 15
Input Voltage: 120VAC
Pretest Verification
w/ BB Source: **No**

Test Date: 7/13/2010
Test Levels: Class A
Ambient Temperature: 22 ºC
Relative Humidity: 54 %
Atmospheric Pressure: 998 mbars

Deviations, Additions, or Exclusions: None

8 Revision History

Revision Level	Date	Report Number	Notes
0	7/26/2010	100146942BOX-001	Original Issue

ACKNOWLEDGEMENTS

The participation of many traffic engineers at the Arizona Department of Transportation, MassDOT, MaineDOT, and New Hampshire Department of Transportation is acknowledged. Their dedication to the pedestrians of their cities and their hard work made this project successful.

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