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**National Institute of Justice (NIJ)  
Sensor, Surveillance, and Biometric Technologies (SSBT)  
Center of Excellence (CoE)  
Laboratory Test and Evaluation (T&E) of  
Long-Range 3D Facial Recognition Devices**



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**T&E of the SVI Face Capture & Matching  
System (Final Report)**

November 6, 2012

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## **Contents**

EXECUTIVE SUMMARY .....	5
Conclusions .....	7
SCOPE.....	9
BACKGROUND.....	9
SVI Dataset Description.....	9
EVALUATIONS .....	11
EVALUATION RESULTS .....	12
Enrollment vs. Enrollment (L1R1, MMR1) .....	15
L1 Run 1 Enrollment vs. Enrollment Matcher Results (L1R1).....	15
MM Run 1 Enrollment vs. Enrollment Matcher Results (MMR1).....	16
48 Meters.....	17
Run 3.....	17
Run 7.....	19
50 Meters.....	20
Run 2.....	20
Run 3.....	23
L1R350 P3 .....	25
Run 4.....	28
Run 5.....	31
Run 6.....	34
Run 7.....	37
Run 8.....	42
Run 9.....	46
75 Meters.....	49
Run 2 (L1R275) .....	49
Run 3 (L1R375) .....	50
Run 7 (L1R775) .....	52
100 Meters.....	53
Run 2 (L1R2100) .....	53
Run 3 (L1R3100) .....	55
Run 7 (L1R7100) .....	57
ANALYSIS .....	59

ADDITIONAL COMMENTS .....	68
CONCLUSIONS.....	69
APPENDIX A - Acronyms and Abbreviations .....	70
Figure 1 - L1 Run 1.....	15
Figure 2 - MM Run 1 .....	16
Figure 3 - L1 MM Run 1.....	17
Figure 4 - L1 Run 3 (P1) 48 Meter .....	18
Figure 5 - L1 Run 7 48 Meter .....	20
Figure 6 - L1 Run 2 50 Meter .....	21
Figure 7 - MM Run 2 50 Meter .....	22
Figure 8 - L1 MM Run 2 50 Meter.....	23
Figure 9 - L1 Run 3 (P1) 50 Meter .....	24
Figure 10 - L1 Run 3 (P3) 50 Meter .....	25
Figure 11 - L1 Run 3 P1 & P3 50 Meter.....	26
Figure 12 - MM Run 3 50 Meter .....	27
Figure 13 - L1 MM Run 3 50 Meter.....	28
Figure 14 - L1 Run 4 50 Meter .....	29
Figure 15 - MM Run 4 50 Meter .....	30
Figure 16 - L1 MM Run 4 50 Meter.....	31
Figure 17 - L1 Run 5 50 Meter .....	32
Figure 18 - MM Run 5 50 Meter .....	33
Figure 19 - L1 MM Run 5 50 Meter.....	34
Figure 20 - L1 Run 6 50 Meter .....	35
Figure 21 - MM Run 6 50 Meter .....	36
Figure 22 - L1 MM Run 6 50 Meter.....	37
Figure 23 - L1 Run 7 50 Meter .....	38
Figure 24 - L1 Run 7 P3 50 Meter.....	39
Figure 25 - L1 Run 7 P1 & P3 50 Meter.....	40
Figure 26 - MM Run 7 50 Meter .....	41
Figure 27 - L1 MM Run 7 50 Meter.....	42
Figure 28 - L1 Run 8 50 Meter .....	43
Figure 29 - MM Run 8 50 Meter .....	44
Figure 30 - L1 MM Run 8 50 Meter.....	45
Figure 31 - L1 Run 9 50 Meter .....	46
Figure 32 - MM Run 9 50 Meter .....	47
Figure 33 - L1 MM Run 9 50 Meter.....	48
Figure 34 - L1 Run 2 75 Meter .....	50
Figure 35 - L1 Run 3 75 Meter .....	51
Figure 36 - L1 Run 7 75 Meter .....	53
Figure 37 - L1 Run 2 100 Meter .....	54
Figure 38 - L1 Run 3 100 Meter .....	56
Figure 39 - L1 Run 7 100 Meter .....	58
Figure 40 - L1 R2 R3 R7 50 Meter.....	59
Figure 41 - L1 R2 R3 R7 75 Meter.....	60

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Figure 42 - L1 R2 R3 R7 100 Meter.....	60
Figure 43 - L1 Run 2 50 75 100 Meter .....	61
Figure 44 - L1 MM Run 3 50 Meter .....	62
Figure 45 - L1 MM Run 4 50 Meter .....	63
Figure 46 - L1 MM Run 5 50 Meter .....	63
Figure 47 - L1 R2 R7 50 Meter .....	65
Figure 48 - L1 Run 3 48 & 50 Meter .....	66
Figure 49 - L1 Run 7 48 & 50 Meter .....	66
Figure 50 - L1 R8 R9 50 Meter .....	67

## EXECUTIVE SUMMARY

Azimuth Incorporated, as a subcontractor of ManTech International Corporation, is supporting the National Institute of Justice (NIJ) Sensor, Surveillance, and Biometric Technologies (SSBT) Center of Excellence (CoE) program in the areas of Test and Evaluation (T&E) of prototype biometric technologies and devices. This document describes the evaluation of the StereoVision Imaging (SVI) Incorporated system. The SVI system evaluated consisted of a binocular imaging subsystem and a laptop that hosts the imaging and face matching subsystem. The laptop software consisted of a proprietary Disparity Calculator and commercial L1 face-matching product. This document describes the SVI evaluations conducted and documents the results using the face image dataset collected by West Virginia University (WVU).

The evaluations described in this document were conducted using an image set that was collected by WVU. The WVU SVI dataset contains 100 subjects with indoor studio quality images (collected with a Canon EOS 5D Mark II & EF 70-200mm f/2.8L IS II USM lens), and outdoor images and video recordings which were collected using three different cameras; a Canon EOS 5D Mark II with an 800mm fixed focal length lens, a Sony DEV-3 3D binoculars, and the SVI binoculars which we are evaluating. The image collection goal for each subject was to collect 3 enrollment images (3 frontal), 9 Canon outdoor images (3 each @ 50m, 75m, and 100m), 1 Sony video recording (~5 sec in length) and an image (1 each @ 50m, 75m, and 100m). The SVI video recordings consisted of a left and right VUR video file (VUR pairs) for each capture event. A total of 81 VUR pairs were collected for each subject. There were 27 pairs (3 each @ 48m, 50m, 52, 73m, 75m, 77m, 98m, 100m, and 102m) and at each distance an additional video recording for each of the 3 binocular presets. The binocular preset allows the imaging system to focus at the three primary distances of 50, 75, and 100 meters. The SVI and Sony collected JPEG images were not used during these system performance evaluations. The Disparity Calculator creates 15 TIFF images for each of the VUR pairs. The 15 TIFF images consisted of 5 left, 5 right, and 5 occluded. The occluded images are a combination of a left and right matching pair for the purpose of background removal. The total potential number of images in the performance study for the SVI collection is 121,500 TIFF images created by the Disparity Calculator from the VUR pairs. The WVU image collection has 122,800 images available in (or can be created from) the WVU collected SVI dataset for test face matching run scenarios. Actual test dataset content, enrollment and probe, was created and recorded for each of the test events (data Runs).

The SVI evaluation team has completed 28 data Runs that characterize the performance of the SVI system at collection distances of 48, 50, 75, and 100 meters. Two of the runs conducted were using the enrollment images as both probe and gallery to baseline the performance of the L1 and MegaMatcher (MM) algorithms. Both algorithms provided a 100% True Accept Rate at Rank 1. It should be noted that the enrollment images were collected using a Canon 5D MkII camera w/ 70–200mm f/2.8 lens and were of excellent quality. The outdoor collection cameras were the Canon 5D MkII w/ 800mm prime lens, the SVI binocular, and the Sony DEV-3 binocular. The Sony images (Runs 8 & 9) extracted from the recorded video at 50 meters provided very poor matching performance. We believe this is due to the face matcher having a small resolution image of only 20 pixels between the pupils to extract features for matching. Because of the poor performance at 50 meters the Sony images were not matched at 75 or 100 meter distances. The Canon images (Run 2) at all distances provided better match performance

than did the images collected with the SVI binoculars. Run 2 represents the ability of a currently available commercial off-the-shelf (COTS) surveillance camera and lens to capture faces at a distance and match to a small watch list.

The SVI binocular collected images were evaluated in Runs 3, 4, 5, 6, and 7 at distances of 48, 50, 75, and 100 meters. The SVI data runs provided an opportunity to determine if the Disparity Calculator is selecting the best images for matching and if the distance presets on the binocular function correctly or have any influence on the match performance of the images collected. Run 3 represents the performance of the SVI system in an autonomous mode of operation. In Run 3 the Disparity Calculator was allowed to select the images for matching. It is of interest to note that none of the occluded images were selected for matching at any of the tested distances (48, 50, 75, or 100 meters). Runs 4, 5, 6, and 7 was conducted by storing all images that resulted from running the Disparity Calculator on the left and right VUR pairs created by the SVI binocular. Run 4 represents the match performance of all left images created from the Disparity Calculator. Run 5 are all right images from the Disparity Calculator. Runs 4 and 5 represent the ability of the SVI binocular optic and sensor to collect quality face images. Run 6 are all the occluded images and Run 7 are all occluded images that have a face present as determined by the MegaMatcher. Runs 6 and 7 represent the ability of the SVI system to extract the background in the face images. Again, none of the occluded images were automatically selected for matching.

The Canon 5D MkII with an 800mm prime lens provided the probe images for Run 2. Run 2 was used as a comparison point for the SVI system, even though the Canon provided greater resolution and a longer focal length lens. The Canon camera focus and exposure were automatically set and the lens had image stabilization. The match performance of the Canon system collected images outperformed the SVI system at all distances and using either face matcher.

The SVI system evaluated in a “black box” mode is represented in Run 3, where it did not perform very well. Run 3 is the SVI binocular collected VUR files, face images created and selected for matching by the Disparity Calculator, and matched using the L1 and MegaMatcher for images collected at 48, 50, 75, and 100 meters. The Disparity Calculator did not select any occluded images for matching. SVI images were collected using the binocular preset 1 at both 48 and 50 meters. These images were evaluated in Runs 3 and 7. The Run 3 did not identify any change in match performance, although Run 7 did show an improved match performance at 50 meters. Additional tests were conducted to determine the effect of changing the preset (focal length) on the SVI binocular. Data runs for 50 meter preset 1 and 50 meter preset 3 did not show any statistical difference in matching performance. In a subjective evaluation of the images at 50 meters between preset 1 and 3, the test team did not observe changes in contrast or focus. These tests are evidence of problems with the preset functionality of the SVI binocular.

The Disparity Calculator and L1 selected images for Run 3 at 50 meters preset 1 was repeated using the MegaMatcher algorithm with an enormous change in match performance. The L1 rank 1 True Accept Rate was 0.83% and the MegaMatcher rank 1 True Accept Rate was 47.38%. Based on these results, it appears that a matching parameter(s) for the L1 matcher is incorrect. Runs 4 and 5 show similar changes in match performance between the L1 and MegaMatcher. Runs 4 and 5 are all the left and right images produced by the Disparity Calculator. However, in

Run 6 (all occluded) and Run 7 (all occluded with faces) the L1 and MegaMatcher have similar match performance, with the L1 being slightly better. The match performance improvement in Run 6 (occluded images) above Runs 4 and 5 (left and right images) shows the value of background removal to the face matching performance.

The best possible match performance of the SVI system with the WVU collected data is represented by Run 7. Run 7 takes the video files from the binocular and provides them to the Disparity Calculator where all occluded images are created and saved. An additional step is added for Run 7 where all occluded images are ran through a face finding algorithm that is a part of MegaMatcher. Only those occluded images with faces are then provided as probes to the matchers. The SVI system performed reasonably well with the L1 algorithm having a rank 1 True Accept Rate of 50.53% and MegaMatcher 47.63%. As a point of comparison, the Canon probe images at 50 meters resulted in rank 1 True Accept Rates of 83.67% for L1 and 82% for MegaMatcher.

The Sony DEV-3 collected images were evaluated as Runs 8 and 9. Runs 8 and 9 were only conducted at 50 meters. The additional Runs for 75 and 100 meters were not conducted due to the poor match performance at 50 meters. The Sony DEV-3 binoculars performed poorer than the SVI system and was not capable of collecting face images at 50 meters and greater distances for automated face matching.

## Conclusions

In general, six key issues/observations were identified during the evaluation:

- 1.) **The Disparity Calculator failed to produce occluded images that were acceptable in quality to the L1 matcher.** In all subject cases, left and/or right standard images were determined by L1 to be the best quality and used as probes into the gallery. This is evidenced in the True Match Rates in Run 3 (0.8%) as compared to Runs 4 (1.0%) and 5 (0.7%). The subprocess that selects images for submission as probes is not working.
- 2.) **The change in match performance between SVI images collected at 50 meters using the preset 1 and preset 3 is not statistically significant.** This leads the test team to believe that the SVI binocular images are not correctly focused. However contrary to this finding the Run 7 matching performance was improved at 50 meters over the match performance at 48 meters. Both the 48 and 50 meter image collections were using the SVI binocular preset 1 which is supposed to be optimized for 50 meters.
- 3.) **There is a stark improvement in match performance produced by matching all occluded (Run 6, 27.4%) as compared to running all left (Run 4, 1.0%) and right (Run 5, 0.7%) images produced by the Disparity Calculator.** The background removal does improve match performance in this system, however; the current implementation does not seem to choose any occluded images.

- 4.) **The significantly improved match performance of the MegaMatcher over the L1 matcher in Runs 3, 4, and 5 leads the test team to believe that some parameter(s) of the L1 matcher is incorrectly set.** The results of Runs 1, 2, 6, and 7 shows that the L1 and MegaMatcher are about equal in rank 1 True Accept Rates. In fact, the L1 is slightly better.
- 5.) **The Disparity Calculator produces occluded images that often contain partially or fully obscured faces.** This is observed qualitatively in examining resulting images, and is confirmed in the improvement in match performance when face finding is used as filter. The match performance between Runs 6 and 7 almost doubled, from 27.41% to 50.52%. The Disparity Calculator settings for automated processing require further adjustment or improvements.
- 6.) **The Sony DEV-3 binocular was not up to the challenge of collecting face images at 50 meters or greater distances for the purpose of automated face matching.**

## SCOPE

The Department of Justice (DOJ) National Institute of Justice (NIJ) is currently evaluating several products that are the result of biometric research funding to academic institutions and industry. Azimuth Incorporated, as a subcontractor of ManTech International Corporation, is supporting the National Institute of Justice (NIJ) Sensor, Surveillance, and Biometric Technologies (SSBT) Center of Excellence (CoE) program in the areas of Test and Evaluation (T&E) of prototype biometric technologies and devices. This document describes the evaluation of the StereoVision Imaging Incorporated (SVI) system evaluation and results. This document describes the evaluations conducted and documents the results using the face image dataset collected by WVU and provided by ManTech. This document describes the SVI binocular product evaluation using this dataset.

## BACKGROUND

SVI provided two identical binoculars, serial number 100064 and serial number 100068, an external battery pack and charger, a wall power cable, and a laptop loaded with both the database server and client side software necessary for the image segmentation and matching to occur. SVI utilizes the commercially available L1 ABIS System for facial recognition. The binocular is capable of collecting face images at 50, 75, and 100 meters and matching to a local or remote database. To perform a collection, the operator presses the shutter button and a short 3D video clip is taken. If the binocular is connected directly to the laptop for real-time use, images taken are routed through the SVI FRT Tracker application where 3D segmented images are generated. The 2D and 3D segmented images are then routed from the FRT Tracker application to the L1 ABIS System backend for matching. Results of the identification are shown in L1's Argus Monitor application. If post-surveillance identification or more information about the generation of 3D segmented images is desired, the operator can select images to be analyzed by SVI's Disparity Calculator application; with this program, images are not automatically downloaded from the binocular. Disparity Calculator accepts VUR RAW video files or standard format image files, creates 3D segmented images from left and right 2D images, performs image enhancement, and displays detailed information about the 3D segmentation process. Each VUR file contains a sequence of five frames, comprising a sequence of approximately 70 milliseconds; as the .VUR format is proprietary, the files can only be opened using the Disparity Calculator. When the RAW images are loaded into the program, 15 images will be seen in the Disparity Calculator. These 15 images are five from the left optical path; five from the right, and the last five involve the 3D processing of both the left and right frames, or as used in this report, "occluded" images. All 15 frames are sent to the L1 ABIS System for quality analysis and selection for the matching and identification process.

## SVI Dataset Description

Azimuth has been tasked to evaluate the ability of the SVI software, FRT Tracker and Disparity Calculator, to extract or segment the faces contained in images. The FRT Tracker software is automated to extract the images from an SVI binocular connected to a laptop and provide them to the L1 ABIS subsystem for facial recognition. The Disparity Calculator is a manual process conducted in a binocular disconnected mode of operation and provides more information to the operator. The images from the Disparity Calculator are then provided as an input to the L1

ABIS. The video collected using the SVI proprietary FRT 3DVuCAM binocular are in a proprietary video format, VuCAM RAW (VUR). The binocular creates two VUR video files (left & right) from which 5 images are extracted from each video file, for a total of 10. These 10 images are combined, first left with first right and so on, to create an additional 5 composite or occluded images. The occluded images have faces with the background removed. The 5 occluded images are of primary importance for this evaluation because SVI claims improved match performance using these images. These 15 images are then fed into the L1 ABIS face matching algorithm where they are judged for quality. Only the images that the matcher considers of high quality are used for matching to the enrolled identities. A complete description of the SVI dataset can be found in the WVU report, from Dr. Bojan Cukic, titled “WVU – Long Range 3D Face Collection – Final Report”. A short summary of the dataset is provided in the following paragraph.

The WVU SVI dataset contains 100 subjects with indoor studio quality images (collected with a Canon EOS 5D Mark II & EF 70-200mm f/2.8L IS II USM lens), and outdoor images and video recordings were collected using three different cameras; a Canon EOS 5D Mark II with an 800mm fixed focal length lens, a Sony DEV-3 3D binocular, and the SVI binoculars which we are evaluating. Although other images are provided for each subject, we selected only the full frontal image for enrollment. These studio quality images were enrolled into the matching dataset and all outdoor collections were used as ‘probe’ images for matching. The image collection goal for each subject was to collect 5 enrollment images (3 frontal, left 45°, and right 45°), 9 Canon outdoor images (3 each @ 50m, 75m, and 100m), 1 Sony video recording and image (1 each @ 50m, 75m, and 100m), and the SVI collection, which consisted of video recordings and .JPEG images. The SVI and Sony collected .JPEG images will not be used during the SVI system performance evaluations. The SVI video recordings consisted of a left and right VUR file (VUR pairs) for each capture event. A total of 81 VUR pairs were collected for each subject. There were 27 video recordings (3 each @ 48m, 50m, 52, 73m, 75m, 77m, 98m, 100m, and 102m) and at each distance, additional video recordings were captured for each of the 3 binocular presets. The Disparity Calculator creates 15 .TIFF images for each of the VUR pairs. The total potential number of images to be used in the performance study for the SVI collection is 121,500 .TIFF images created by the Disparity Calculator from the VUR video recording pairs. If all subjects provided all images and video recordings for all the cameras it would have resulted in 28,633 images and 16,500 video recordings. However, not all subjects were successfully collected with all devices or at all distances. In addition, not all images or video recordings collected are of sufficient quality to be utilized in the evaluations. Therefore the total number of possible N:N matches will always be greater than what is actually run in the test events described in this report. The SVI system evaluation has 122,800 images available in (or can be created from) the WVU SVI dataset for test scenarios. Actual test dataset content, enrollment and probe, were created and recorded for each of the test events.

## EVALUATIONS

The purpose of using the WVU SVI data collections is to allow the laboratory team to evaluate the effectiveness of the SVI binocular, Disparity Calculator background removal and face segmentation, and the resulting face matching performance using the SVI provided L1 commercial face matching algorithm. As a point of comparison, the Neurotechnology MegaMatcher algorithm will duplicate the L1 matching runs where appropriate. The following test scenarios are designed to provide insight into the performance of the SVI product. The Run 3 test scenarios used the quality algorithm in the L1 face matcher as a “gate keeper” that defined the dataset input to both the L1 and MegaMatcher for Runs 4, 5, and 6. Run 7 used a subset of images from Run 6 where the face finding capability of the MegaMatcher was used to select only those images that contained faces. This method provides the best opportunity to directly compare match results from the two matchers.

The evaluation created a “best” case baseline for the performance of both the L1 and MegaMatcher using the enrollment images from the WVU SVI collection. Using the enrollment dataset as both the enrolled images and as the probe images, a baseline match performance was created for each matcher. We enrolled the studio quality enrollment dataset and using the same dataset as probes, performed an N:N data run for both the L1 and MegaMatcher. Again, the purpose of this test is to determine the match performance using the WVU SVI dataset for each matcher under the most ideal conditions.

The match performance of the SVI system was compared against the Canon outdoor collection. The capability of the Canon camera system is very different than that of the SVI binocular. The Canon has a much larger aperture, better resolution, image stabilization, and auto focus and exposure. Our goal is to isolate to the extent possible the performance changes as a result of the 3D SVI Disparity Calculator, as well as to compare the SVI system to a currently available commercial off-the-shelf (COTS) surveillance system. This evaluation will assist in understanding the advantages, if any, of the SVI 3D images over the Canon. The evaluation measures the L1 and MegaMatcher matching performance of the Canon outdoor dataset for each of the 3 camera distances collected, 50m, 75, and 100m using the studio collection templates as enrollments for matching.

Having drawn a performance baseline for the L1 and MegaMatcher matchers (enrollment to enrollment images) and determined the matching performance (for the L1 & MegaMatcher) for the 2D Canon outdoor collection, we next evaluated the match performance of the SVI data collection at the primary distances of 50m, 75m, and 100m, using only images collected at the correct matching preset. The SVI video recordings collected at secondary distances of 48, 52, 73, 77, 98, and 102 meters were not all utilized in the evaluation. The SVI images collected at 48 meters were compared to the 50 meter collection to assist in understanding the binocular focal length. The evaluations of collections occurring at secondary distances are concerned with determining correct focal length for the images collected and whether the preset buttons on the binocular operate correctly. The SVI dataset will be created by using the video recording VUR files and the Disparity Calculator to create the images to run against the enrolled set. Within the SVI dataset, we compared the match performance differences between those 5 images that are 3D composites (occluded images) and the 10 2D images (5 left and 5 right) extracted from the

VUR video recordings. The results did show an improved match performance for the occluded images over the 2D images.

The Sony outdoor video and image collection contained a video recording for each subject at each of the primary distances (50m, 75m, and 100m). The Sony outdoor video collection does not appear to provide images of sufficient resolution for sufficient match performance using either face matching algorithm. The Sony dataset consists of 100 subjects, of which only 95 have video recordings at all distances. Only 11 subjects provide JPEG images, 3 subjects were JPEGs only, and 8 subjects were provided JPEG images and video recordings. Due to the low resolution problem, the Sony image collection was only ran at 50 meters (Runs 8 & 9).

## EVALUATION RESULTS

These evaluation results determine the effectiveness of the SVI system in determining the true identity of an enrolled subject, as compared to existing face capture surveillance technology and another commercially available binocular. In addition to the overall performance of the SVI system, another evaluation goal is to determine the change, improvement or degradation, in match performance using the SVI Disparity Calculator to produce the composite 3D occluded images with the background removed. The first set of tests are designed to baseline the performance of the face matchers using the WVU provided face dataset in a best case scenario, by using the enrollment images both as the matching dataset and as the probes. This will determine the very best performance expectation for the matchers given the dataset provided. The second test is to determine the ability of existing camera surveillance equipment and the match performance at the same distances as the SVI system and Sony binocular.

The SVI evaluation has completed 28 data Runs that characterize the performance of the SVI system at collection ranges of 48, 50, 75, and 100 meters. These evaluation results are organized by the distance at which the images were collected and by which matcher provided the performance results. Additional comparisons of performance across the distances and binocular presets are provided at the bottom of the report. The following run definitions are provided below.

- **Run 1** – Enrollment images matched to themselves (L1 & MegaMatcher runs completed but independent of distance).
- **Run 2** – Canon 800mm images ran against the enrollment gallery.
- **Run 3** – SVI Binoculars “Black Box” performance. All SVI VUR files input into the Disparity Calculator-L1 processes to match against the enrollment gallery.
- **Run 4** – All left images (tiff not color) generated from the Disparity Calculator matched against the enrollment gallery.
- **Run 5** – All right images (tiff not color) generated from the Disparity Calculator matched against the enrollment gallery.
- **Run 6** – All occluded images generated from the Disparity Calculator matched against the enrollment gallery.
- **Run 7** – All occluded images output from the Disparity Calculator that contained faces (as determined by MegaMatcher) as inputs against the enrollment gallery.

- **Run 8** – Randomly selected left images frames extracted from the Sony video file matched against the enrollment gallery.
- **Run 9** – The Sony right paired image frames of those frames randomly selected in Run 8 matched against the enrollment gallery.

The 28 performance runs are organized by matcher, run number, and probe collection distance; and are presented in this report in the following order:

2 Runs - Enrollment vs. Enrollment

- L1 matcher (L1)
- MegaMatcher (MM)

2 Runs – at 48 Meters both using preset 1 (Matcher used followed by Run number)

- L1R348, and L1R748

18 Runs – at 50 Meters (Matcher used followed by Run number) Note that two of the 50 meter range were conducted with images using the 100 meter focus setting on the SVI binocular (P3)

- L1R250 & MMR250, L1R350 & MMR350, L1R350 (P3), L1R450 & MMR450, L1R550 & MMR550, L1R650 & MMR650, L1R750 & MMR750, L1R750 (P3), L1R850 & MMR850, and L1R950 & MMR950

3 Runs – at 75 Meters all using preset 2 (Matcher used followed by Run number)

- L1R275, L1R375, and L1R775

3 Runs – at 100 Meters all using preset 3 (Matcher used followed by Run number)

- L1R2100, L1R3100, and L1R7100

The matching performance of either the L1 or MegaMatcher face algorithms is dependent on the quality of the probe and enrollment images. The probe images were captured outdoor and in less than ideal conditions. The enrollment images are of excellent studio quality and are captured in accordance with the ANSI/NIST-ITL 1-2007 Best Practice Recommendation for the Capture of Mugshots. The Intra-Ocular Distance (IOD) quantified in the number of pixels was recorded for each capture camera device and distance. This IOD pixel count directly correlates to face matching performance. The following measurements (pixel counts) were taken from the devices (Canon enrollments, Canon 800mm outdoor, SVI, and Sony cameras) and distances (48, 50, 75, and 100 meters) in the WVU SVI dataset. For each device and distance, the IOD pixel count for three random images was measured and the average pixel count is recorded below.

Canon Enrollment Images –	779 pixels
Canon 800mm outdoor –	@ 50 Meters – 153.3
	@ 75 Meters – 103
	@ 100 Meters – 78.3
SVI Camera @ correct preset –	@ 48 Meters – 92.3
	@ 50 Meters – 101
	@ 75 Meters – 66.3
	@ 100 Meters – 46.3
Sony Camera –	@ 50 Meters – video 19.7 - Stills 68.5
	@ 75 Meters – video 14.8 - Stills 46.9
	@ 100 Meters – video 11.3 - Stills 34

**Enrollment vs. Enrollment (L1R1, MMR1)**

**L1 Run 1 Enrollment vs. Enrollment Matcher Results (L1R1)**

The L1 Run 1 was conducted to baseline the performance of the L1 face matching algorithm using the enrollment dataset collected by WVU. It consisted of 99 probes and 99 enrolled subjects where the true accept rate was 100% and the false accept rate was 0%. The similarity scores for the genuine population ranged from a low of 214.18 to a high of 338.57.<sup>1</sup> There were no similarity scores generated for the imposter population. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R1 En vs. En</b>						
Enrollment vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	99			
		Unique Subjects	99			
	Matches					
		True Mat	99	<b>100.00</b>	214.18	338.57
		False Mat	0	<b>0.00</b>	0.00	0.00
	Total	9801				

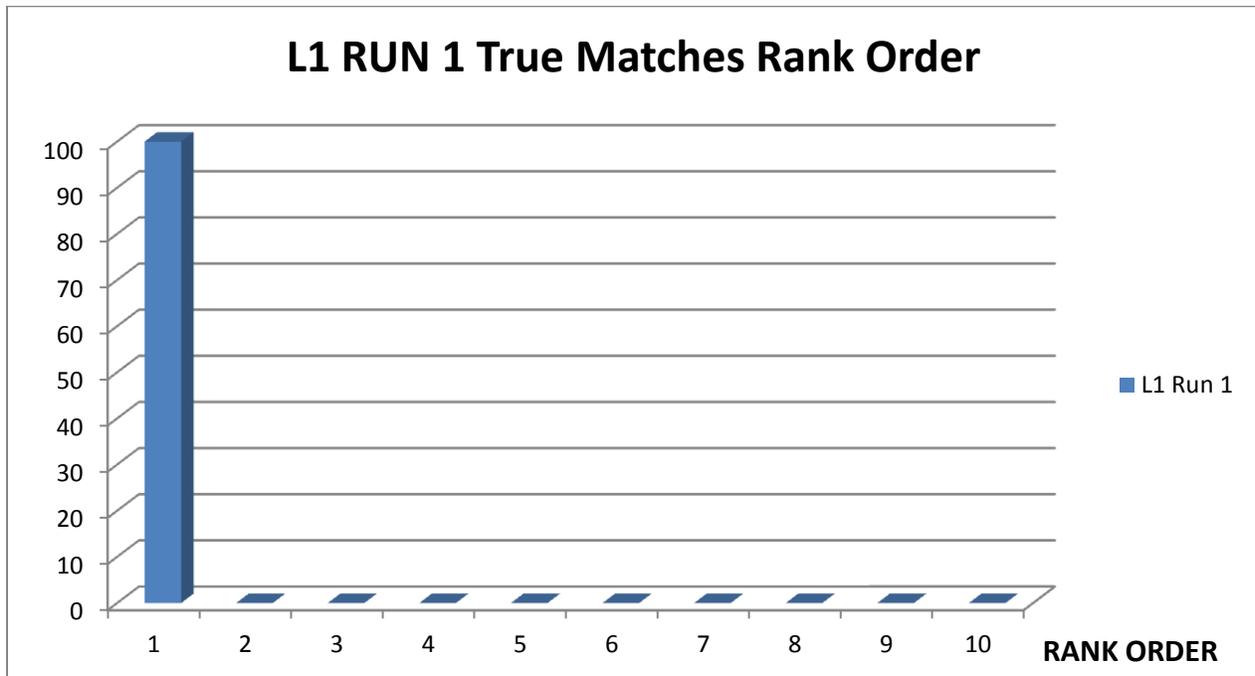


Figure 1 - L1 Run 1

<sup>1</sup> Note that the similarity score is a relative score within a given matcher.

### MM Run 1 Enrollment vs. Enrollment Matcher Results (MMR1)

The MM Run 1 was conducted to baseline the performance of the MM face matching algorithm using the enrollment dataset collected by WVU. It consisted of 99 probes and 99 enrolled subjects where the true accept rate was 100% and the false accept rate was 0%. The similarity scores for the genuine population ranged from a low of 10080 to a high of 10080. There were no similarity scores generated for the imposter population. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R1 En vs. En</b>						
Enrollment vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	99			
		Unique Subjects	99			
	Matches					
		True Mat	99	<b>100.00</b>	10080	10080
		False Mat	0	<b>0.00</b>	0.00	0.00
	Total	9801				

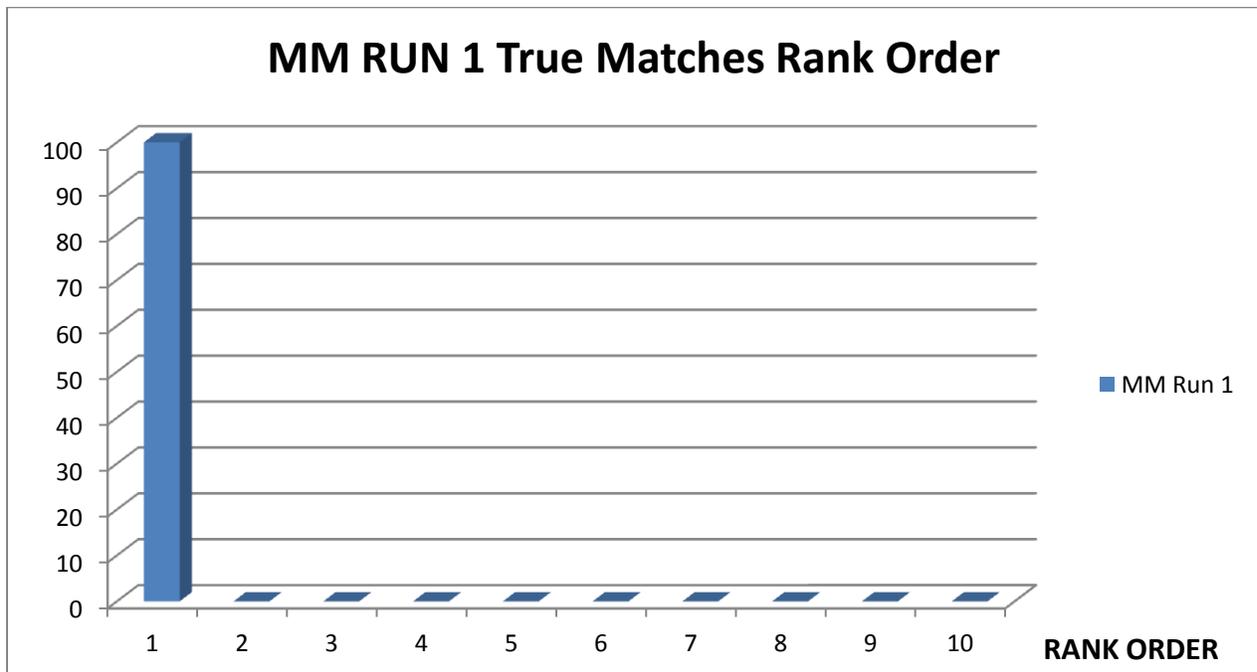


Figure 2 - MM Run 1

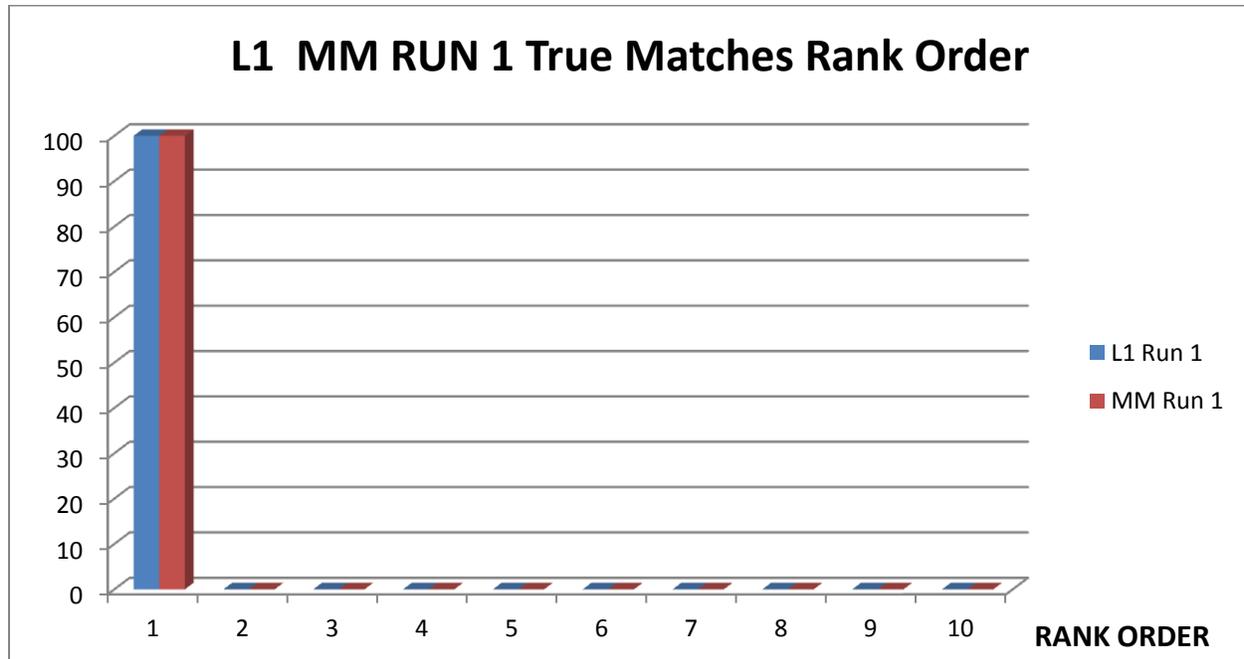


Figure 3 - L1 MM Run 1

### 48 Meters

The purpose of the 48 meter runs is to determine the accuracy of the SVI binocular focal length. The binocular collected the 48 meter images using preset 1, which corresponds to a focal distance of 50 meters. The 48 meter Runs match performance will be compared to the match performance of those collected at 50 meters. There were only 2 matching runs conducted (Runs 3 and 7) at 48 meters. They were both using the L1 matching algorithm.

- L1R348 P1 & L1R748 P1

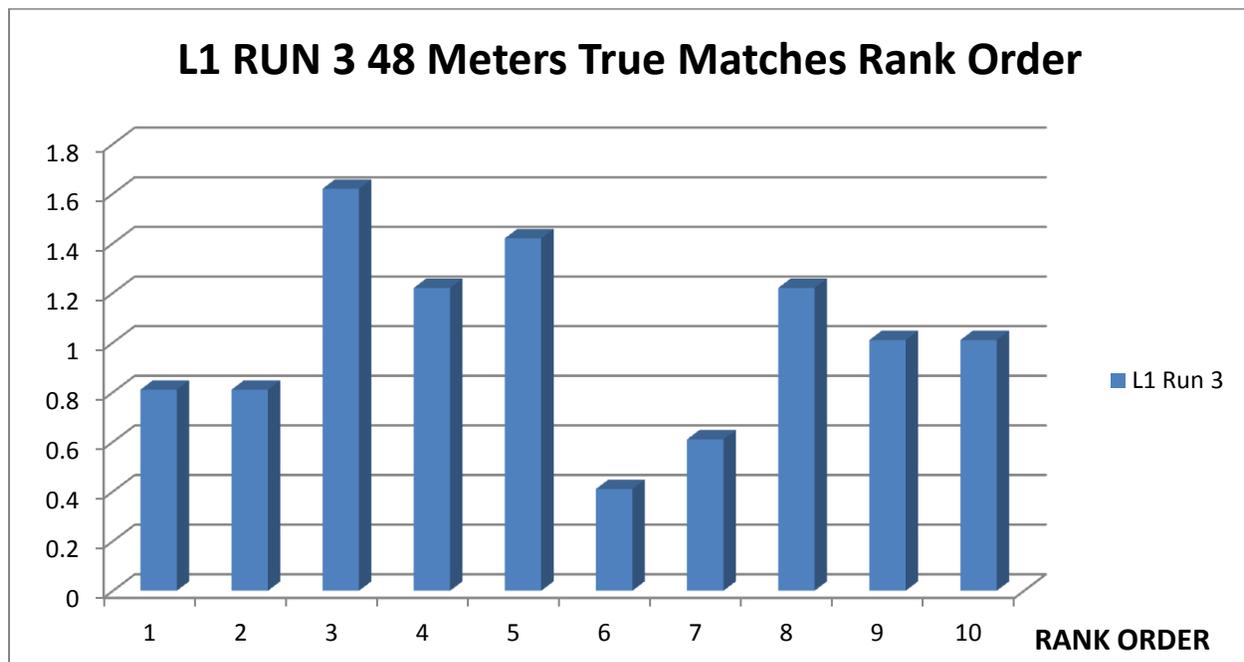
### Run 3

The Run 3 consisted of probe images collected by the SVI binocular at 48 meters preset 1 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of the SVI system software in an autonomous mode. This Run represents the capability of the SVI Disparity Calculator to operate without manual intervention. The SVI binocular collected left and right VUR files that were input to the SVI Disparity Calculator where 15 images are created (5 left, 5 right, and 5 occluded) and the L1 face matcher selected the images that are probes for matching to the enrollment gallery. The SVI system did not choose any of the occluded images; it only chose a subset of the left and right images.

**L1 (L1R348 P1)**

L1 Run 3 consisted of 499 probes and 99 enrolled subjects. There were 493 True Matches with 50 of those True Matches occurring within the top rank 10 and 4 matches were rank 1. The true accept rate was 0.8% and the false accept rate was 98%. The similarity scores for the genuine population ranged from a low of 0 to a high of 0.25. The similarity scores generated for the imposter population was 0.04 to 0.28. Also of note, there were 4 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R3 SVI48p1DC vs. EN</b>						
48 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	499			
		Unique Subjects	88	Note: 4 image pairs crashed DC		
	Matches	True Mat	4	<b>0.8</b>	0	0.25
		False Mat	469	<b>98</b>	0.04	0.28
		Total	49401			



**Figure 4 - L1 Run 3 (P1) 48 Meter**

**Run 7**

Run 7 is similar to Run 6 (not performed at 48 meters) except the occluded probe images were selected only where the MegaMatcher extractor marked a face as present in the image. The occluded probe images with faces present were matched against the enrollment gallery as in Run 6. The purpose of the Run 7 was to determine the possible matching performance of occluded images collected by the SVI system if the Disparity Calculator had the ability to evaluate and select only the images that had faces. The SVI Disparity Calculator did not select any of the occluded images for matching. This Run is used to determine the performance that is possible if the Disparity Calculator had selected better quality face images for matching.

**L1 (L1R748 P1)**

The L1 Run 7 consisted of 835 probes and 99 enrolled subjects where the true accept rate was 46% and the false accept rate was 52%. There were 820 True Matches with 577 of those True Matches occurring within the top rank 10 and 383 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.00 to a high of 5.40. The similarity scores generated for the imposter population was 0.06 to 1.93. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>
<b>L1 R7 SVI48p1FaceOnly Occluded vs. EN</b>						
48 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	835			
		Unique Subjects	78			
	Matches					
		True Mat	383	<b>45.87</b>	0.10	5.40
		False Mat	437	<b>52.34</b>	0.06	1.93
		Total	82665			

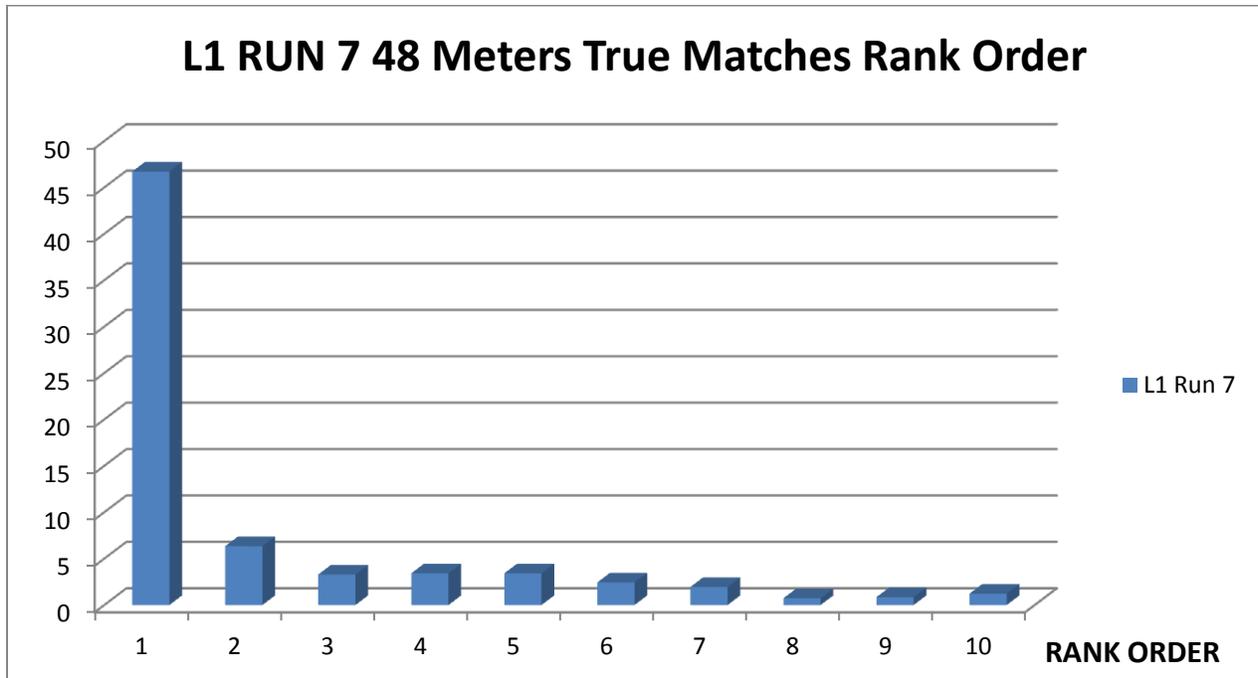


Figure 5 - L1 Run 7 48 Meter

### 50 Meters

There were 18 matching runs conducted at 50 meters; Runs 2, 3, 4, 5, 6, and 7, were ran with both the L1 and MegaMatcher algorithms. In addition, the Sony image frames were ran as Runs 8 (left) and 9 (right). The 18 Runs where images were collected at 50 Meters (Matcher used followed by Run number followed by distance) are identified below: (Note that two of the 50 meter range were conducted with images using the 100 meter focus setting on the SVI binocular (P3).

- L1R250 & MMR250, L1R350 & MMR350, L1R350 (P3), L1R450 & MMR450, L1R550 & MMR550, L1R650 & MMR650, L1R750 & MMR750, L1R750 (P3), L1R850 & MMR850, and L1R950 & MMR950

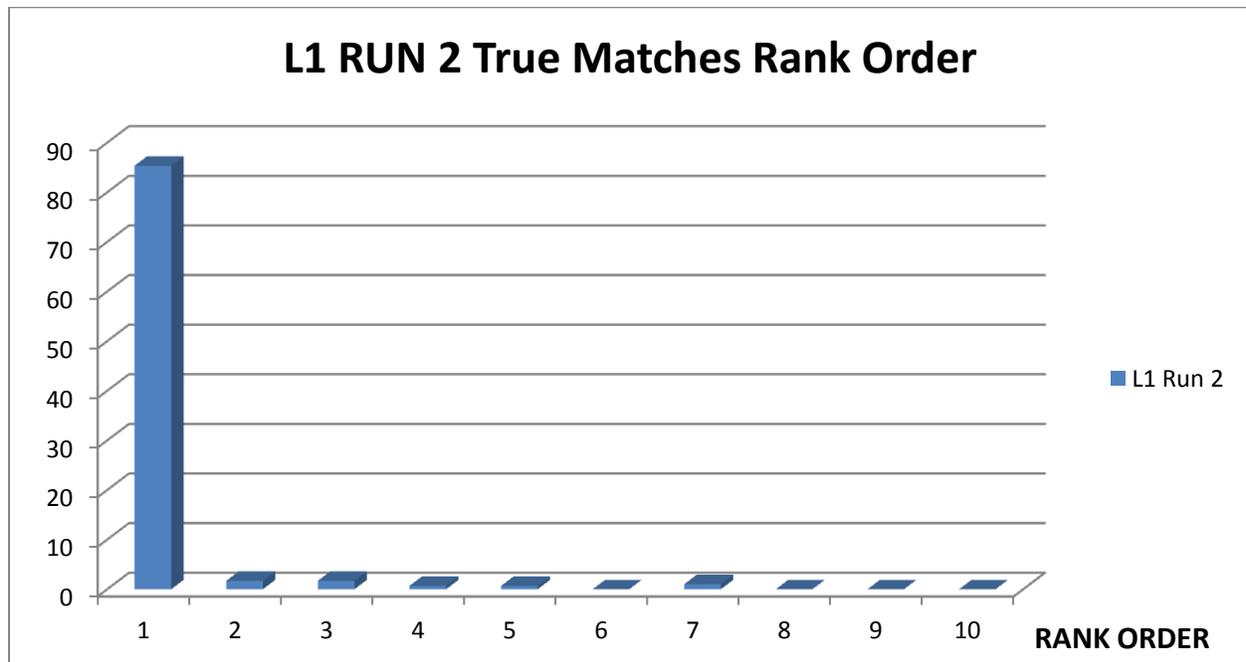
### Run 2

The Run consisted of probe images collected by the Canon w/ 800mm lens at 50 meters matched against the enrollment gallery. Run 2 was executed using both the L1 and MegaMatcher algorithms. The purpose of the Run was to determine the matching performance of current surveillance camera capture capability and match performance using the L1 and MegaMatcher face matching algorithms.

**L1 (L1R250)**

The L1 Run 2 consisted of 300 probes and 99 enrolled subjects where the true accept rate was 84% and the false accept rate was 15%. There were 294 True Matches with 268 of those True Matches occurring within the top rank 10 and 251 were rank 1. The similarity scores for the genuine population ranged from a low of 0.35 to a high of 29.25. The similarity scores generated for the imposter population was 0.1 to 4.82. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R2 Canon vs. En</b>						
50 Meters Canon 800mm vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	300			
		Unique Subjects	98			
	Matches					
		True Mat	251	<b>83.67</b>	0.35	29.25
		False Mat	46	<b>15.33</b>	0.10	4.82
		Total	29700			



**Figure 6 - L1 Run 2 50 Meter**

### MegaMatcher (MMR250)

The MegaMatcher Run 2 consisted of 300 probes and 99 enrolled subjects where the true accept rate was 82% and the false accept rate was 17%. There were 297 True Matches with 263 of those True Matches occurring within the top rank 10 and 246 were rank 1. The similarity scores for the genuine population ranged from a low of 7 to a high of 387. The similarity scores generated for the imposter population was 4 to 21. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R2 Canon vs. En</b>						
50 Meters Canon 800mm vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	300			
		Unique Subjects	98			
	Matches					
		True Mat	246	<b>82.00</b>	7	387
		False Mat	51	<b>17.00</b>	4	21
		Total	29700			

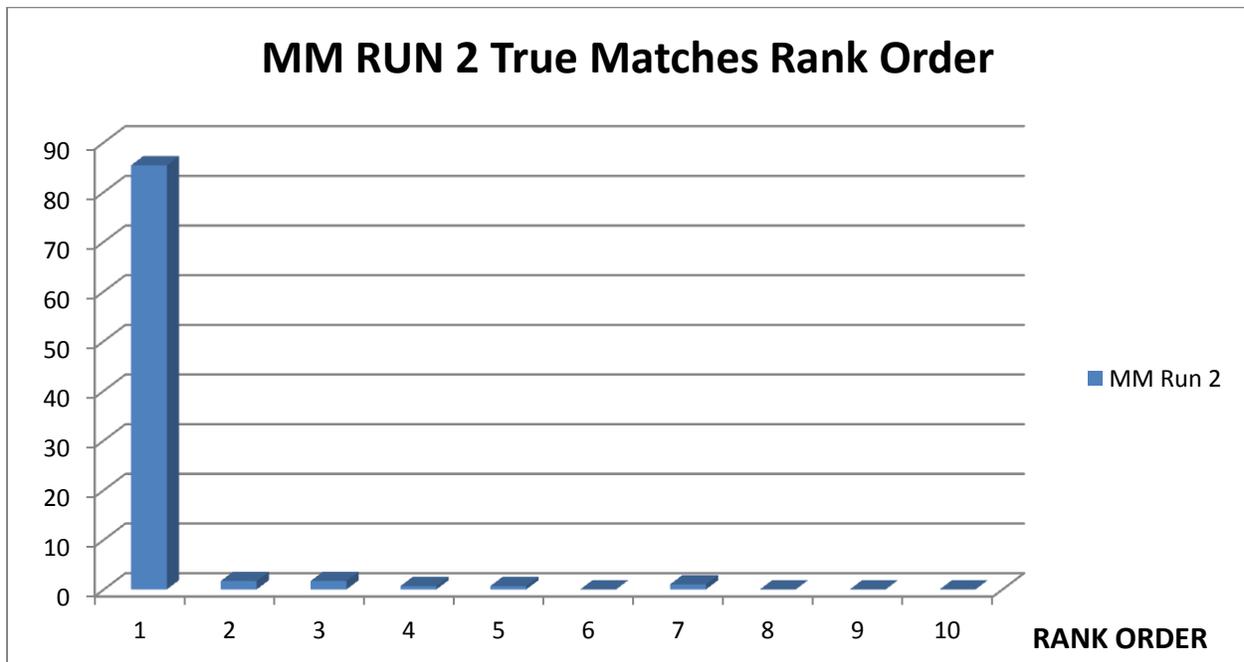


Figure 7 - MM Run 2 50 Meter

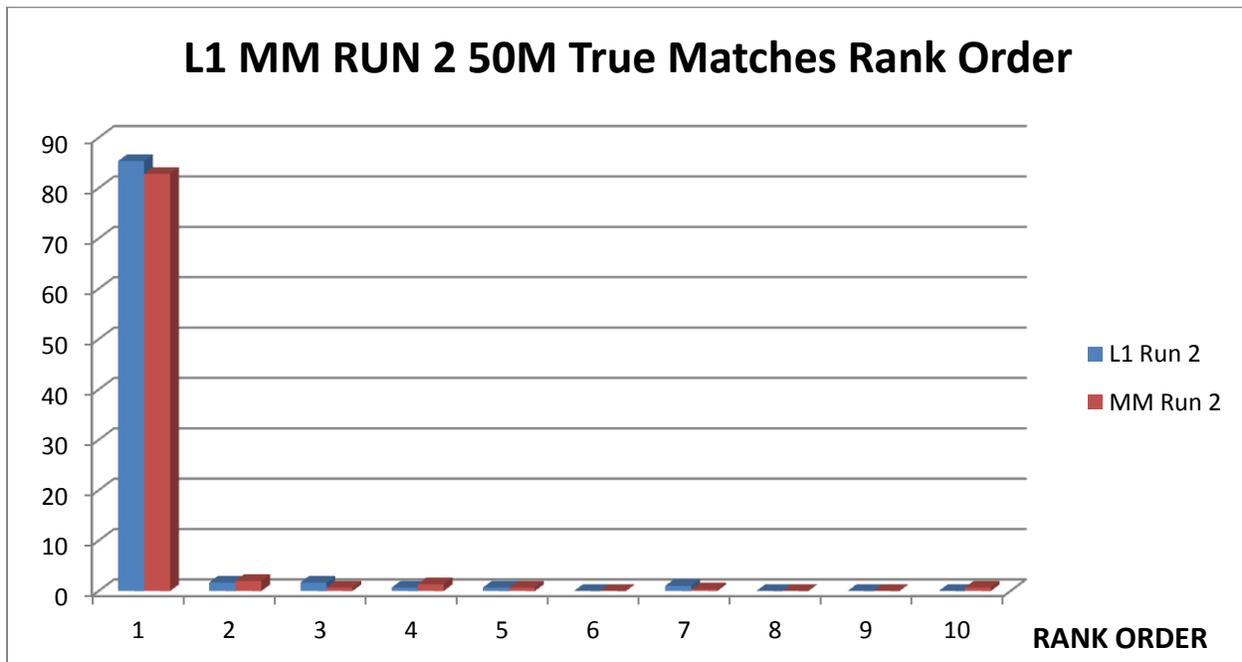


Figure 8 - L1 MM Run 2 50 Meter

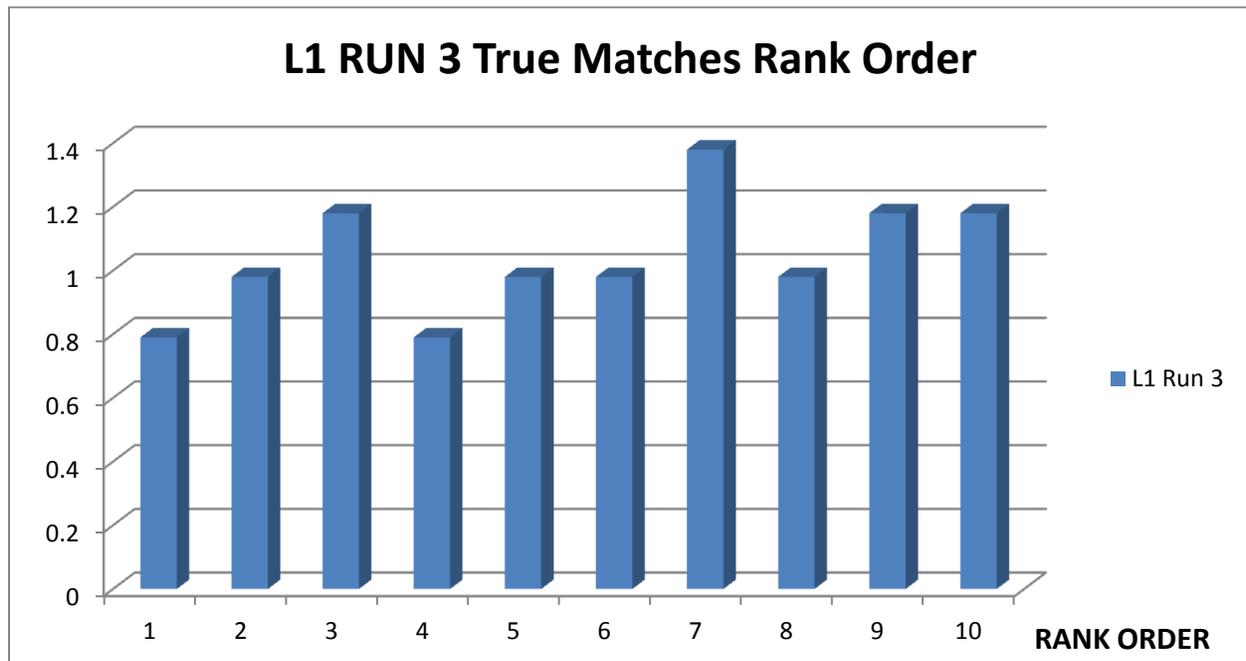
### Run 3

The Run 3 consisted of probe images collected by the SVI binocular at 50 meters presets 1 and 3 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of the SVI system software in an autonomous mode. This Run represents the capability of the SVI Disparity Calculator to operate without manual intervention. The SVI binocular collected left and right VUR files that were input to the SVI Disparity Calculator where 15 images are created (5 left, 5 right, and 5 occluded) and the L1 face matcher selected the images that are probes for matching to the enrollment gallery. The SVI system did not choose any of the occluded images only left and right.

**L1 (L1R350 P1)**

L1 Run 3 consisted of 515 probes and 99 enrolled subjects. There were 509 True Matches with 53 of those True Matches occurring within the top rank 10 and 4 matches were rank 1. The true accept rate was 0.8% and the false accept rate was 98%. The similarity scores for the genuine population ranged from a low of 0.10 to a high of 0.34. The similarity scores generated for the imposter population was 0.04 to 0.94. Also of note, there were 7 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R3 SVI50p1DC vs. EN</b>						
50 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	515			
		Unique Subjects	91	Note: 7 image pairs crashed DC		
	Matches	True Mat	4	<b>0.78</b>	0.10	0.34
		False Mat	505	<b>98.06</b>	0.04	0.94
		Total	50985			



**Figure 9 - L1 Run 3 (P1) 50 Meter**

### L1R350 P3

L1 Run 3 (P3) was repeated using the 50 meter images collected with the SVI focal setting on 100 meters (P3). It consisted of 120 probes and 99 enrolled subjects where the true accept rate was 0.8% and the false accept rate was 99%. There were 120 True Matches with 7 of those True Matches occurring within the top rank 10 and 1 match was rank 1. The similarity scores for the genuine population ranged from a low of 0.09 to a high of 0.09. The similarity scores generated for the imposter population was 0.04 to 0.25. Also of note, there were 7 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description	Results	Percent	Score Min	Score Max	
<b>L1 R3</b> <b>SVI50p3DC vs.</b> <b>EN</b>						
50 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	120			
		Unique Subjects	36	Note: 7 image pairs crashed DC		
	Matches					
		True Mat	1	<b>0.83</b>	0.09	0.09
		False Mat	119	<b>99.17</b>	0.04	0.25
		Total	11880			

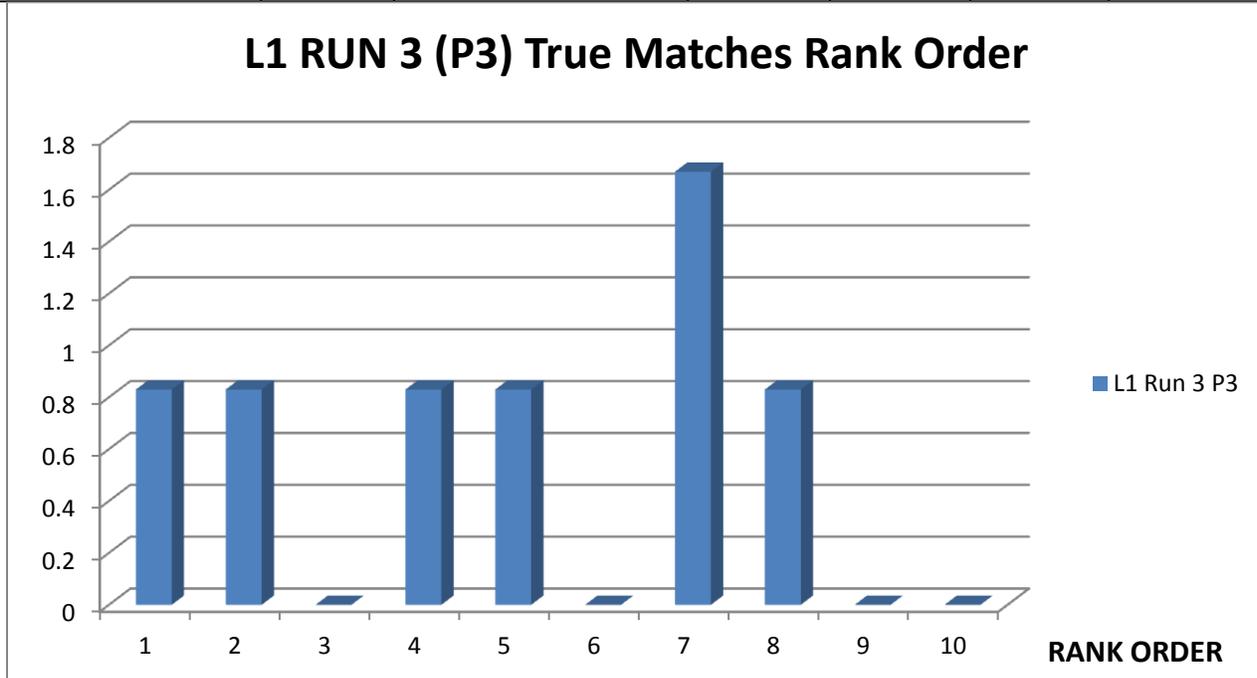
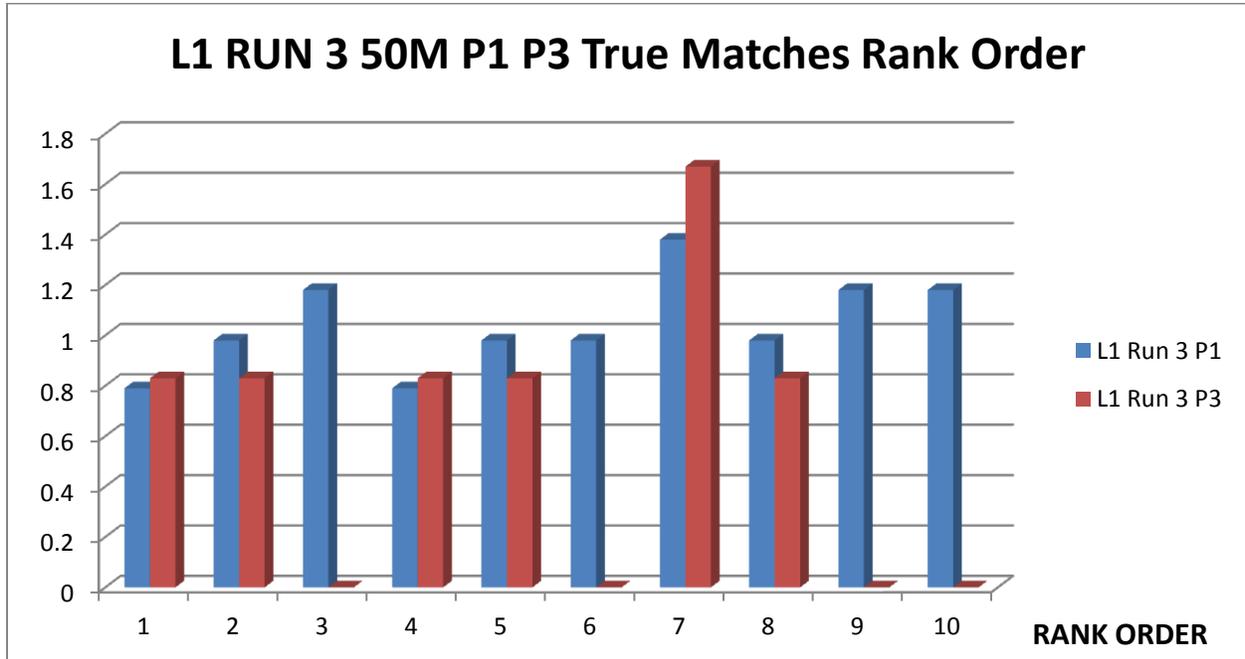


Figure 10 - L1 Run 3 (P3) 50 Meter

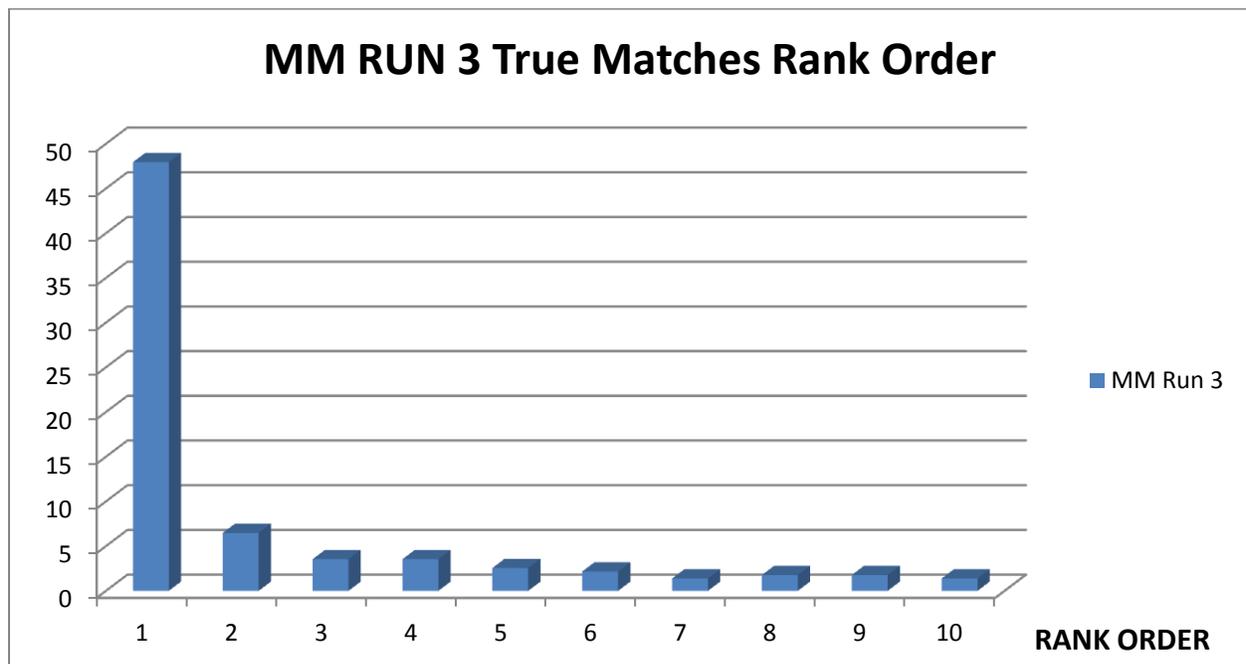


**Figure 11 - L1 Run 3 P1 & P3 50 Meter**

**MegaMatcher (MMR350)**

MegaMatcher Run 3 consisted of 515 probes and 99 enrolled subjects where the true accept rate was 47% and the false accept rate was 51%. There were 509 True Matches with 369 of those True Matches occurring within the top rank 10 and 244 matches were rank 1. The similarity scores for the genuine population ranged from a low of 7 to a high of 114. The similarity scores generated for the imposter population was 5 to 28. Also of note, there were 7 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R3 SVI50p1DC vs. EN</b>						
50 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	515			
		Unique Subjects	91	Note: 7 image pairs crashed DC		
	Matches	True Mat	244	<b>47.38</b>	7	114
		False Mat	265	<b>51.46</b>	5	28
		Total	50985			



**Figure 12 - MM Run 3 50 Meter**

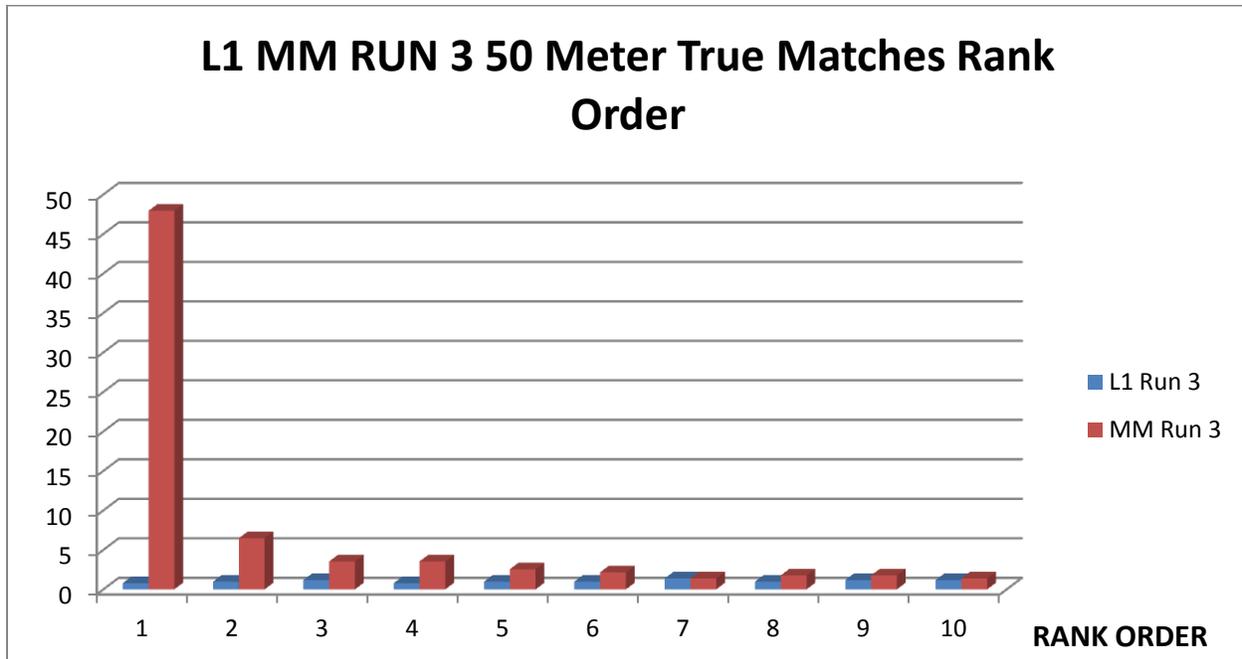


Figure 13 - L1 MM Run 3 50 Meter

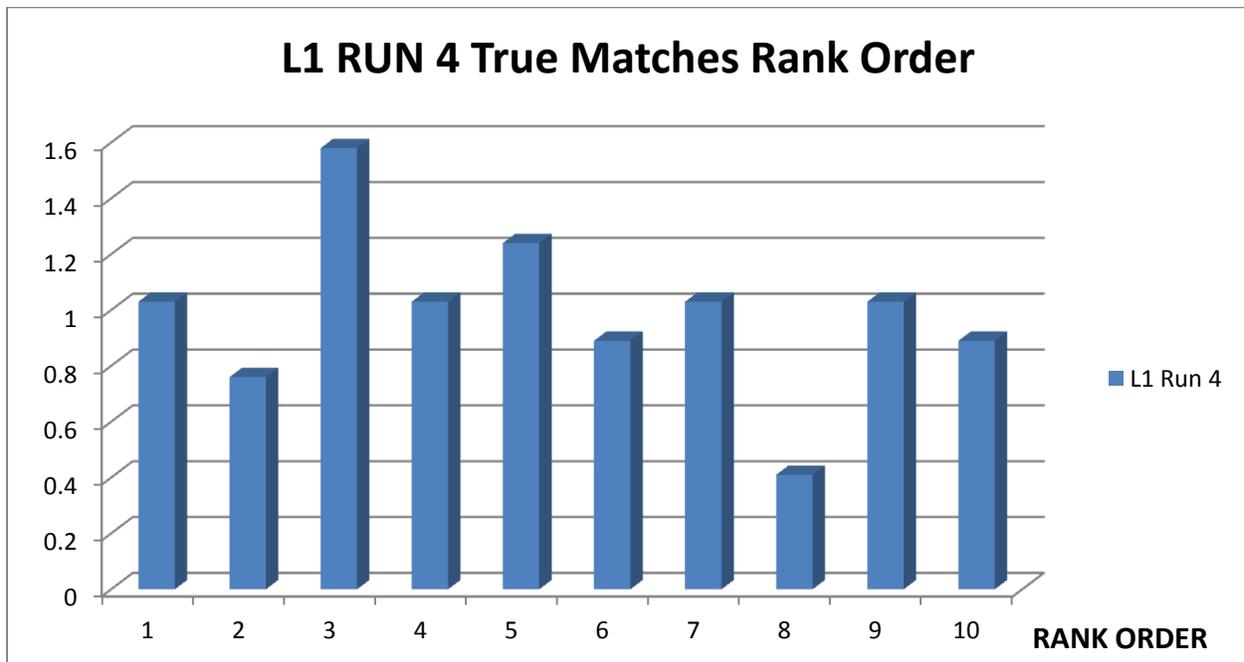
**Run 4**

The Run 4 consisted of the 5 left probe images generated by the Disparity Calculator using the VURs collected by the SVI binocular at 50 meters preset 1 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of all left images collected by the SVI system. This Run will be compared with the right collected images to determine if there is a significant difference in the quality of the images between the left and right imaging paths in the SVI binocular.

**L1 (L1R450)**

The L1 Run 4 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 1% and the false accept rate was 98%. There were 1455 True Matches with 144 of those True Matches occurring within the top rank 10 and 15 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.09 to a high of 1.93. The similarity scores generated for the imposter population was 0.03 to 1.00. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R4 SVI50p1AllLeft vs. EN</b>						
50 Meter SVI all left Tiff (non color, non occluded) vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	1470			
		Unique Subjects	100			
	Matches					
		True Mat	15	<b>1.02</b>	0.09	1.93
		False Mat	1440	<b>97.96</b>	0.03	1.00
		Total	145530			

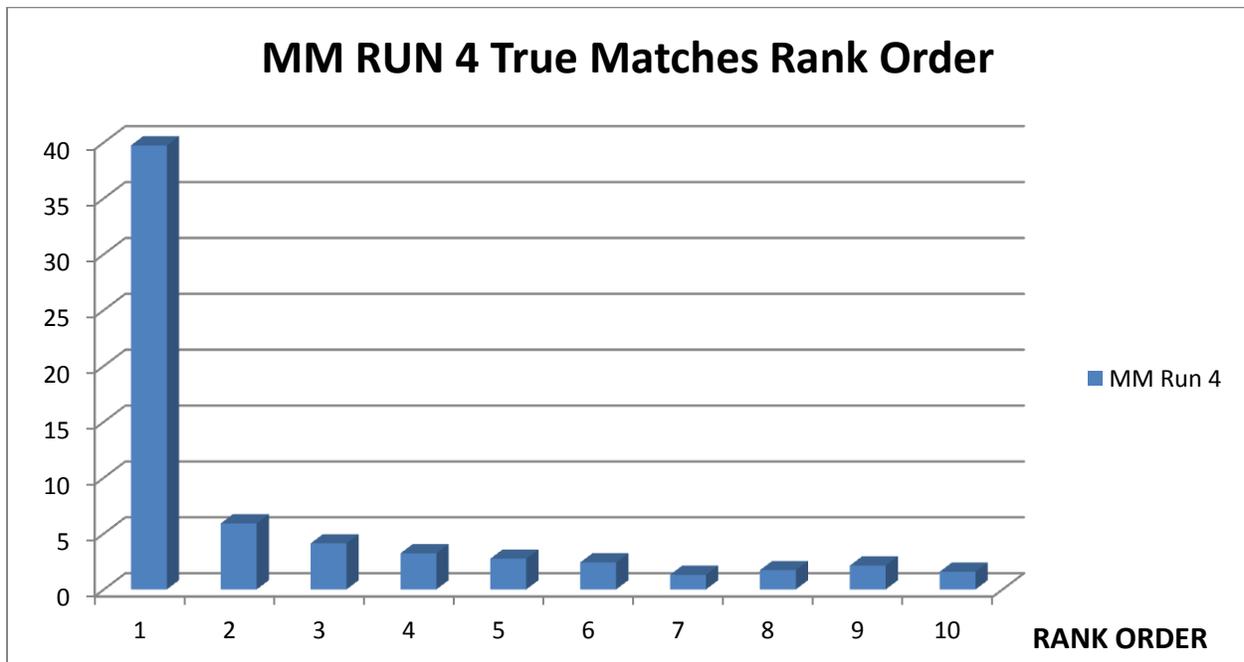


**Figure 14 - L1 Run 4 50 Meter**

**MegaMatcher (MMR450)**

The MegaMatcher Run 4 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 39% and the false accept rate was 60%. There were 1455 True Matches with 944 of those True Matches occurring within the top rank 10 and 578 matches were rank 1. The similarity scores for the genuine population ranged from a low of 6 to a high of 117. The similarity scores generated for the imposter population was 1 to 28. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R4 SVI50p1AllLeft vs. EN</b>						
50 Meter SVI all left Tiff (non color, non occluded) vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	1470			
		Unique Subjects	100			
	Matches					
		True Mat	578	<b>39.32</b>	6	117
		False Mat	877	<b>59.66</b>	1	28
		Total	145530			



**Figure 15 - MM Run 4 50 Meter**

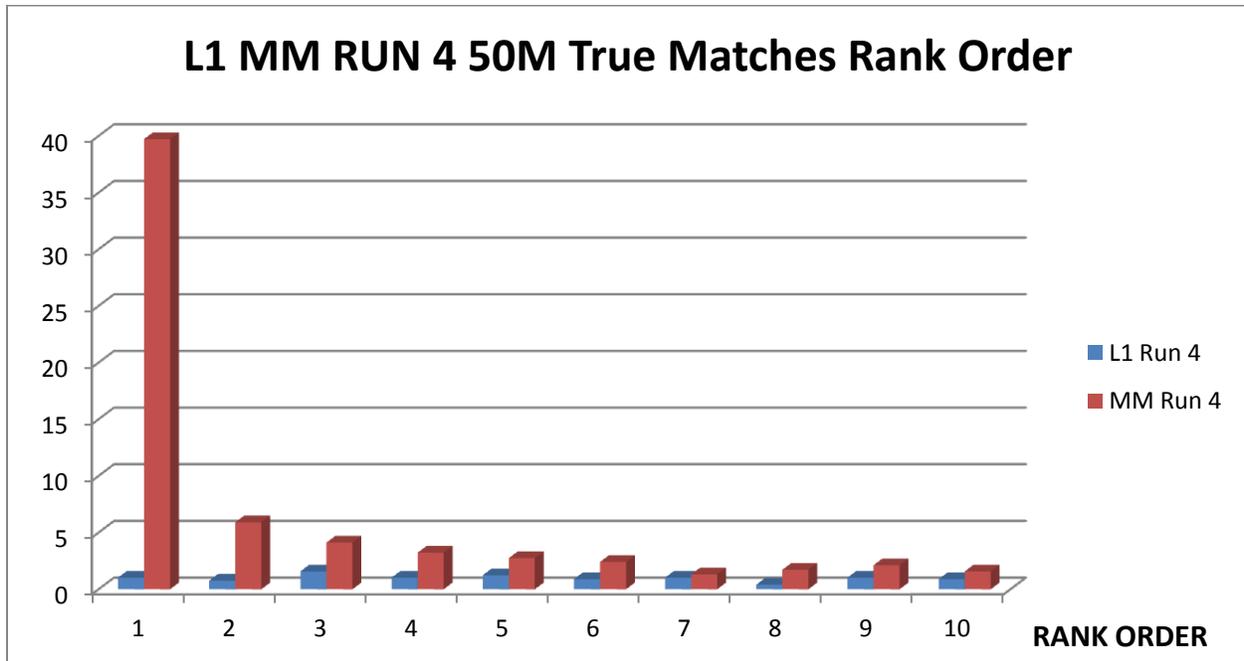


Figure 16 - L1 MM Run 4 50 Meter

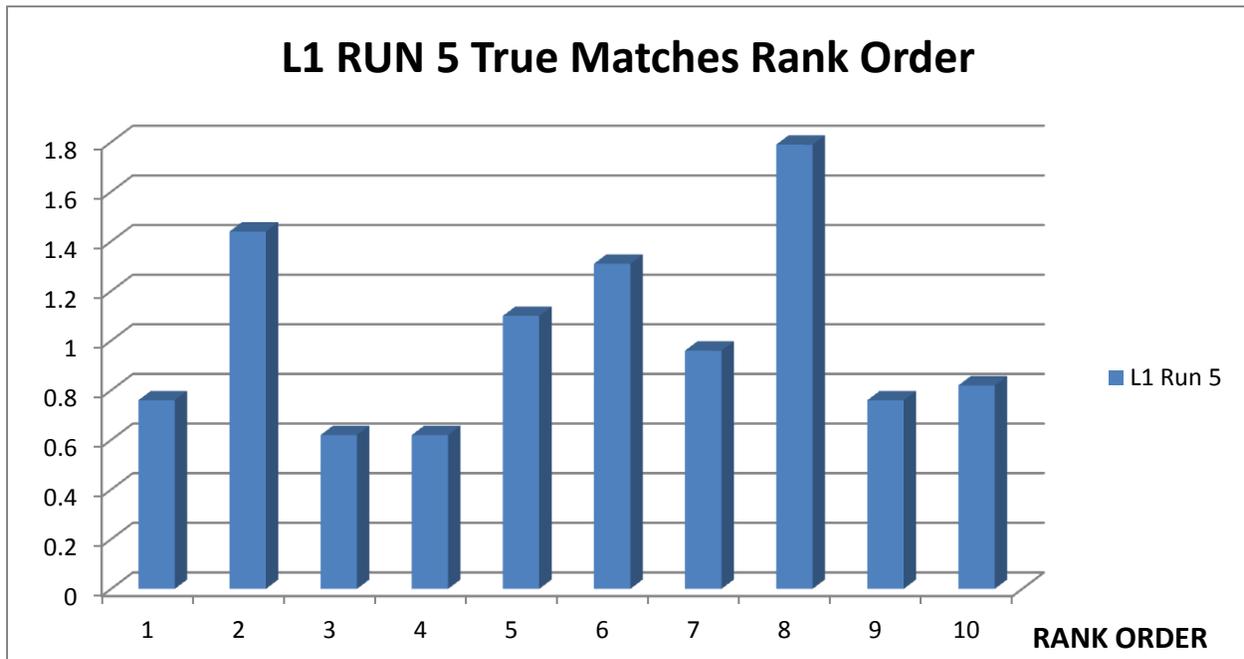
### Run 5

The Run 5 consisted of the 5 right probe images generated by the Disparity Calculator using the VURs collected by the SVI binocular at 50 meters preset 1 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of all right images collected by the SVI system. This Run will be compared with the left collected images to determine if there is a significant difference in the quality of the images between the left and right imaging paths in the SVI binocular.

**L1 (L1R550)**

The L1 Run 5 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 1% and the false accept rate was 98%. There were 1455 True Matches with 148 of those True Matches occurring within the top rank 10 and 11 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.08 to a high of 0.18. The similarity scores generated for the imposter population was 0.04 to 0.96. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max	
<b>L1 R5 SVI50p1AR vs. EN</b>							
50 Meter SVI all right Tiff (non color, non occluded) vs. Enrollments	Gallery	Total	99				
		Unique Subjects	99				
	Probe	Total	1470				
		Unique Subjects	100				
	Matches						
		True Mat	11	<b>0.75</b>	0.08	0.18	
		False Mat	1444	<b>98.23</b>	0.04	0.96	
		Total	145530				

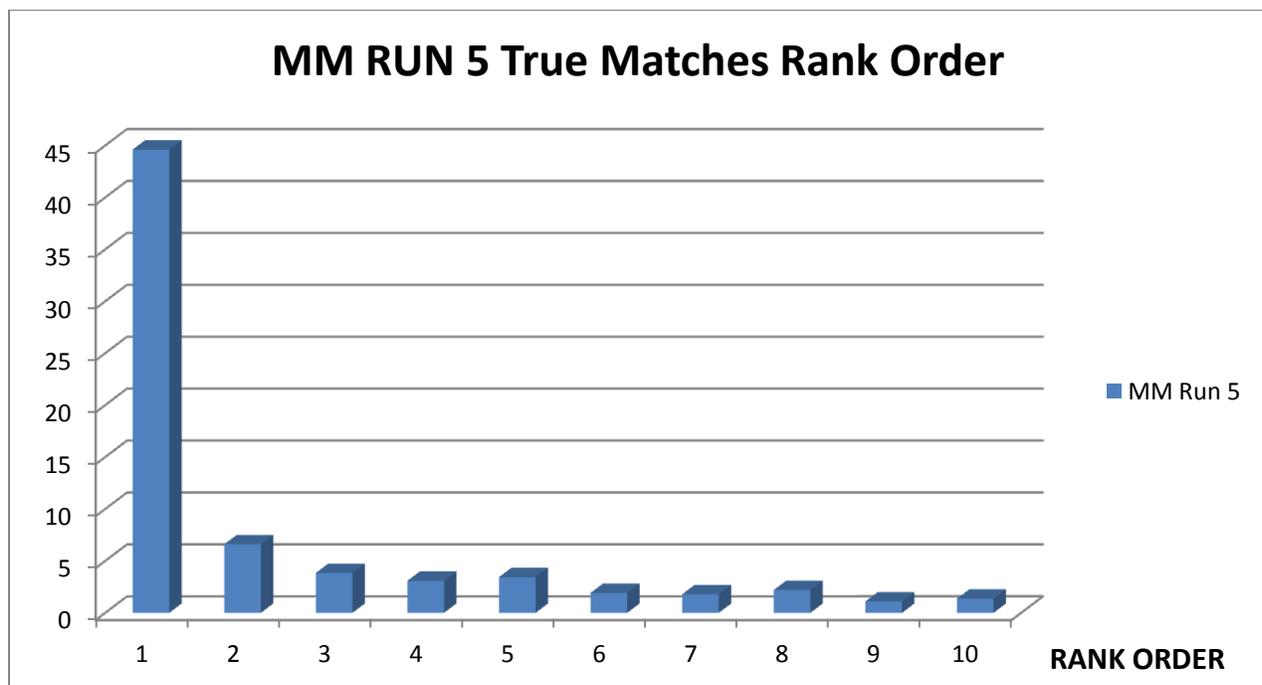


**Figure 17 - L1 Run 5 50 Meter**

**MegaMatcher (MMR550)**

The MegaMatcher Run 5 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 44% and the false accept rate was 55%. There were 1455 True Matches with 1,018 of those True Matches occurring within the top rank 10 and 649 matches were rank 1. The similarity scores for the genuine population ranged from a low of 8 to a high of 104. The similarity scores generated for the imposter population was 2 to 27. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max	
<b>MM R5 SVI50p1AR vs. EN</b>							
50 Meter SVI all right Tiff (non color, non occluded) vs. Enrollments	Gallery	Total	99				
		Unique Subjects	99				
	Probe	Total	1470				
		Unique Subjects	100				
	Matches						
			True Mat	649	<b>44.15</b>	8	104
			False Mat	806	<b>54.83</b>	2	27
			Total	145530			



**Figure 18 - MM Run 5 50 Meter**

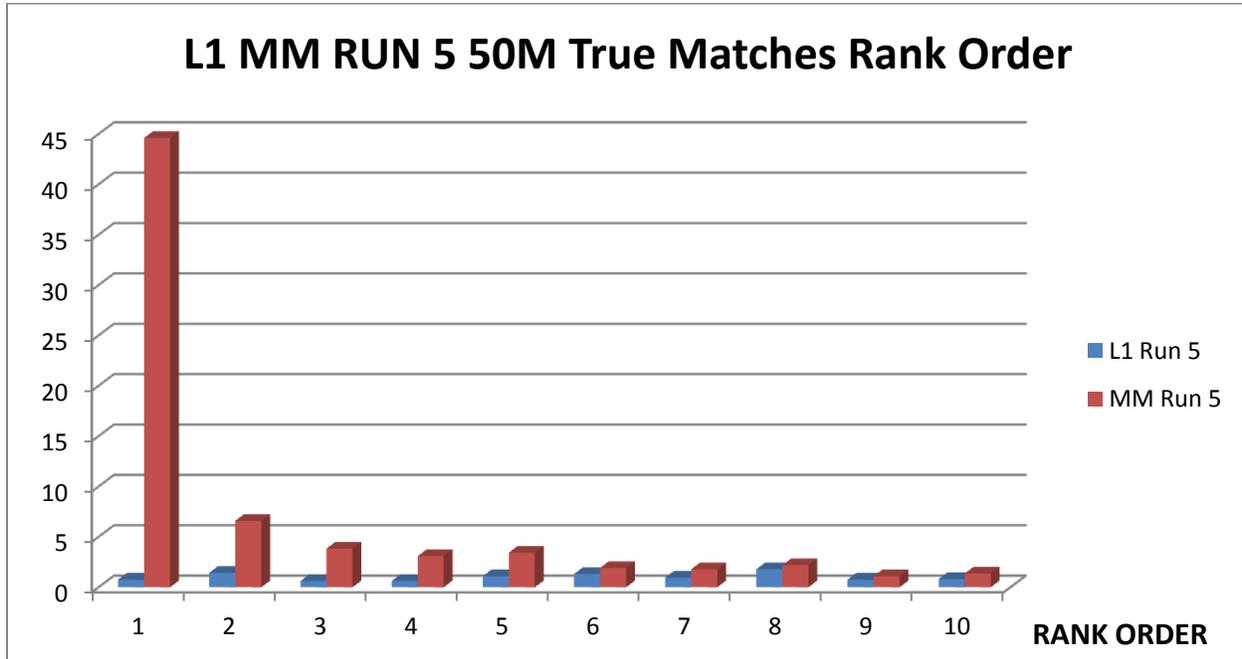


Figure 19 - L1 MM Run 5 50 Meter

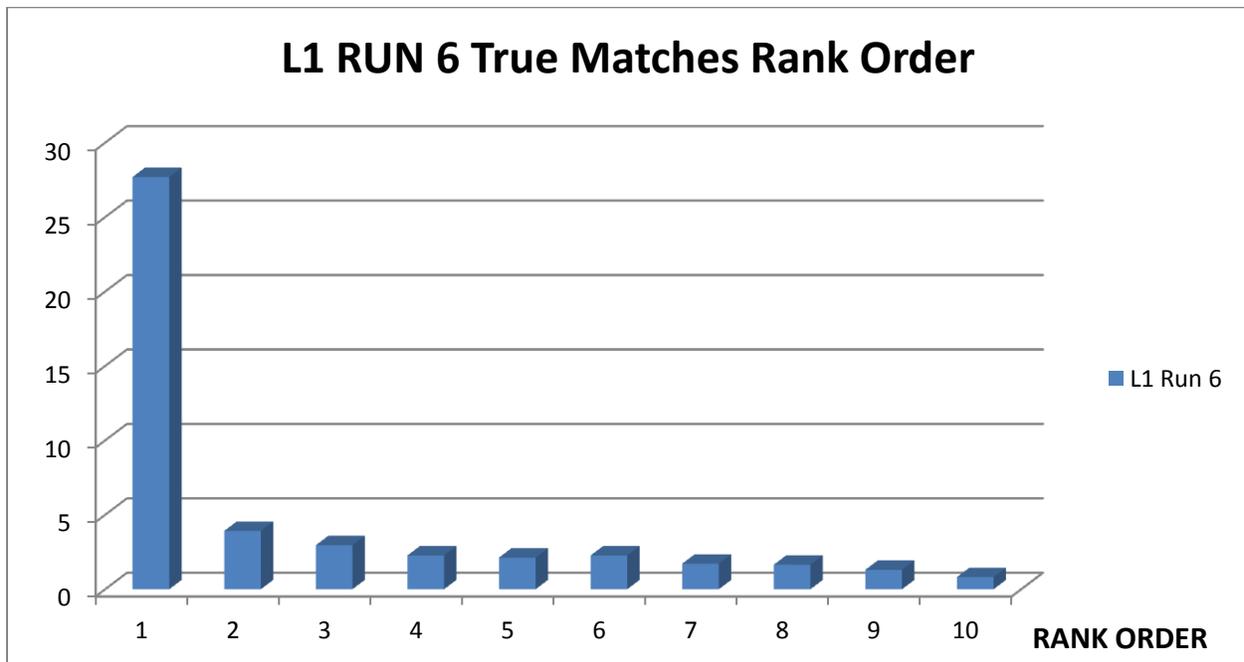
### Run 6

The Run 6 consisted of all occluded probe images generated by the Disparity Calculator from the VURs collected by the SVI binocular at 50 meters preset 1 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of all occluded images collected by the SVI system. This Run is used to determine the change in performance resulting from the Disparity Calculator combining the left and right images so that the background is removed prior to matching.

**L1 (L1R650)**

The L1 Run 6 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 27% and the false accept rate was 72%. There were 1455 True Matches with 680 of those True Matches occurring within the top rank 10 and 403 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.07 to a high of 13.15. The similarity scores generated for the imposter population was 0.04 to 2.18. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R6 SVI50p1All Occluded vs. EN</b>						
50 Meter SVI all occluded Tiff vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	1470			
		Unique Subjects	100			
	Matches					
		True Mat	403	<b>27.41</b>	0.07	13.15
		False Mat	1052	<b>71.56</b>	0.04	2.18
		Total	145530			

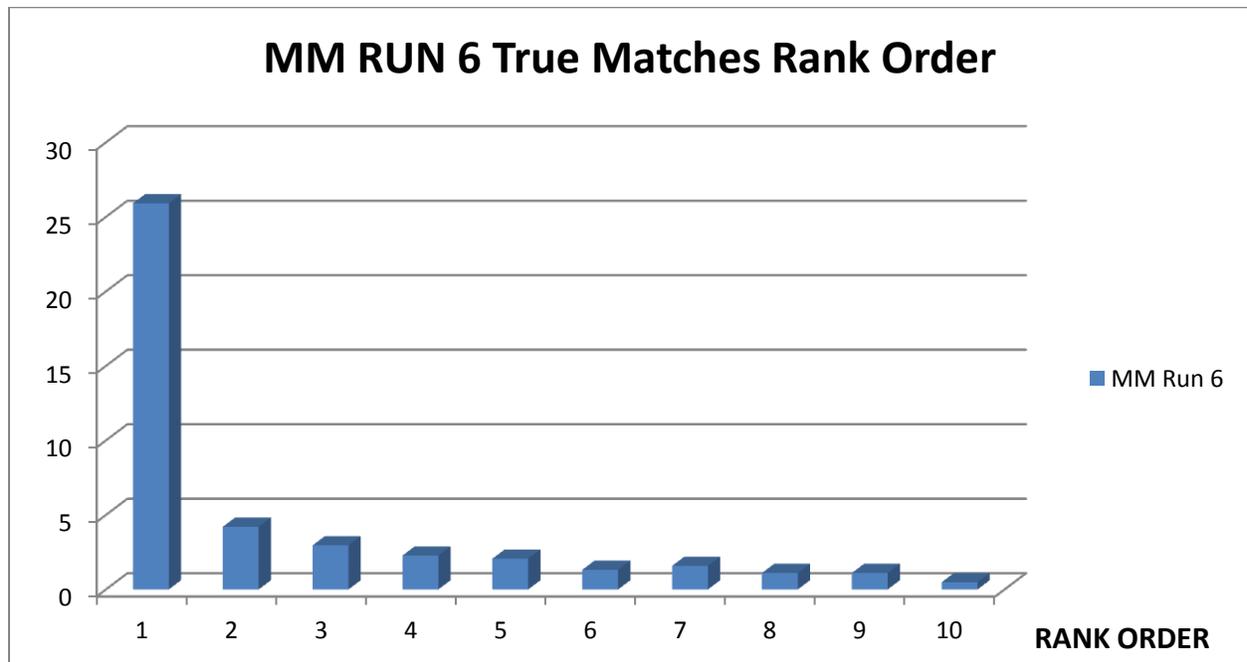


**Figure 20 - L1 Run 6 50 Meter**

**MegaMatcher (MMR650)**

The MegaMatcher Run 6 consisted of 1470 probes and 99 enrolled subjects where the true accept rate was 26% and the false accept rate was 73%. There were 1455 True Matches with 625 of those True Matches occurring within the top rank 10 and 377 matches were rank 1. The similarity scores for the genuine population ranged from a low of 3 to a high of 114. The similarity scores generated for the imposter population was 0 to 28. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R6 SVI50p1All Occluded vs. EN</b>						
50 Meter SVI all occluded Tiff vs. ENrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	1470			
		Unique Subjects	100			
	Matches					
		True Mat	377	<b>25.65</b>	3	114
		False Mat	1078	<b>73.33</b>	0	28
		Total	145530			



**Figure 21 - MM Run 6 50 Meter**

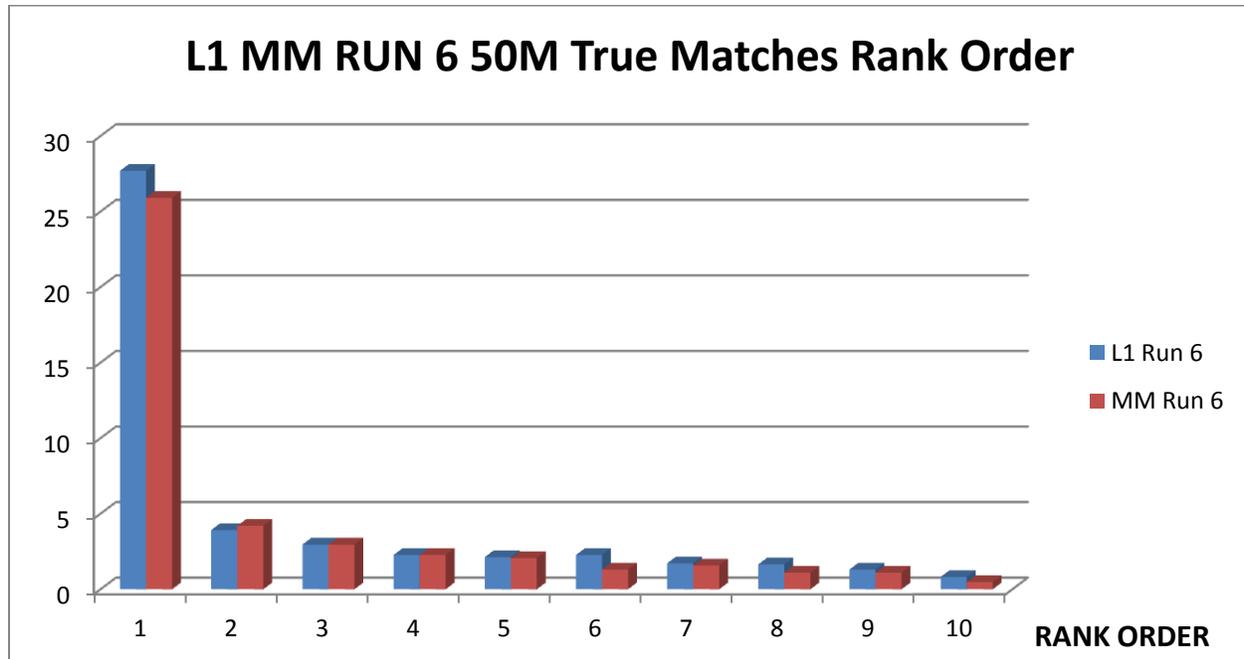


Figure 22 - L1 MM Run 6 50 Meter

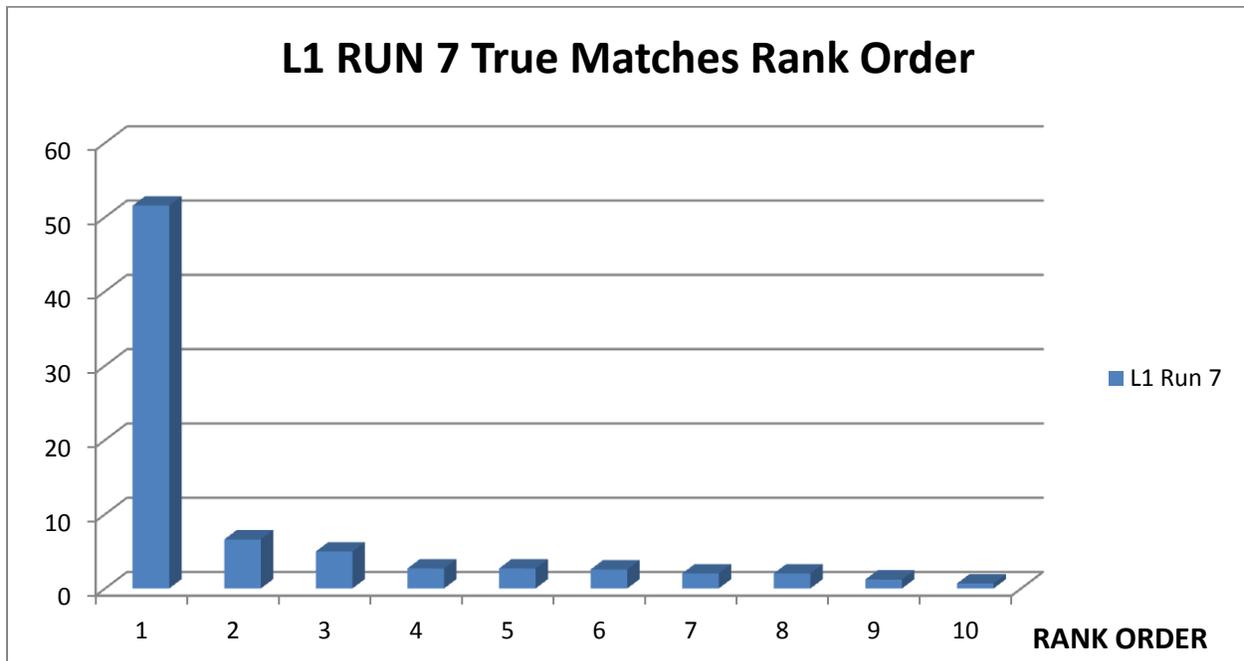
### Run 7

Run 7 is similar to Run 6 except the occluded probe images were selected only where the MegaMatcher extractor marked a face as present in the image. The occluded probe images with faces present were matched against the enrollment gallery as in Run 6. The purpose of the Run 7 was to determine the possible matching performance of occluded images collected by the SVI system if the Disparity Calculator had the ability to evaluate and select only the images that had faces. The SVI Disparity Calculator did not select any of the occluded images for matching. This Run is used to determine the performance that is possible if the Disparity Calculator had selected occluded face images for matching.

**L1 (L1R750 P1)**

The L1 Run 7 consisted of 758 probes and 99 enrolled subjects where the true accept rate was 51% and the false accept rate was 48%. There were 743 True Matches with 572 of those True Matches occurring within the top rank 10 and 383 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.12 to a high of 13.15. The similarity scores generated for the imposter population was 0.06 to 2.18. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max	
<b>L1 R7 SVI50p1FaceOnly Occluded vs. EN</b>							
50 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99				
		Unique Subjects	99				
	Probe	Total	758				
		Unique Subjects	76				
	Matches						
			True Mat	383	<b>50.53</b>	0.12	13.15
			False Mat	360	<b>47.49</b>	0.06	2.18
			Total	75042			

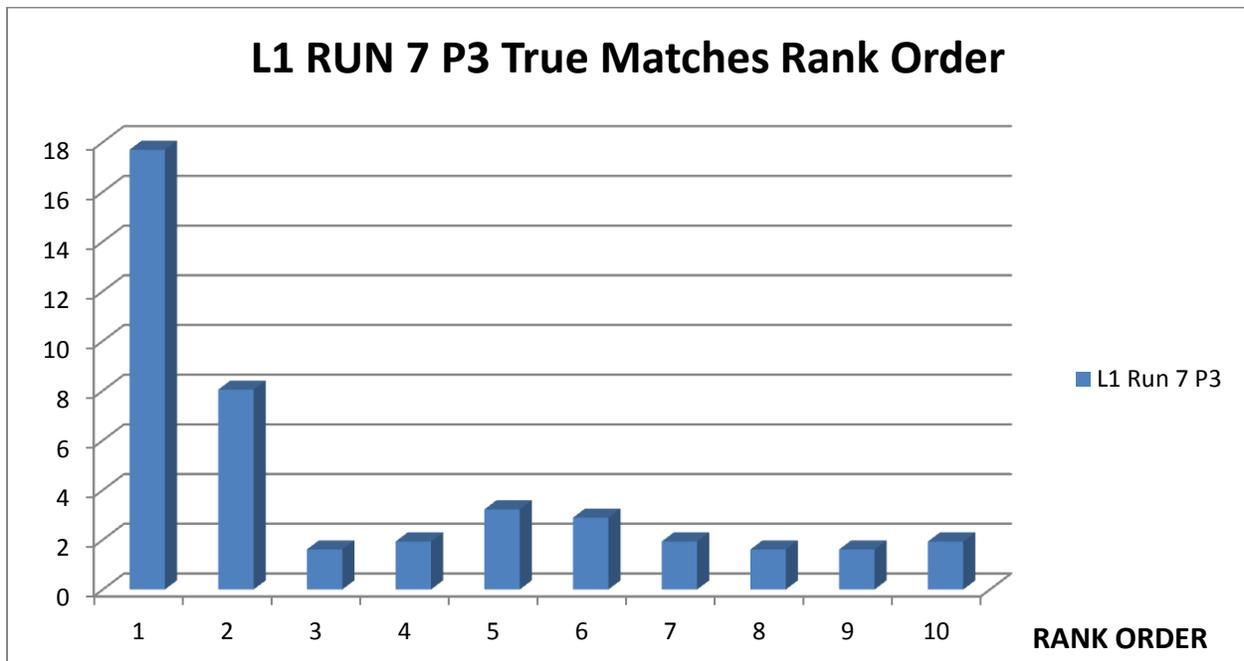


**Figure 23 - L1 Run 7 50 Meter**

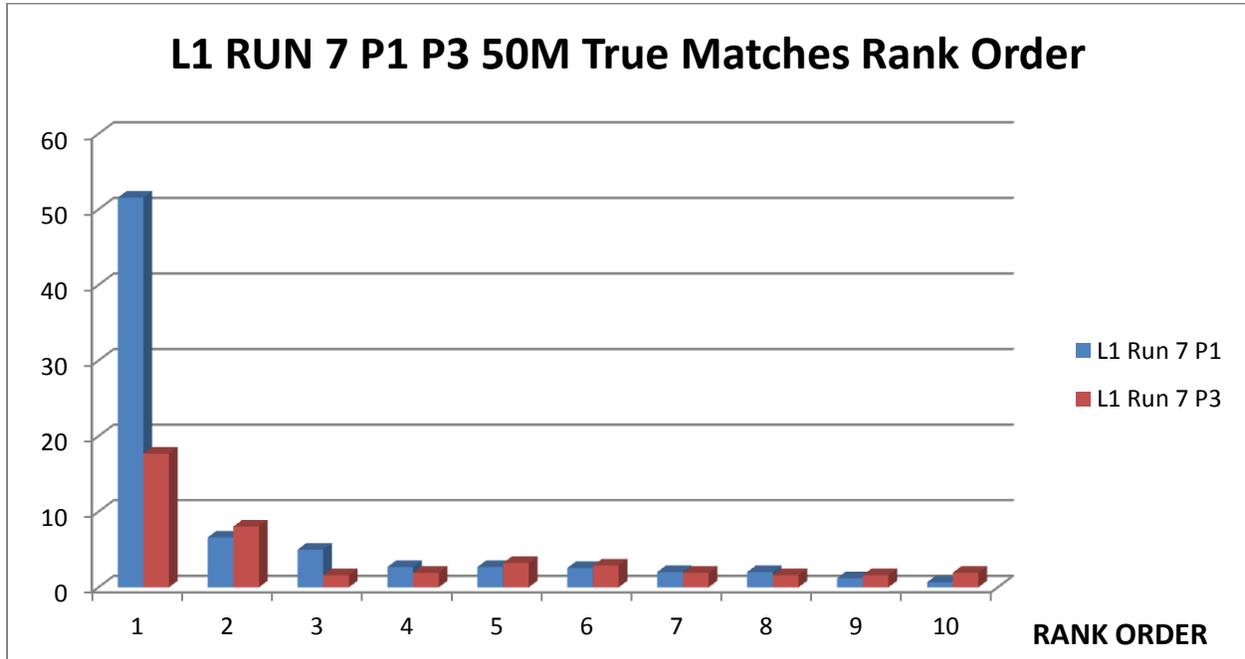
**L1 (L1R750 P3)**

Another L1 Run 7 was conducted using the occluded images collected at 50 meters using the 100 meter SVI binocular setting (P3) where MegaMatcher identified faces. This Run consisted of 311 probes and 99 enrolled subjects where the true accept rate was 18% and the false accept rate was 82%. There were 311 True Matches with 132 of those True Matches occurring within the top rank 10 and 55 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.11 to a high of 2.14. The similarity scores generated for the imposter population was 0.04 to 1.80. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R7 SVI50p3FaceOnly Occluded vs. EN</b>						
50 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	311			
		Unique Subjects	48			
	Matches					
		True Mat	55	<b>17.68</b>	0.11	2.14
		False Mat	256	<b>82.32</b>	0.04	1.80
	Total	30789				



**Figure 24 - L1 Run 7 P3 50 Meter**

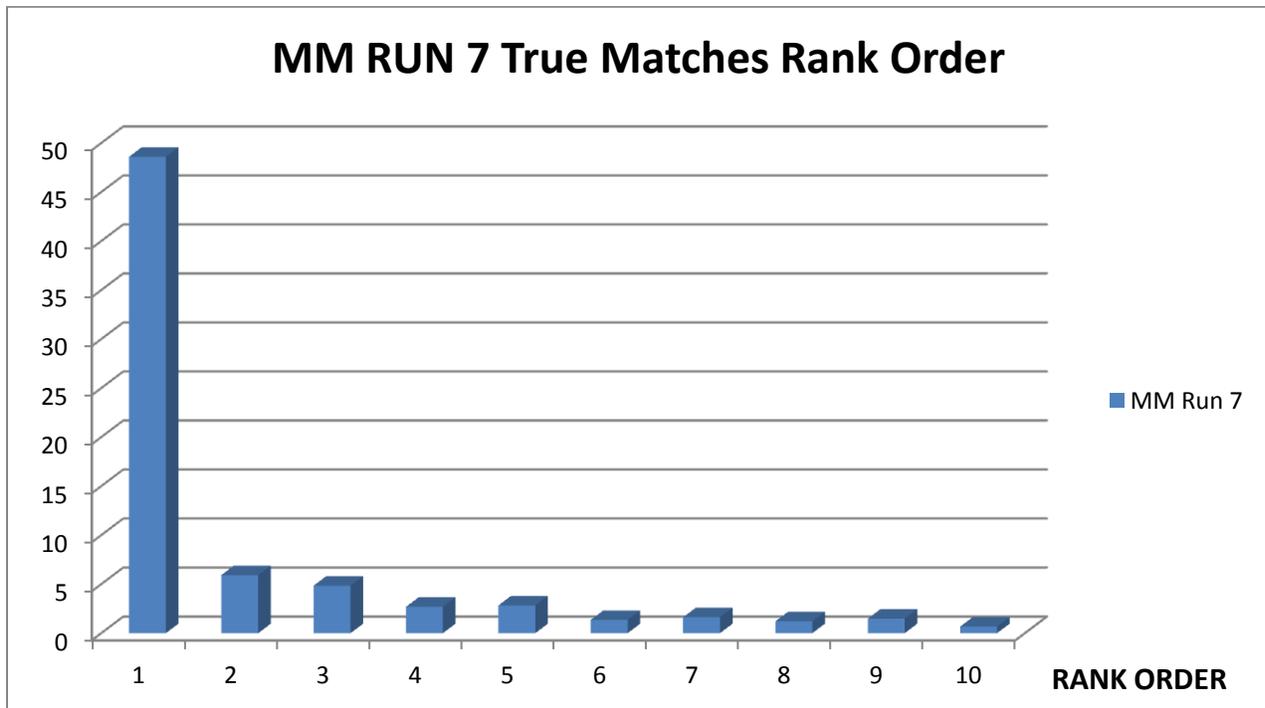


**Figure 25 - L1 Run 7 P1 & P3 50 Meter**

**MegaMatcher (MMR750)**

The MM Run 7 consisted of 758 probes and 99 enrolled subjects where the true accept rate was 48% and the false accept rate was 50%. There were 743 True Matches with 529 of those True Matches occurring within the top rank 10 and 361 matches were rank 1. The similarity scores for the genuine population ranged from a low of 7 to a high of 114. The similarity scores generated for the imposter population was 4 to 28. The graph provided represents the frequency of True Matches for each Rank Order on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max	
<b>MM R7 SVI50p1FaceOnly Occluded vs. EN</b>							
50 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99				
		Unique Subjects	99				
	Probe	Total	758				
		Unique Subjects	76				
	Matches						
			True Mat	361	<b>47.63</b>	7	114
			False Mat	382	<b>50.40</b>	4	28
			Total	75042			



**Figure 26 - MM Run 7 50 Meter**

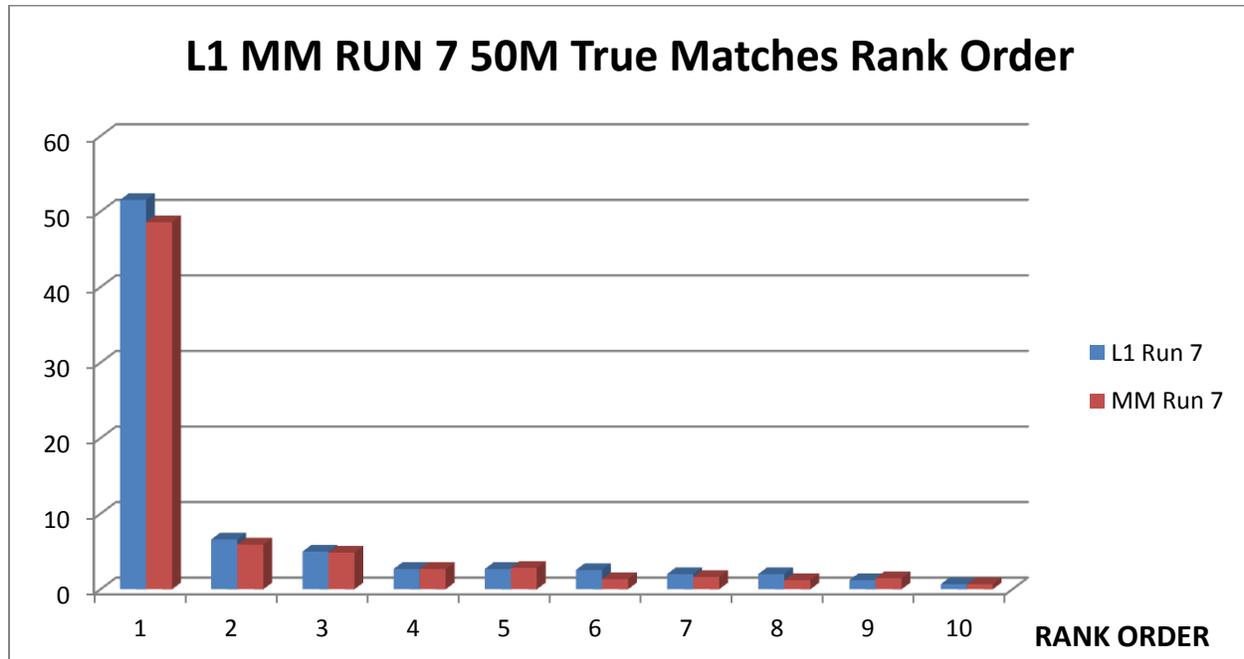


Figure 27 - L1 MM Run 7 50 Meter

### Run 8

Run 8 probe images consisted of 279 left images extracted from the Sony video files and matched to each of the subjects in the enrollment gallery. Three randomly selected image files (frames 7, 18, and 19) from the Sony video file were used for each subject and matched against the enrollment gallery. The 3 right images were selected based on the left selection so that a left/right matched pair of images were evaluated for match performance.

**L1 (L1R850)**

Out of the 279 left probe images only one was a rank 1 true match with 275 false matches. There were 276 True Matches with 26 of those True Matches occurring within the top rank 10 and 1 match was rank 1. The true rank one match rate was 0.4 percent and the false rank was 98.6 percent. The similarity scores for the genuine population ranged from a low of 0.18 to a high of 0.18. The similarity scores generated for the imposter population was 0.05 to 1.97.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R8 Sony Left Images vs. EN</b>						
50 Meter Sony Left Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	279			
		Unique Subjects	93			
	Matches					
		True Mat	1	<b>0.36</b>	0	0.18
		False Mat	275	<b>98.57</b>	0.05	0.39
	Total	27621				

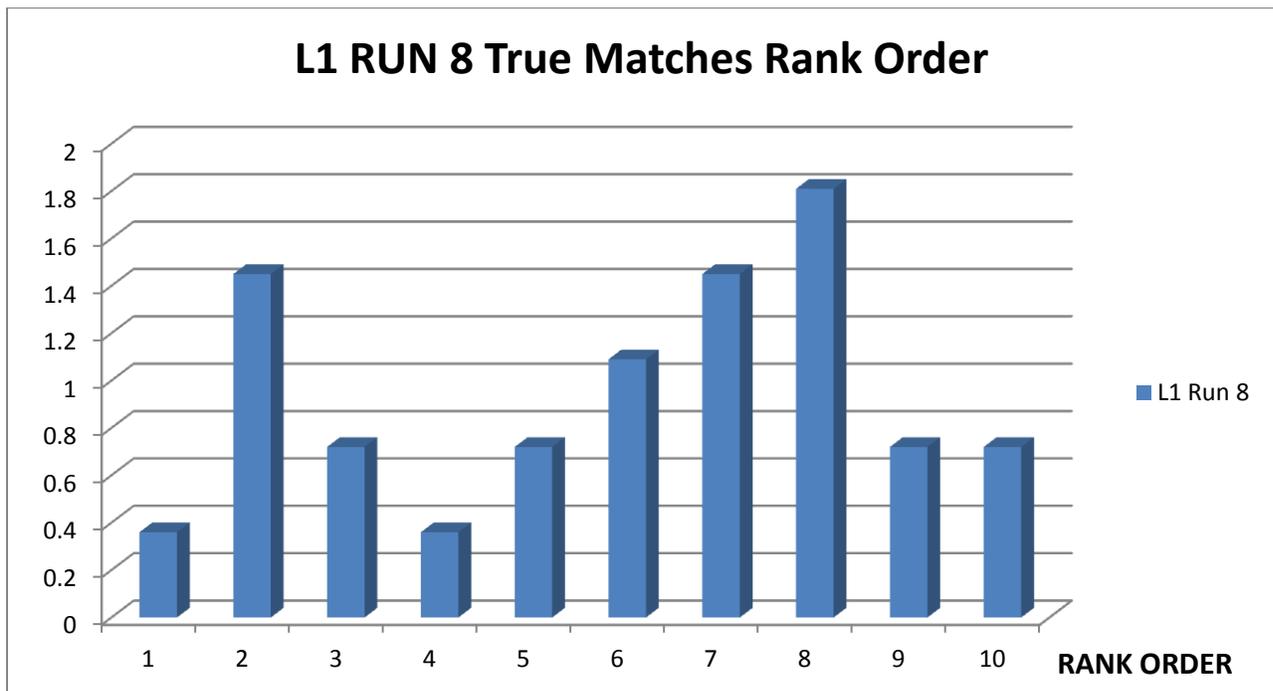


Figure 28 - L1 Run 8 50 Meter

### MegaMatcher (MMR850)

Out of the 279 left probe images only 7 were a rank 1 true match with 269 false matches. There were 276 True Matches with 53 of those True Matches occurring within the top rank 10 and 7 matches were rank 1. The true rank one match rate was 3 percent and the false rank was 96 percent.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R8 Sony Left Images vs. EN</b>						
50 Meter Sony Left Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	279			
		Unique Subjects	93			
	Matches					
		True Mat	7	<b>2.51</b>	0	15
		False Mat	269	<b>96.42</b>	1	23
		Total	27621			

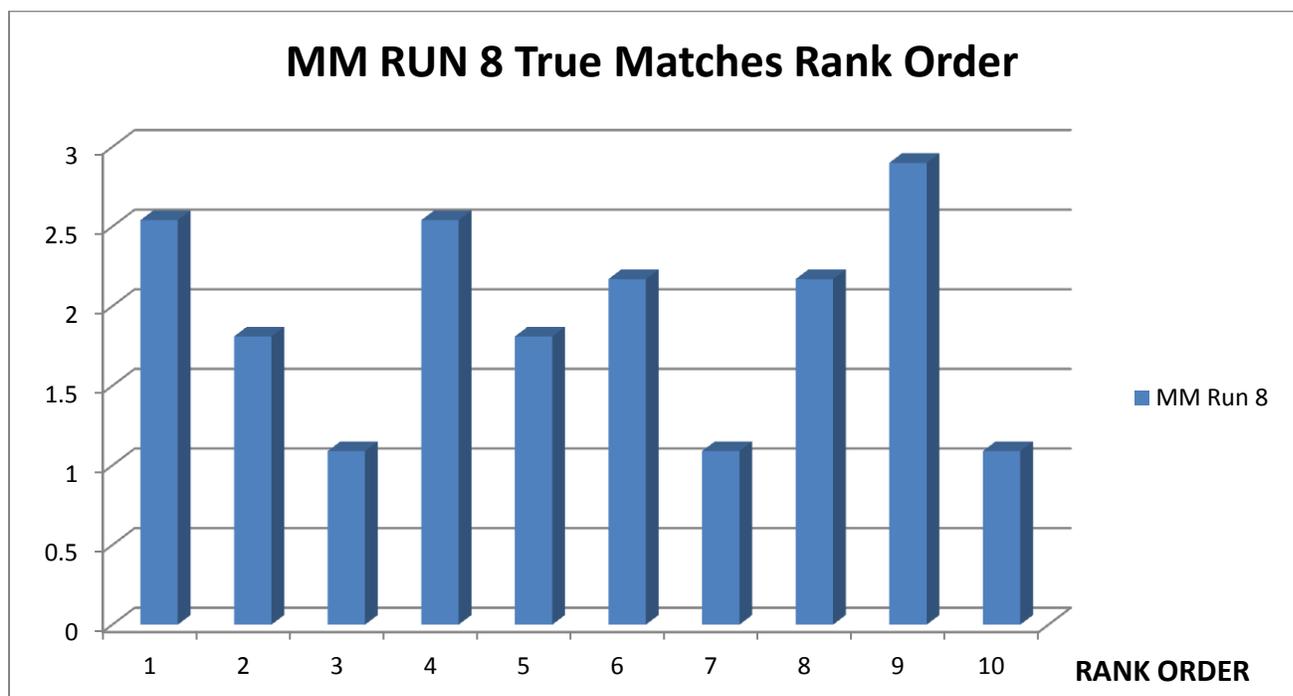
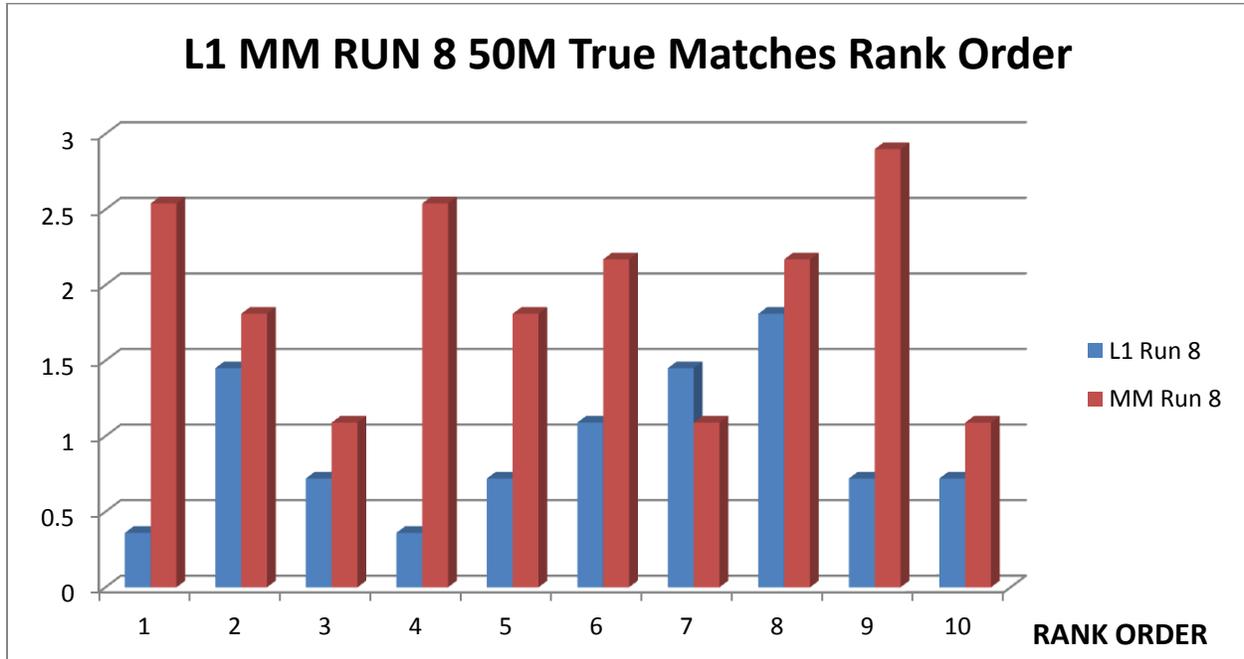


Figure 29 - MM Run 8 50 Meter



**Figure 30 - L1 MM Run 8 50 Meter**

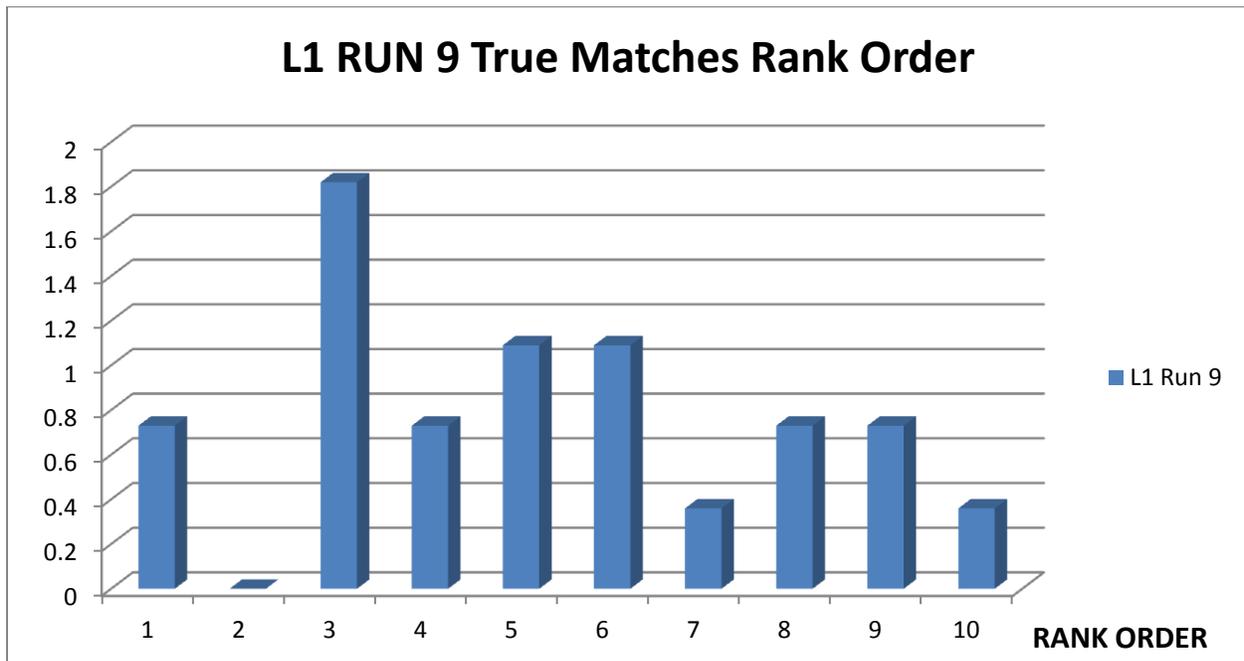
**Run 9**

Run 9 consisted of the 3 right images extracted from each of the subjects Sony video recordings. The 3 right images were selected based on the left selection so that a left/right matched pair of images were evaluated for match performance. The Sony video files images were matched against the enrollment gallery.

**L1 (L1R950)**

Out of the 279 right probe images only two were a rank 1 true match with 274 false matches. There were 276 True Matches with 21 of those True Matches occurring within the top rank 10 and 2 matches were rank 1. The true rank one match rate was 1 percent and the false rank was 98 percent.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R9 Sony Right Images vs. EN</b>						
50 Meter Sony Right Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	279			
		Unique Subjects	93			
	Matches					
	True Mat		2	<b>0.72</b>	0.06	0.17
	False Mat		274	<b>98.21</b>	0.04	0.92
	Total		27621			



**Figure 31 - L1 Run 9 50 Meter**

### MegaMatcher (MMR950)

Out of the 279 left probe images only one was a rank 1 true match with 275 false matches. There were 276 True Matches with 49 of those True Matches occurring within the top rank 10 and 2 matches were rank 1. The true rank one match rate was 1 percent and the false rank was 98 percent.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>MM R9 Sony Right Images vs. EN</b>						
50 Meter Sony Right Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	279			
		Unique Subjects	93			
	Matches					
		True Mat	2	<b>0.72</b>	0	14
		False Mat	274	<b>98.21</b>	2	26
		Total	27621			

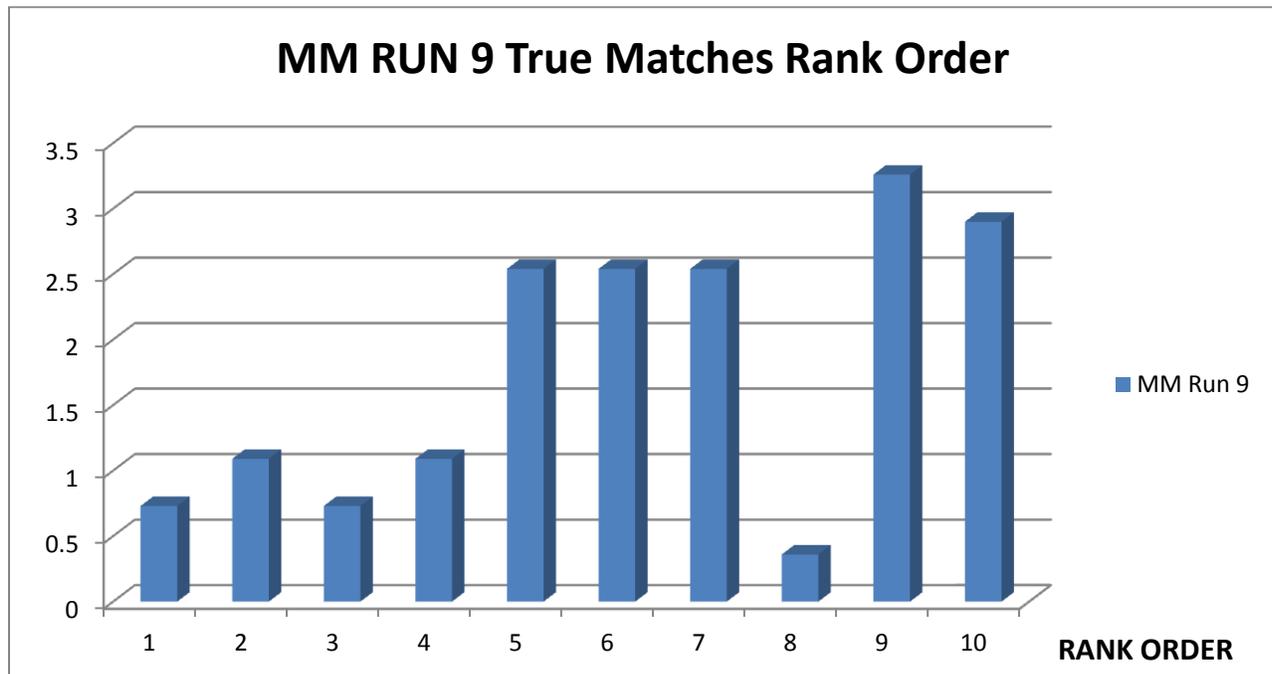
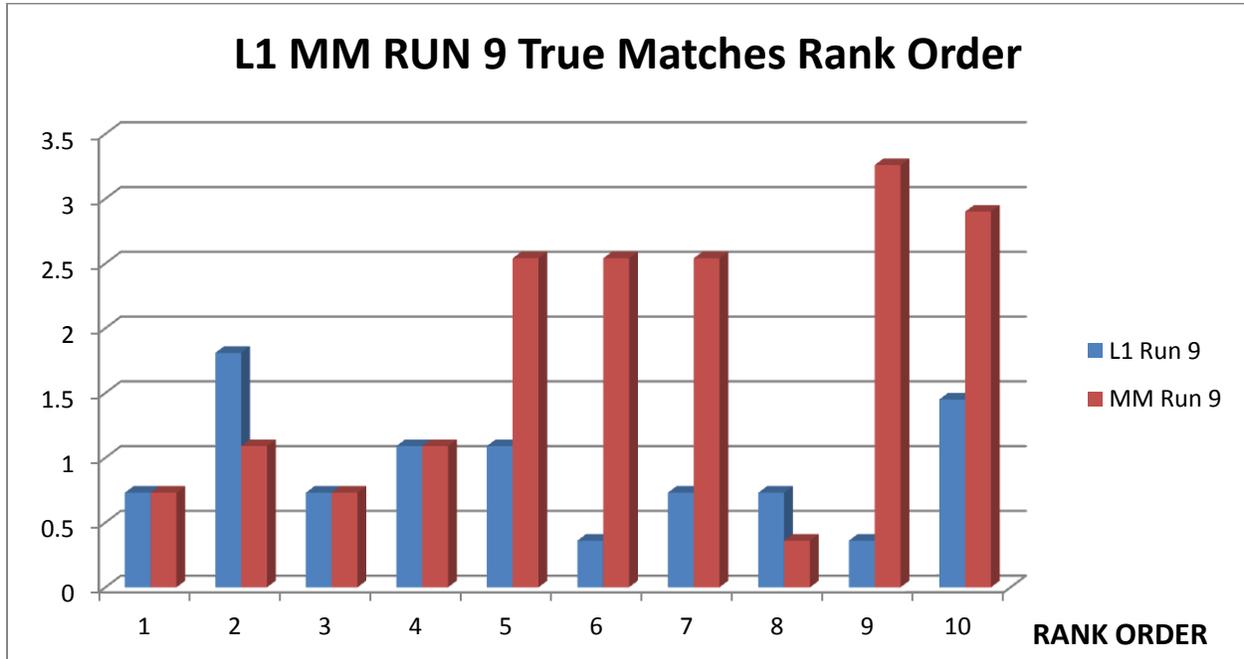


Figure 32 - MM Run 9 50 Meter



**Figure 33 - L1 MM Run 9 50 Meter**

## 75 Meters

There were 3 matching runs conducted at 75 meters (Runs 2, 3, and 7). All runs were conducted using the L1 algorithm.

### Run 2 (L1R275)

Run 2 consisted of probe images collected by the Canon w/ 800mm lens at 75 meters matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of current surveillance camera capture capability. Run 2 consisted of 293 probes and 99 enrolled subjects where the true accept rate was 75% and the false accept rate was 24%. There were 291 True Matches with 239 of those True Matches occurring within the top rank 10 and 220 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.74 to a high of 29.89. The similarity scores generated for the imposter population was 0.07 to 2.53. The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>
<b>L1 R2 75M Canon vs. En</b>						
75 Meters Canon 800mm vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	293			
		Unique Subjects	98			
	Matches					
		True Mat	220	<b>75.09</b>	0.74	29.89
		False Mat	71	<b>24.23</b>	0.07	02.53
		Total	29007			

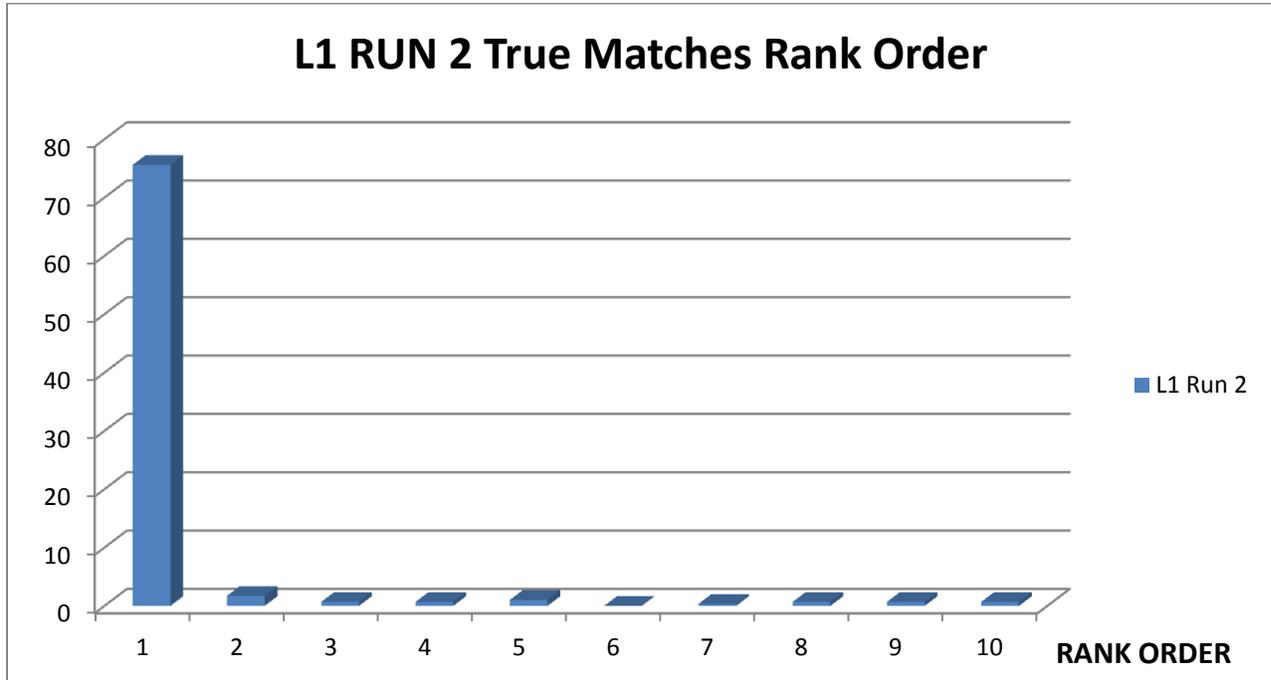
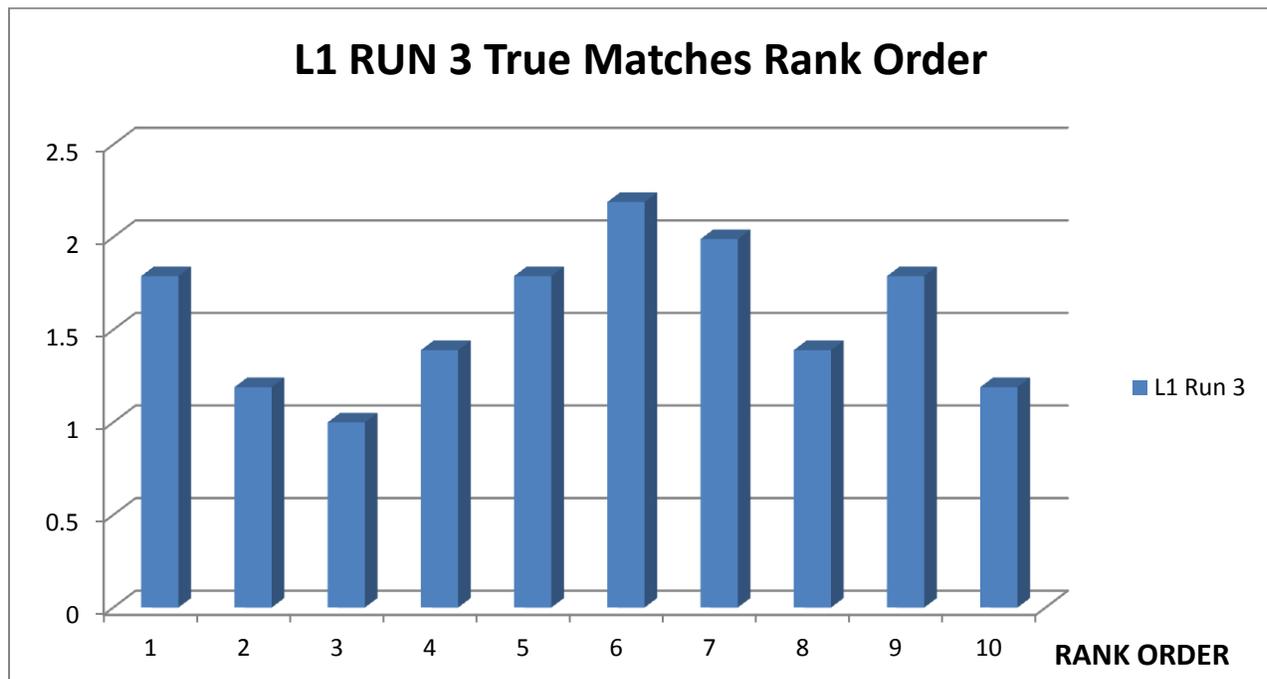


Figure 34 - L1 Run 2 75 Meter

**Run 3 (L1R375)**

Run 3 consisted of probe images collected by the SVI binocular at 75 meters preset 2 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of the SVI Disparity Calculator software in an autonomous mode. This Run represents the capability of the SVI Disparity Calculator software operating without manual intervention. The SVI binocular collected left and right VUR files were input to the SVI Disparity Calculator where 15 images are created (5 left, 5 right, and 5 occluded) and the L1 face matcher selects the images that are probes for matching to the enrollment gallery. Run 3 consisted of 509 probes and 99 enrolled subjects where there were the true accept rate was 2% and the false accept rate was 97%. There were 503 True Matches with 79 of those True Matches occurring within the top rank 10 and 9 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.06 to a high of 0.21. The similarity scores generated for the imposter population was 0.03 to 0.35. Also of note, there were 3 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images (note that there were 7 VUR pairs that crashed the Disparity Calculator in the 50m collection). The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

Run Description	Description		Results	Percent	Score Min	Score Max
<b>L1 R3 SVI75p2DC vs. EN</b>						
75 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	509			
		Unique Subjects	91	Note: 3 image pairs crashed DC		
	Matches					
		True Mat	9	<b>1.77</b>	0.06	0.21
		False Mat	494	<b>97.05</b>	0.03	0.35
		Total	50391			



**Figure 35 - L1 Run 3 75 Meter**

**Run 7 (L1R775)**

Run 7 is similar to Run 6 except the occluded probe images were selected only where the MegaMatcher extractor algorithm verified that a face in the image existed. The occluded probe images with faces present were matched against the enrollment gallery as in Run 6. The purpose of the Run 7 was to determine the possible matching performance of occluded images collected by the SVI system if the Disparity Calculator had the ability to evaluate and select the images better. The SVI Disparity Calculator did not select any of the occluded images for matching. Run 7 consisted of 458 probes and 99 enrolled subjects where the true accept rate was 34% and the false accept rate was 65%. There were 452 True Matches with 307 of those True Matches occurring within the top rank 10 and 155 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.09 to a high of 6.83. The similarity scores generated for the imposter population was 0.05 to 1.97. The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>
<b>L1 R7 SVI75p2FaceOnly Occluded vs. EN</b>						
75 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	458			
		Unique Subjects	68			
	Matches					
		True Mat	155	<b>33.84</b>	0.09	06.83
		False Mat	297	<b>64.85</b>	0.05	01.97
		Total	45342			

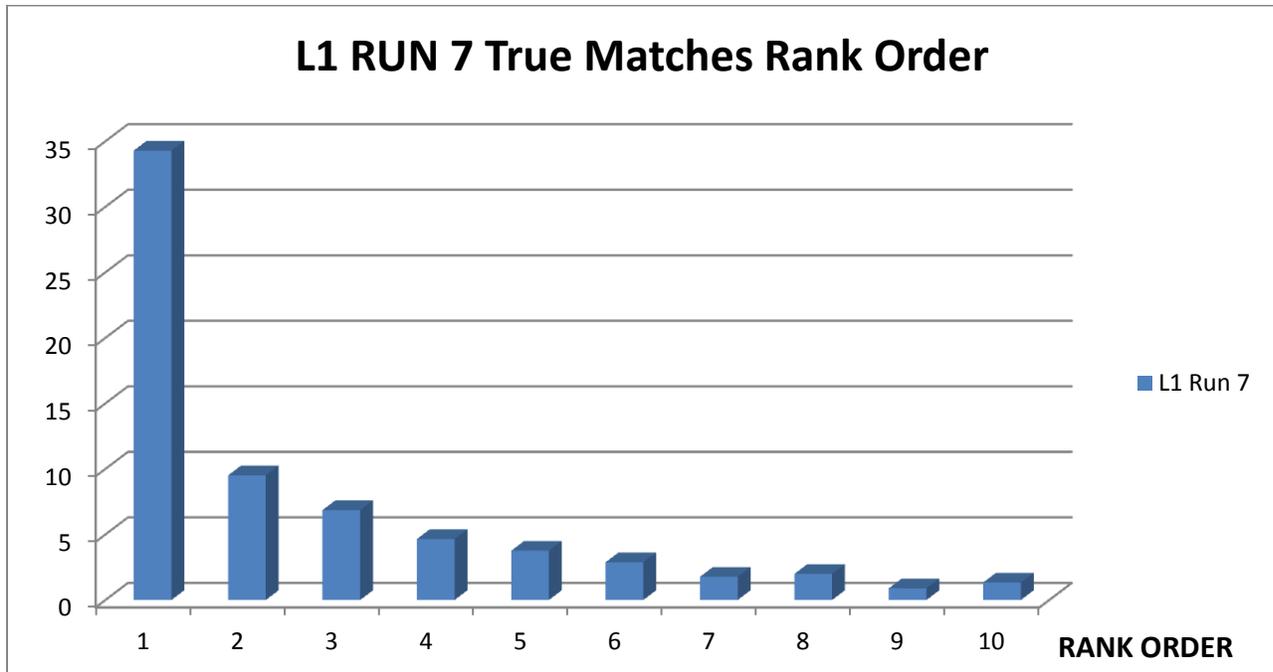


Figure 36 - L1 Run 7 75 Meter

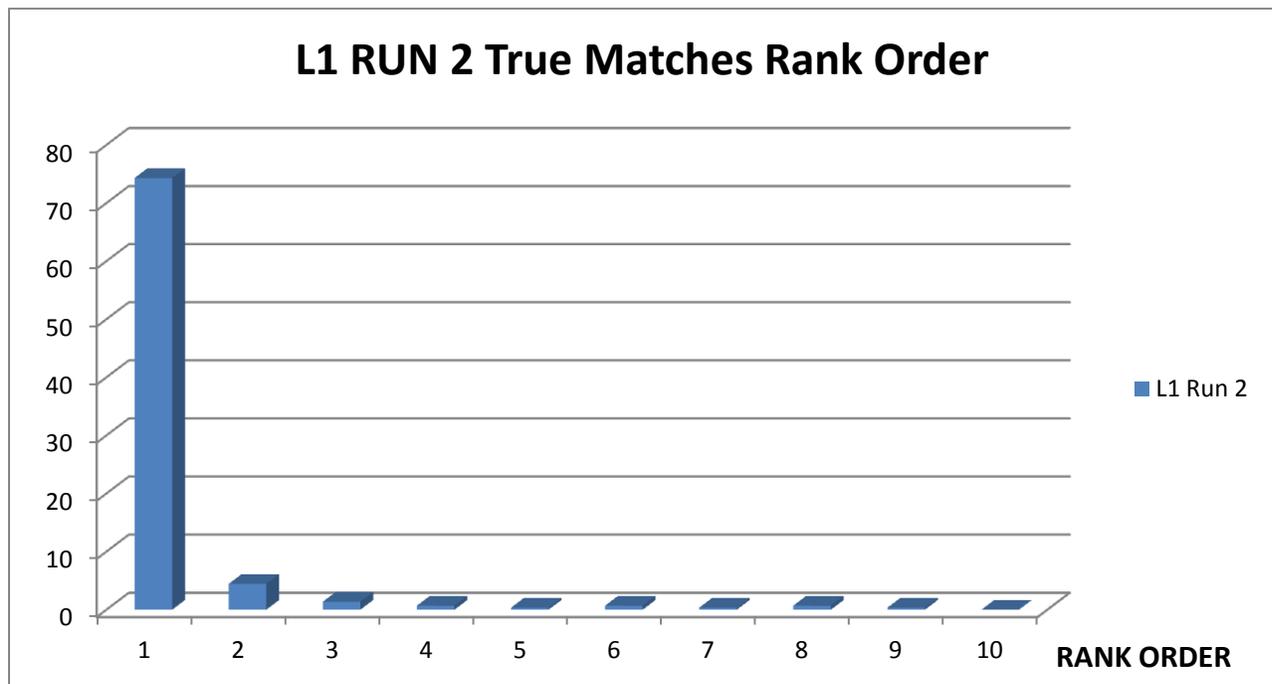
### 100 Meters

There were 3 matching runs conducted for images collected at 100 meters (Runs 2, 3, and 7). All runs were conducted using the L1 face matching algorithm.

#### Run 2 (L1R2100)

Run 2 consisted of probe images collected by the Canon w/ 800mm lens at 100 meters matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of current surveillance camera capture capability. Run 2 consisted of 295 probes and 99 enrolled subjects where there were the true accept rate was 74% and the false accept rate was 25%. There were 292 True Matches with 243 of those True Matches occurring within the top rank 10 and 217 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.08 to a high of 20.84. The similarity scores generated for the imposter population was 0.05 to 2.33. The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>
<b>L1 R2 100M Canon vs. En</b>						
100 Meters Canon 800mm vs. Enrollment	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	295			
		Unique Subjects	99			
	Matches					
		True Mat	217	<b>73.56</b>	0.08	20.84
		False Mat	75	<b>25.4223</b>	0.05	02.33
		Total	29205			



**Figure 37 - L1 Run 2 100 Meter**

### Run 3 (L1R3100)

Run 3 consisted of probe images collected by the SVI binocular at 100 meters preset 3 matched against the enrollment gallery. The purpose of the Run was to determine the matching performance of the SVI system in an autonomous mode. This Run represents the capability of the SVI system operating without manual intervention. The SVI binocular collected left and right VUR files were input to the SVI Disparity Calculator where 15 images are created (5 left, 5 right, and 5 occluded) and the L1 face matcher selects the images that are probes for matching to the enrollment gallery. Run 3 consisted of 489 probes and 99 enrolled subjects where the true accept rate was 1% and the false accept rate was 98%. There were 483 True Matches with 50 of those True Matches occurring within the top rank 10 and 6 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.12 to a high of 0.23. The similarity scores generated for the imposter population was 0.03 to 0.35. Also of note, there were 3 VUR pairs which crashed the SVI Disparity Calculator and did not generate any images (note that there were 7 VUR pairs that crashed the Disparity Calculator in the 50m collection). The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>	
<b>L1R3SVI100Mp3DC vs. EN</b>							
100 Meters SVI Disparity Calculator Selected Submitted Images vs. Enrollments	Gallery	Total	99				
		Unique Subjects	99				
	Probe	Total	489				
		Unique Subjects	90	Note: 3 image pairs crashed DC			
	Matches						
		True Mat	6	<b>1.23</b>	0.12	0.23	
		False Mat	477	<b>97.55</b>	0.03	0.35	
		Total	48411				

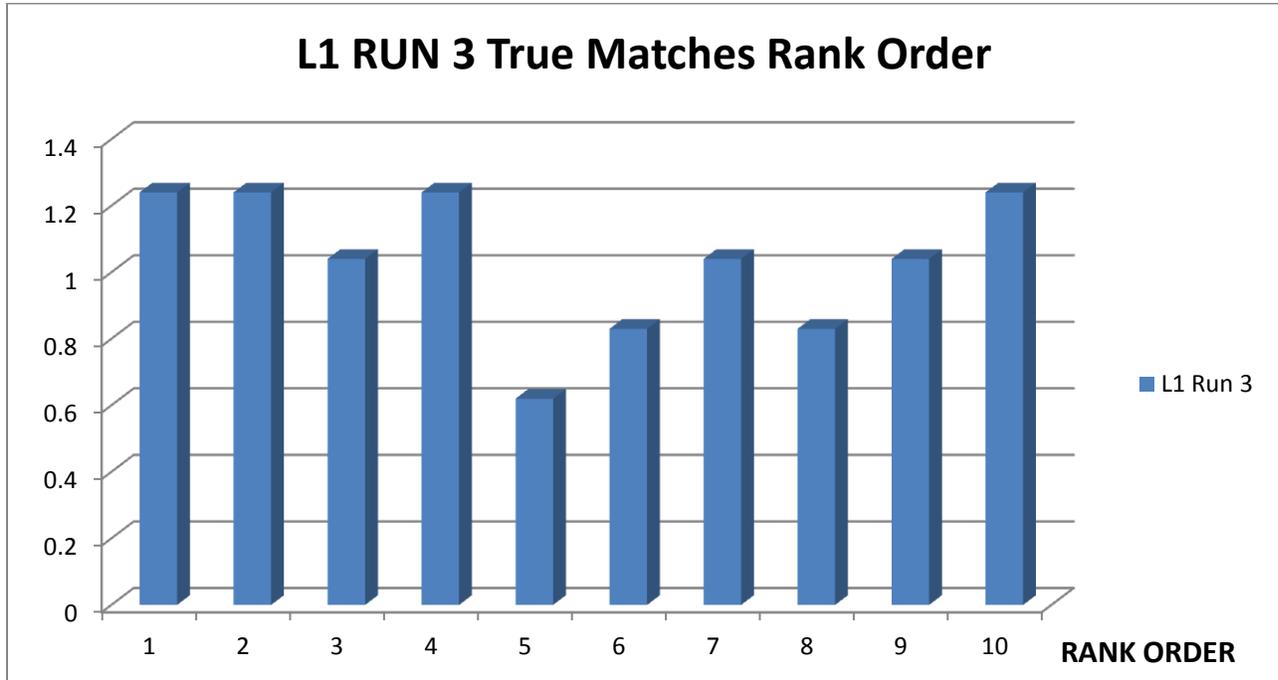


Figure 38 - L1 Run 3 100 Meter

**Run 7 (L1R7100)**

Run 7 is similar to Run 6 except the occluded probe images were selected only where the MegaMatcher face algorithm verified that a face in the image existed. The occluded probe images with faces present were matched against the enrollment gallery as in Run 6. The purpose of the Run 7 was to determine the possible matching performance of occluded images collected by the SVI system if the Disparity Calculator had the ability to evaluate and select the images better. The SVI Disparity Calculator did not select any of the occluded images for matching. This Run is used to determine the performance that is possible if the Disparity Calculator had selected face images for matching. Run 7 consisted of 504 probes and 99 enrolled subjects where the true accept rate was 26% and the false accept rate was 74%. There were 504 True Matches with 283 of those True Matches occurring within the top rank 10 and 129 matches were rank 1. The similarity scores for the genuine population ranged from a low of 0.06 to a high of 4.06. The similarity scores generated for the imposter population was 0.05 to 1.52. The frequency of True Matches for each Rank Order are normalized to 100 on the vertical axis and the True Match Rank Order to rank 10 on the horizontal axis.

<b>Run Description</b>	<b>Description</b>		<b>Results</b>	<b>Percent</b>	<b>Score Min</b>	<b>Score Max</b>
<b>L1 R7 SVI100p3FaceOnly Occluded vs. EN</b>						
100 Meter SVI Face Only Occluded Tiff (using MegaMatcher face finder algorithm) marked as having a face vs. Enrollments	Gallery	Total	99			
		Unique Subjects	99			
	Probe	Total	504			
		Unique Subjects	55			
	Matches					
		True Mat	129	<b>25.60</b>	0.06	04.06
		False Mat	375	<b>74.40</b>	0.05	01.52
		Total	49896			

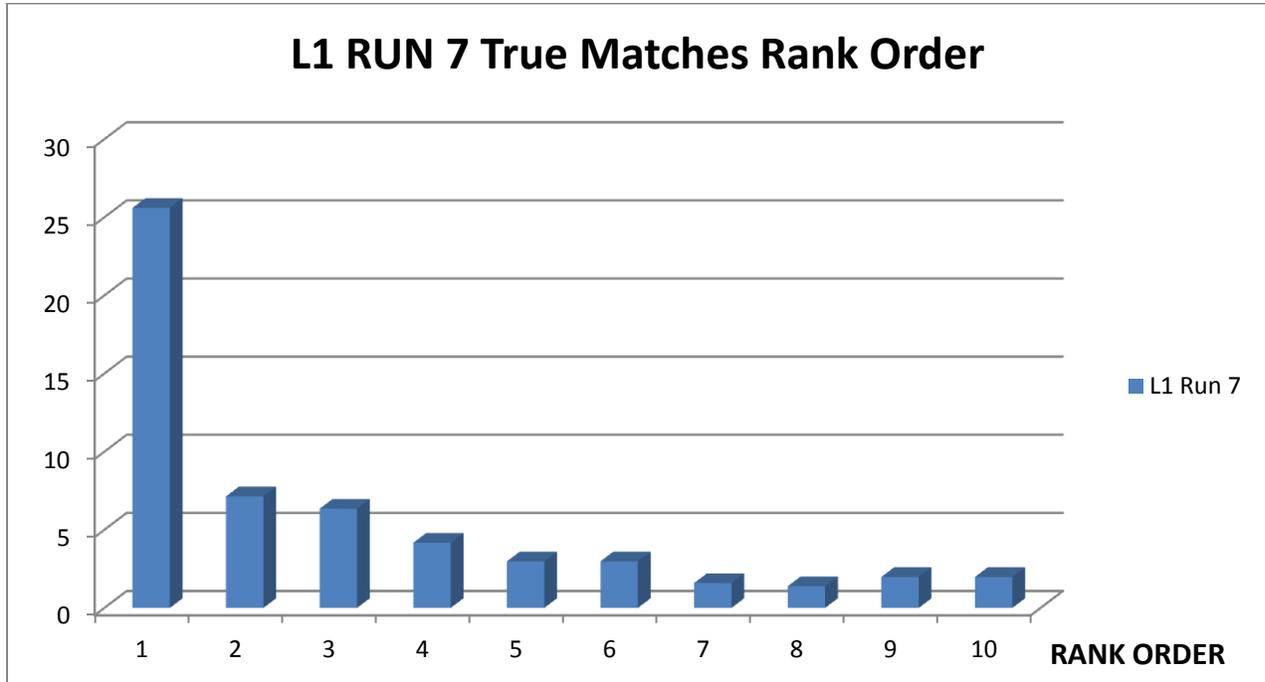
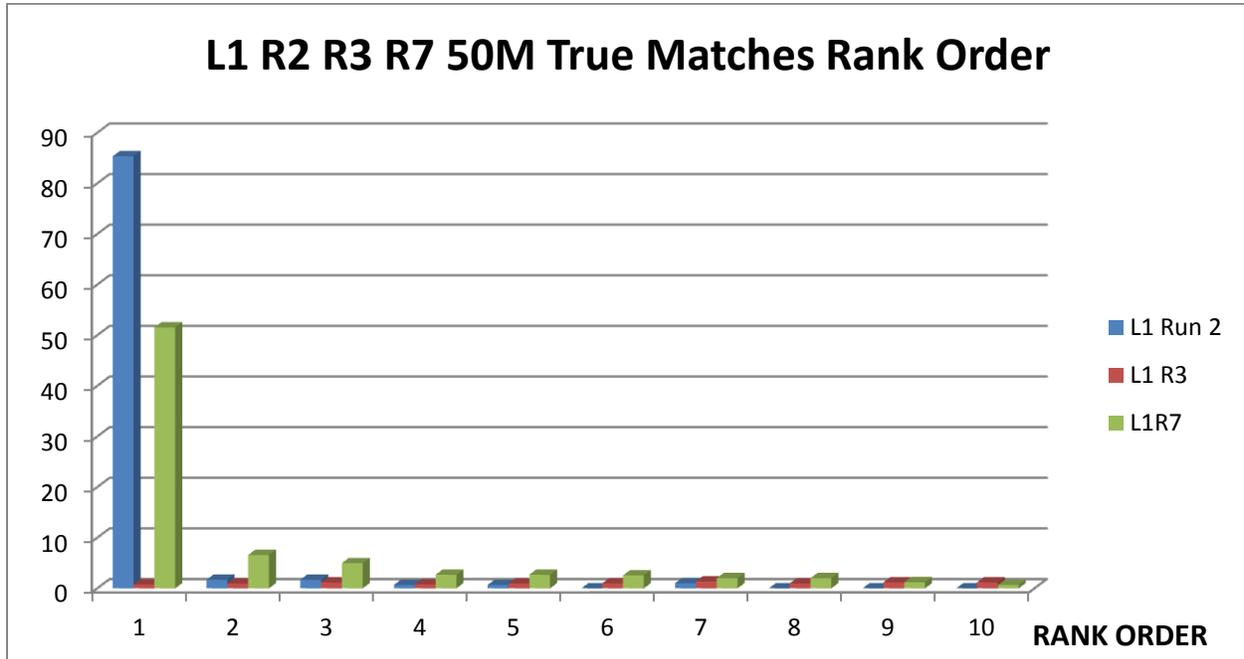


Figure 39 - L1 Run 7 100 Meter

**ANALYSIS**

The SVI evaluation team has completed 28 data Runs that characterize the performance of the SVI system at collection distances of 48, 50, 75, and 100 meters. Two of the runs conducted were using the enrollment images as both probe and gallery for the L1 and MegaMatcher algorithms. Both algorithms provided a 100% True Accept Rate at Rank 1. The performance of both algorithms was very similar using the WVU enrollment images. It should be noted that the enrollment images were collected using a Canon 5D MkII camera w/ 70–200mm f/2.8 lens and were of excellent quality. The outdoor collection cameras were the Canon 5D MkII w/ 800mm prime lens, the SVI binocular, and the Sony DEV-3 binocular. The Sony images (Runs 8 & 9) extracted from the recorded video at 50 meters provided very poor matching performance. We believe this is due to the face matcher having a small resolution image of only 20 pixels between the pupils to extract face features for matching. Because of the poor performance at 50 meters, the Sony images were not matched at 75 or 100 meter distances. The Canon images (Run 2) at all distances (50, 75, and 100 meters) provided better match performance than the images collected with the SVI binoculars (Runs 3 and 7). Three Figures comparing the performance of the Canon and SVI collections at 50 (Figure 40), 75 (Figure 41), and 100 (Figure 42) meters are shown below.

Two items to note from the figures are that the Canon (Run 2) at all distances provided better match performance than the SVI system, and when the Disparity Calculator selected images for matching (Run 3) the performance was very poor. Also of note in the three figures is that using only occluded images with faces present (Run 7) significantly improved SVI’s performance.



**Figure 40 - L1 R2 R3 R7 50 Meter**

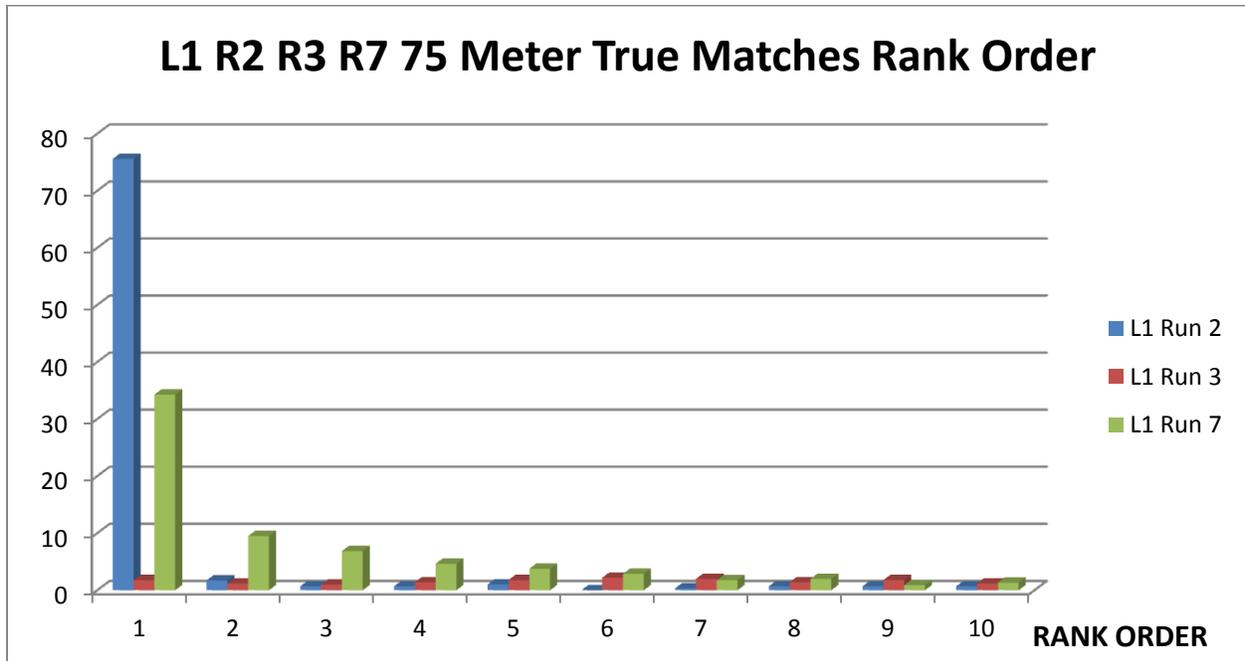


Figure 41 - L1 R2 R3 R7 75 Meter

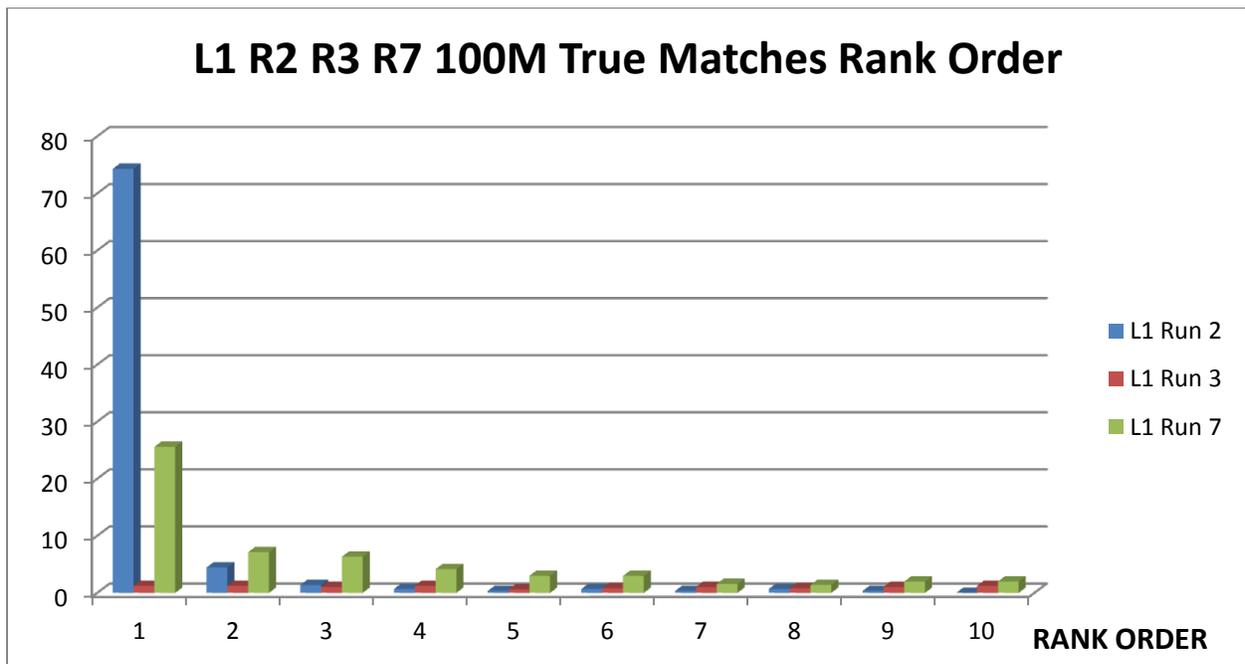
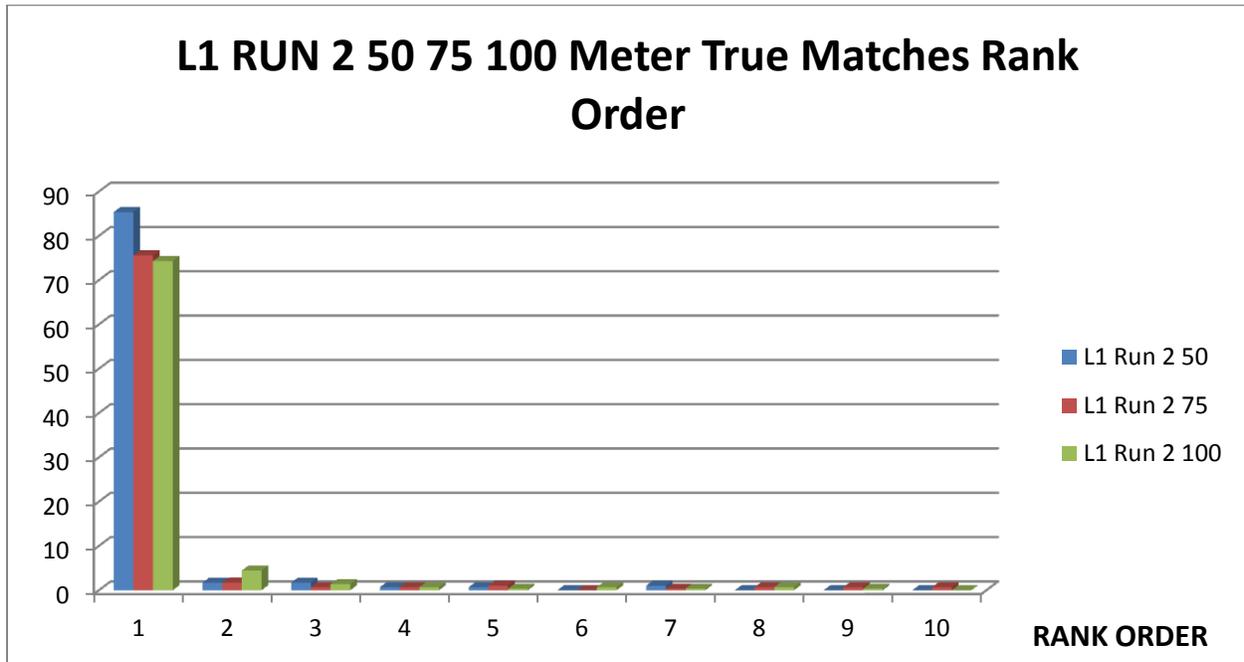


Figure 42 - L1 R2 R3 R7 100 Meter

Run 2 (see Figure 43 below) represents the ability of currently available commercial off-the-shelf equipment (Canon with the 800mm lens) to capture faces at a distance and match to a small watch list. A note of caution: these face match performance numbers are not likely to ever occur in a real world operational scenario due to the very high quality enrollments and the cooperative individuals contributing to the probe dataset.



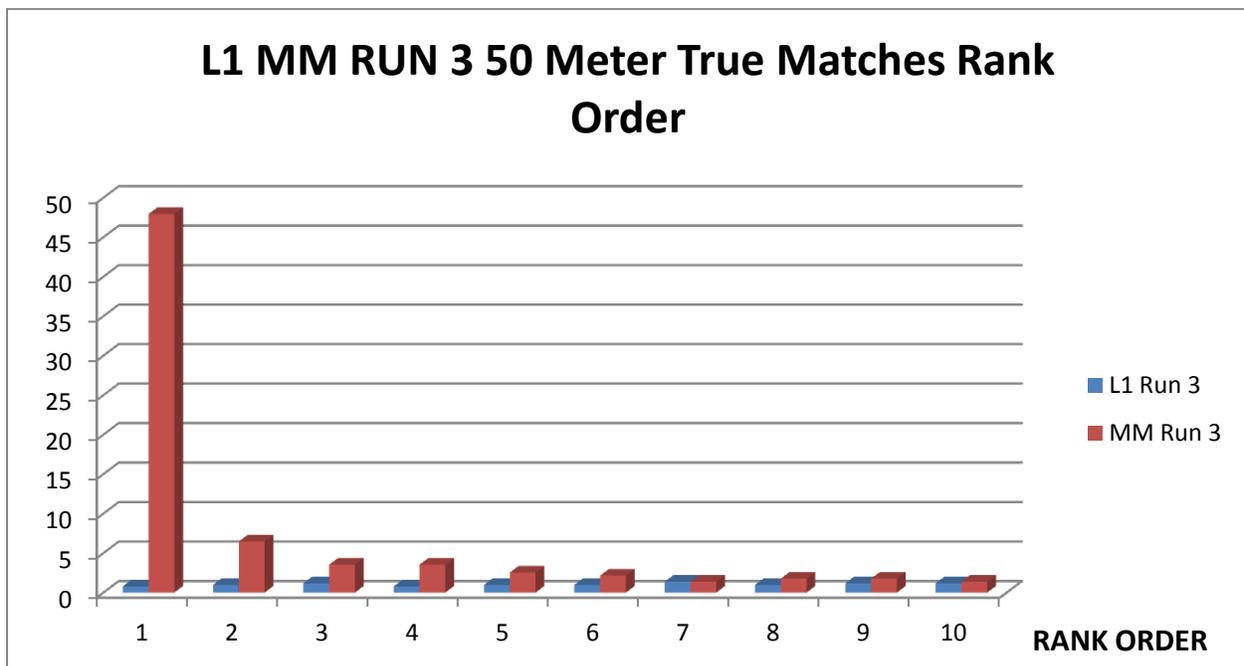
**Figure 43 - L1 Run 2 50 75 100 Meter**

The SVI binocular collected images were evaluated in Runs 3, 4, 5, 6, and 7 at distances of 48, 50, 75, and 100 meters. The SVI data runs provided an opportunity to determine if the Disparity Calculator is selecting the best images for matching and if the distance presets on the binocular function correctly or have any influence on the match performance of images collected. Run 3 represents the performance of the SVI system in an autonomous mode of operation. In Run 3, the Disparity Calculator was allowed to select the images for matching. It is of interest to note that none of the occluded images were selected for matching at any of the three primary distances (50, 75, or 100 meters), or the secondary distance of 48 meters. Runs 4, 5, 6, and 7 were conducted by storing all images that resulted from running the Disparity Calculator on the left and right VUR video pairs created by the SVI binocular. Run 4 represents the match performance of all left images created from the Disparity Calculator. Run 5 are all right images from the Disparity Calculator. Runs 4 and 5 represent the ability of the SVI binocular optic and sensor to collect quality face images. Run 6 are all the occluded images and Run 7 are all occluded images that have a face present as determined by MegaMatcher. Runs 6 and 7 represent the ability of the SVI system to extract the background in the face images. Again, none of the occluded images were automatically selected for matching.

In general, the SVI binocular system had several issues that hindered the overall performance of the system. The SVI images collected at 50 meters are out of focus and exhibit low contrast. The SVI images collected at 75 and 100 meters appear somewhat sharper and of higher contrast.

In addition, images collected at 50 meters using both the preset 1 and preset 3 exhibited very similar match performance in Runs 3 and 7. The new hardware spin for the SVI binocular may correct these problems. The Disparity Calculator is not able to automatically produce occluded images that are acceptable to the L1 face matcher. None of the occluded image files were selected for matching. This problem might be somewhat mitigated with the new binocular hardware because it could provide higher quality video files to the Disparity Calculator, which might result in better occluded images.

The L1 face matching algorithm is currently not configured correctly. This is evident when looking at the radical improvement in match performance of the MegaMatcher over L1 during Runs 3, 4, and 5 for the same set of images collected by the SVI binocular at 50 meters. The L1 and MegaMatcher True Accept Rate is shown in Figures 44, 45, and 46, which represent the performance for Runs 3, 4, and 5. As shown in the body of this report through Runs 1, 2, 6, and 7, the L1 matcher is not a poor matcher, in fact in most instances it outperforms the MegaMatcher for rank 1 True Accept Rate. Again, there appears to be an L1 configuration parameter(s) that is in need of adjustment. The particular results of each run are discussed below.



**Figure 44 - L1 MM Run 3 50 Meter**

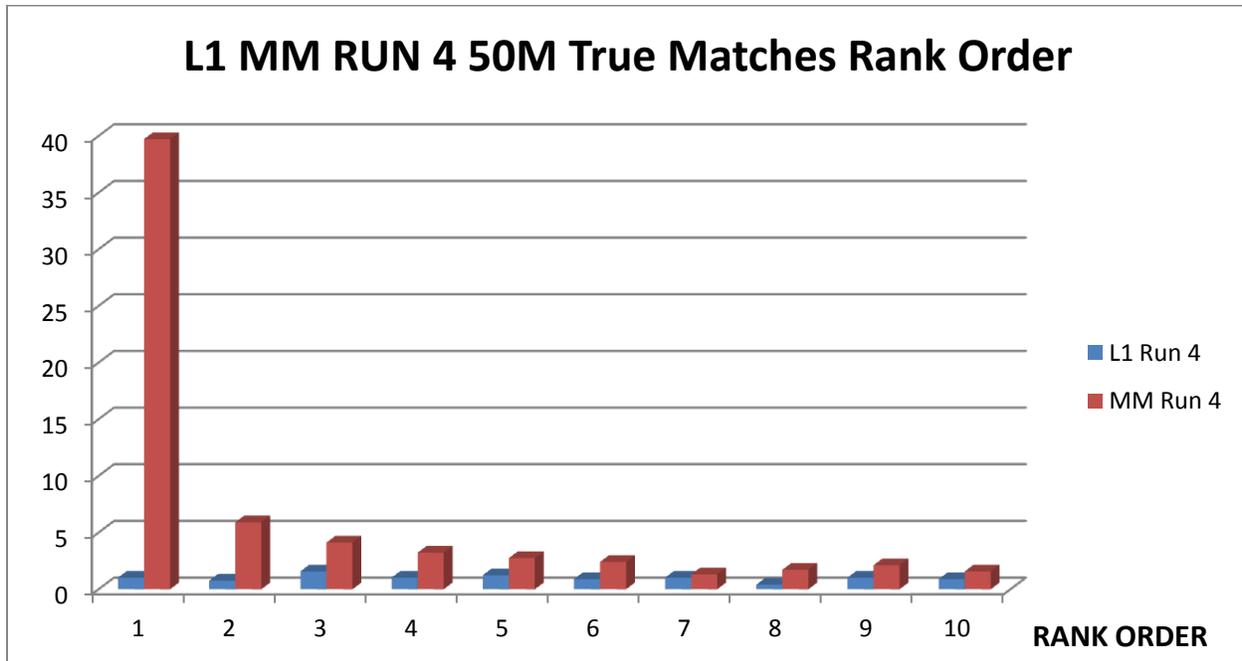


Figure 45 - L1 MM Run 4 50 Meter

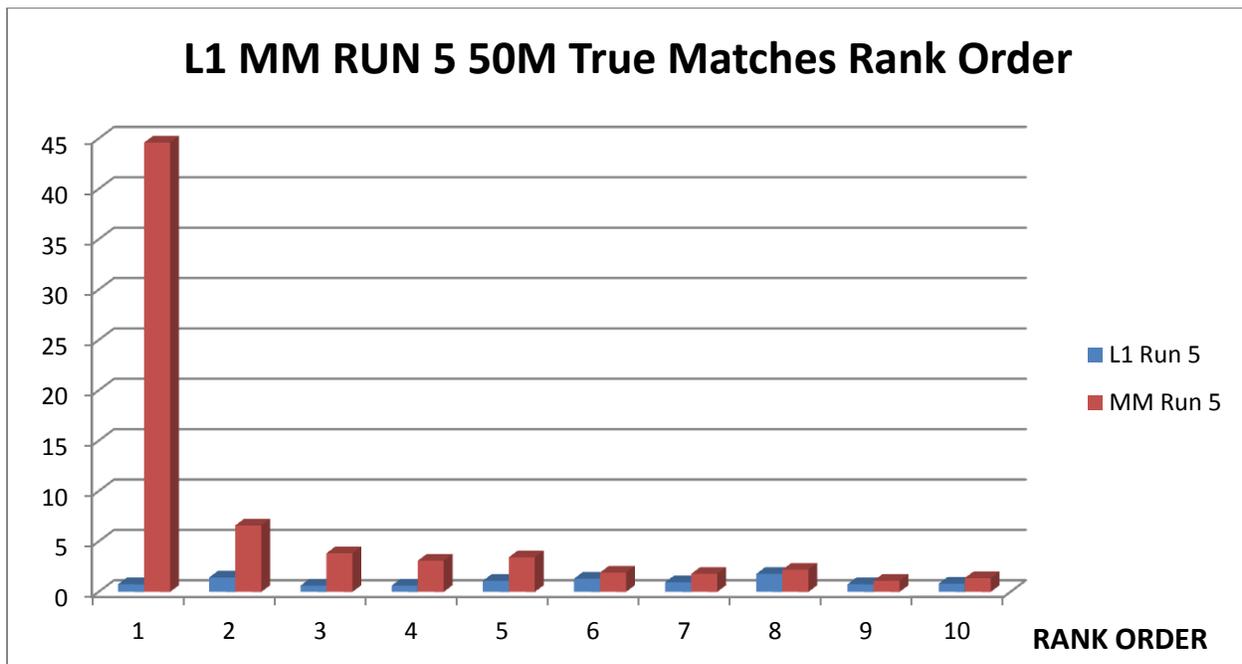


Figure 46 - L1 MM Run 5 50 Meter

The excellent results of Run 1 (both the probe and gallery are same enrollment photos) are a result of the very high quality and resolution of the WVU enrollment image collection and the quality of the L1 and MegaMatcher face matching algorithms. This Run 1 set the bar for the maximum performance that could be expected using the L1 and MegaMatcher algorithms with the provided WVU enrollment image collection. All similarity scores returned were true matches at rank 1 and there were no false matches. Theoretically, with either matcher and with

enrollment and probe images of this quality, the threshold of the system could be set at zero and the system would never reject an enrolled subject and never allow an imposter into the system. This matcher and dataset created a very high bar of match performance expectations.

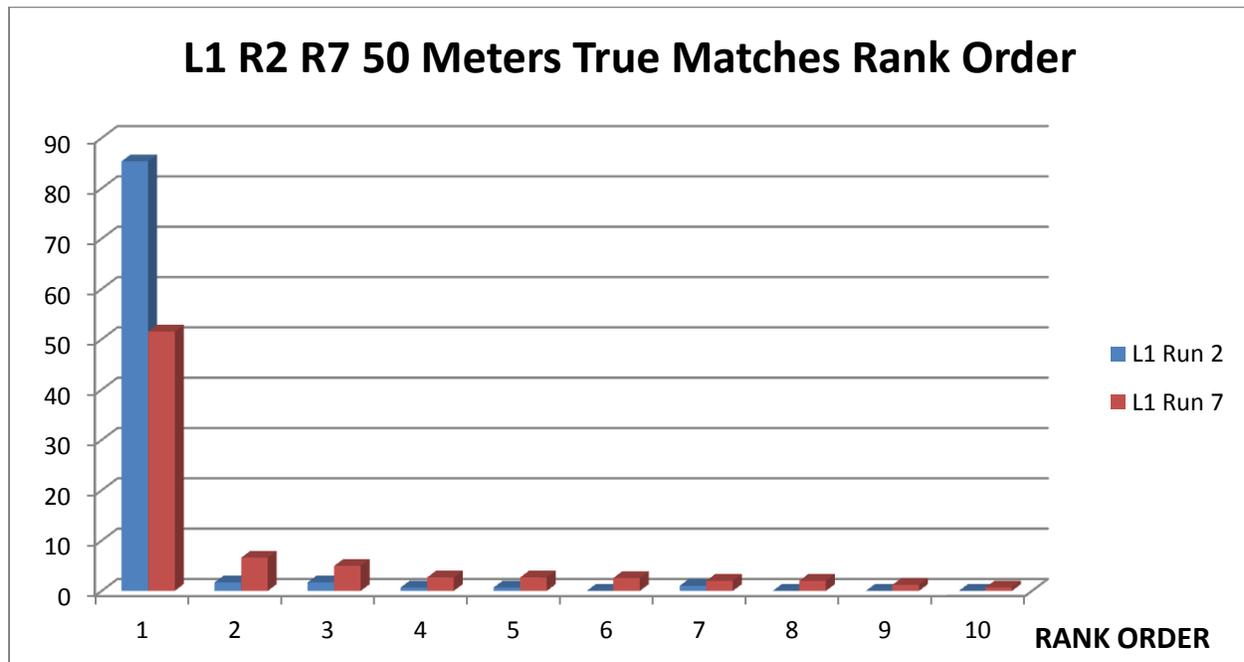
The Canon outdoor face collection and Run 2 were performed to establish a baseline of what was possible for collecting face images at a distance for the purpose of automated face matching using currently available COTS surveillance equipment. The match performance of the Canon 5D Mark II camera w/ 800 mm lens images cannot be directly compared to the match performance of the SVI binocular system, as the Canon camera is a 21 MP sensor and the lens used during collections had a fixed focal length of 800mm. The Canon camera also provided auto focus, auto exposure, and image stabilization. By comparison, the specifications state that the SVI binocular was half the resolution (10 MP) and the focal length was 130 mm. The SVI binocular currently does not provide auto focus, auto exposure, or image stabilization. The images collected at 50 meters (approximately 3 per subject) by the Canon camera resulted in a True Match Rate of 84%. In comparison, Run 7 was the very best match performance of the SVI data Runs which was 50.52% at 50 meters. The Canon system outperformed the SVI system at all distances and using either matcher. Simply running all the occluded images (Run 6) resulted in a True Match Rate of 27.41%. During Run 7 the MegaMatcher was used to select only the occluded images that contained a face. Evaluation of Run 7 represents what the SVI system is capable of if the Disparity Calculator was better able to automatically select occluded images where faces are present.

The SVI system evaluated in a black box mode was best represented in Run 3, where it did not perform very well. Run 3 is the SVI binocular collected VUR files, face images created and selected for matching by the Disparity Calculator, and matched using the L1 and MegaMatcher for images collected at 50, 75, and 100 meters. The Disparity Calculator did not select any occluded images for matching. Tests were conducted to determine the effect of changing the preset (focal length) on the SVI binocular. Data runs for 50 meter preset 1 and 50 meter preset 3 did not show any statistical difference in matching performance. During a subjective evaluation of the images at 50 meters between preset 1 and 3, the test team did not observe changes in contrast or focus.

Run 3 at 50 meters preset 1 was repeated using the MegaMatcher with an enormous change in match performance. The L1 rank 1 True Accept Rate was 0.83% and the MegaMatcher rank 1 True Accept Rate was 47.38%. Based on these results the test team believes that a matching parameter for the L1 matcher is incorrect. Runs 4 and 5 show similar changes in match performance between the L1 and MegaMatcher. Runs 4 and 5 are all the left and right images produced by the Disparity Calculator. However, in Run 6 (all occluded) and Run 7 (all occluded with faces) the L1 and MegaMatcher have similar match performance, with the L1 being slightly better. The match performance improvement in Run 6 (occluded images) above Runs 4 and 5 (left and right images) shows the value of background removal to face match performance.

The best possible match performance of the SVI system with the WVU collected data is represented by Run 7. Run 7 takes the video files from the binocular provides them to the Disparity Calculator and all occluded images are saved. An additional step was added where all occluded images were run through the MegaMatcher face finding algorithm. Only those

occluded images with faces were then provided as probes to the matchers. The SVI system at 50 meters performed reasonably well with the L1 algorithm having a rank 1 True Accept Rate of 50.53% and MegaMatcher 47.63%. As a point of comparison the Canon probe images at 50 meters resulted in rank 1 True Accept Rates of 83.67% for L1 and 82% for MegaMatcher (see Figure 8).



**Figure 47 - L1 R2 R7 50 Meter**

In an effort to understand the function of the SVI binocular focal distance, two runs (Runs 3 & 7) were conducted using the images collected at 48 meters using preset 1 on the binocular. These runs were compared to the images collected at 50 meters (same Runs 3 & 7) to determine the effect of moving the subject closer to the binocular by 2 meters. There was little difference in match performance in Run 3 between 48 and 50 meters (see Figure 48 below). However, there appears to be an improvement in match performance at 50 meters in Run 7 (see Figure 49 below). The comparison of match performance between 48 and 50 meters in Run 7 validates and supports that the SVI focal length preset seems to function correctly.

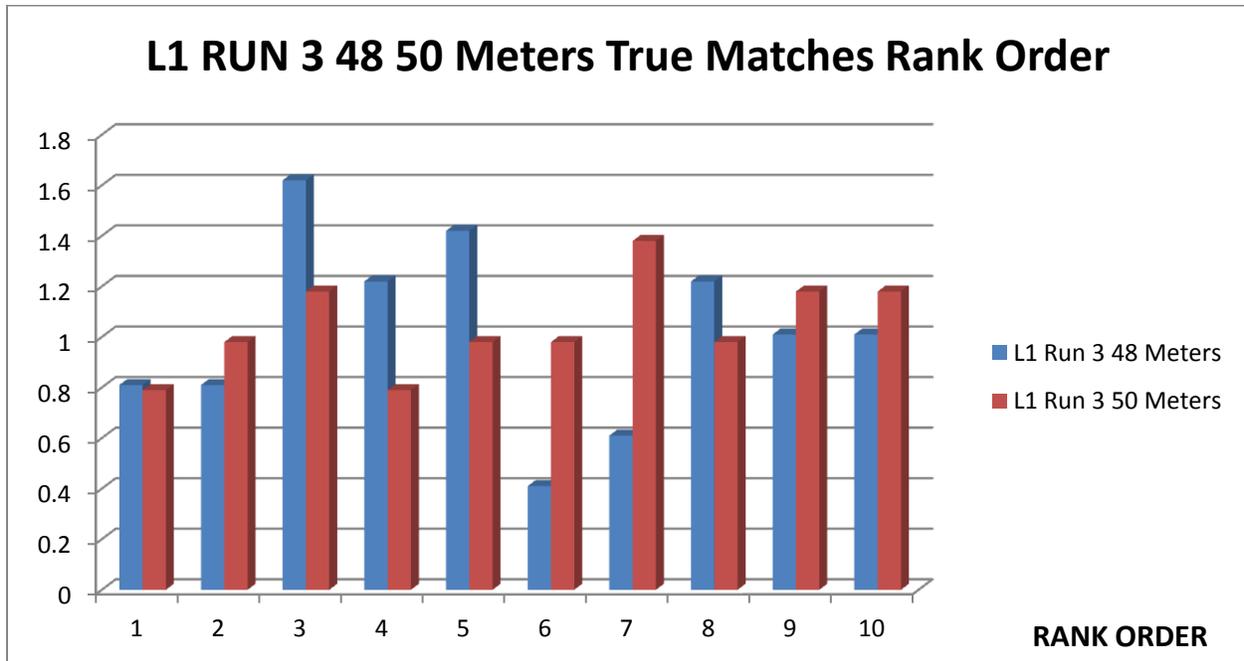


Figure 48 - L1 Run 3 48 & 50 Meter

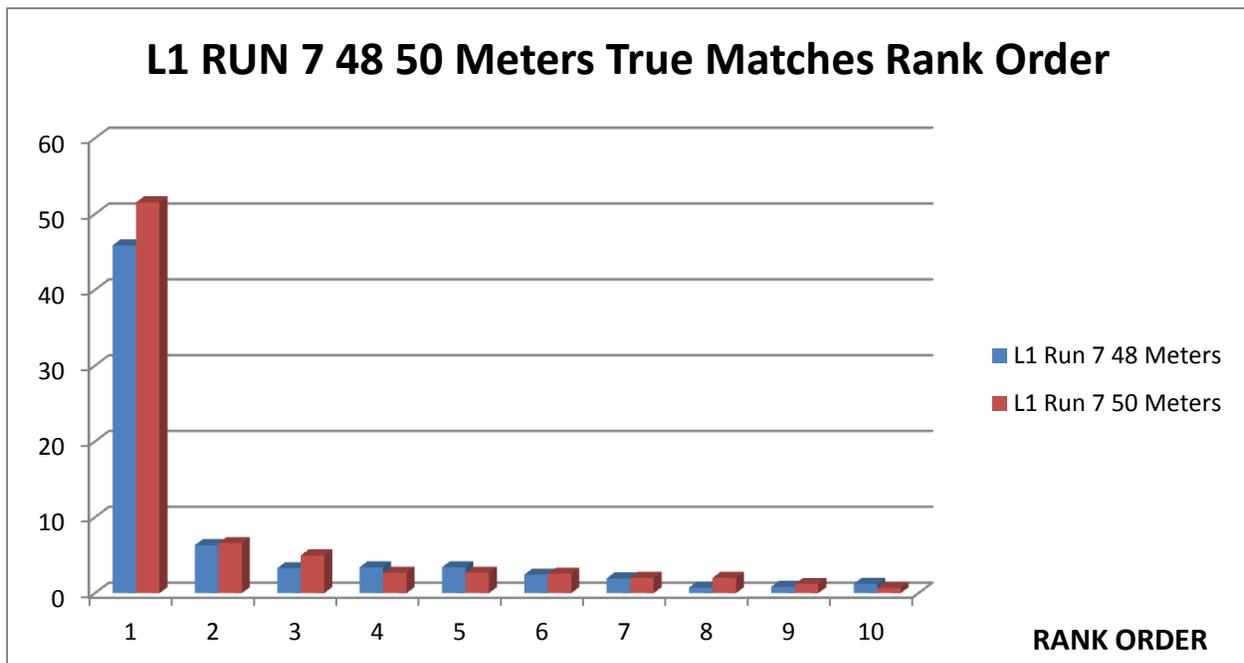


Figure 49 - L1 Run 7 48 & 50 Meter

The Sony DEV-3 collected images were evaluated as Runs 8 and 9. Runs 8 and 9 were only conducted at 50 meters. The additional Runs for 75 and 100 meters were not conducted due to the poor match performance at 50 meters. Figure 50 depicts the True Accept Rate match performance for the left and right Sony binocular images collected at 50 meters. The Sony

DEV-3 binoculars were not capable of collecting face images at 50 meters and greater distances for automated face matching.

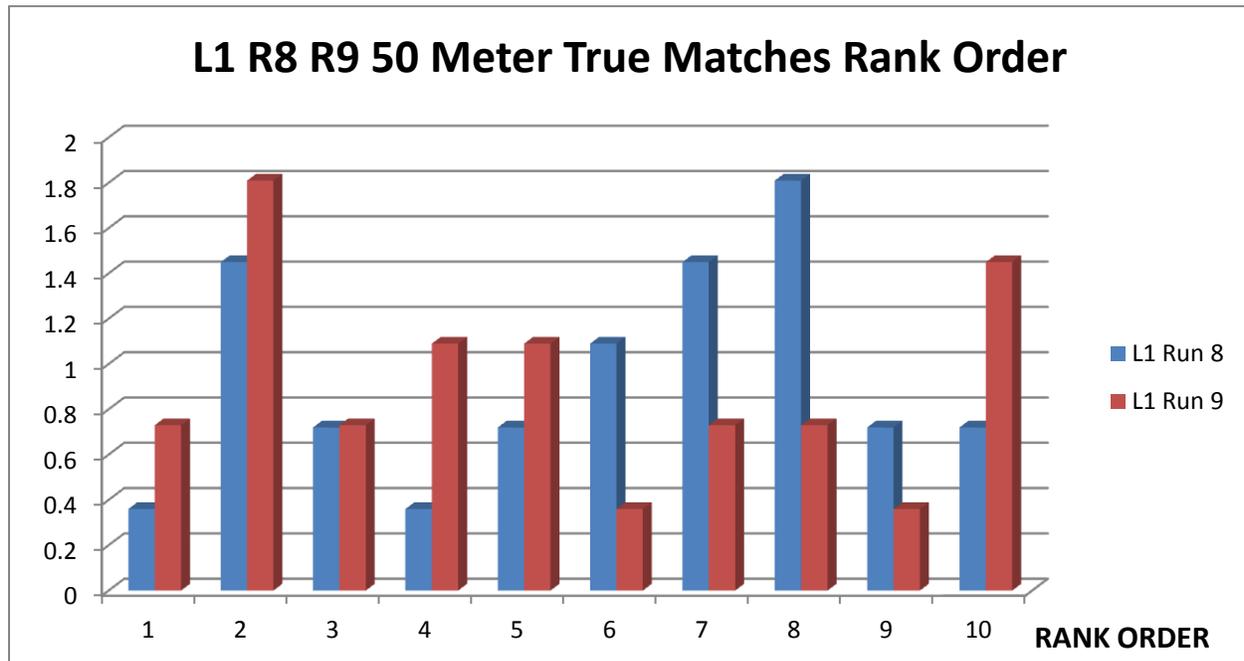


Figure 50 - L1 R8 R9 50 Meter

The results obtained and documented in this report are not representative of real world, operationally viable performance and should not be used to make any judgments concerning the performance of these collection systems or face matching algorithms in the real world. This testing was conducted in such a way as to determine the face matching performance of the Canon, SVI, and Sony camera face images particular to the WVU collection requirements. Neither the enrollment nor the probe images represent operationally relevant face image collections. The enrollment images for each subject was collected under near perfect conditions, 21 MP resolution camera (780 pixels center pupil to center of pupil), 3 point lighting (1250 watts), 18% gray scale backdrop, no obstructions such as hats or glasses, neutral facial expressions, and full frontal faces with correct pose angle. The outdoor probe images, whether collected with the SVI, Canon, or Sony Cameras, were from cooperative subjects, during daylight hours, and sun angle problems were minimized to prevent face shadows. Again, these face match performance test results are NOT representative of real world conditions.

## ADDITIONAL COMMENTS

In undertaking the evaluation of the SVI system, some observations and comments are worth noting to improve the development of a next-generation version of the system and for future T&E.

1. **Real-Time vs. Sequential Processing** – The evaluation of the SVI system necessitated the use of sequential steps rather than the laptop-tethered real-time use. As a result, all analysis utilized the Disparity Calculator combined with the L-1 ABIS processed in control stages. SVI has reported that the system functions identically when run in real-time tethered mode vs. offline processing. However, if discrepancies in performance and function exist, then the results will not mirror field use.
2. **Benefit of Background Removal Dependent on Algorithm** – The T&E performed demonstrates that the L-1 matcher performance contained within the SVI system benefits from utilizing background removal (L1R450 @ 1.02% vs. L1R750 @ 50.53%). However, the same benefit was not observed when using the exact same images fed into the MegaMatcher algorithm (MMR450 @ 39.32% vs. MMR750 @ 47.63%). SVI is cautioned from making a generalization about background removal benefits, especially if the system will be marketed as algorithm/matcher agnostic.
3. **SVI Performance Issues Independent of Dataset Quality** – Data collection with the SVI binoculars would ideally be performed using a light meter and careful control of exposure and gain settings for optimal image capture. However, the realities of a large-scale data collection operated in a university setting required some compromises in collection procedures. However, the key performance issues in the SVI system related to the L-1 matcher integration are independent of these starting suboptimal settings. Regardless of the starting image quality, the SVI system produced a low true match rate when run as a “black box” (i.e., Run 3) as compared to selectively utilizing occluded images with known faces (i.e., Run 7).
4. **Sony DEV-3 Potential** – The Sony DEV-3 did not perform well in this evaluation, primarily due to the low resolution of the available 1080p stereoscopic video capture. However, the technology still possesses significant potential as a platform for long-range face recognition. The device has a good form factor, electronic capabilities, and price point. The native sensors could be leveraged for higher resolution video capture. There is potential in coupling the Sony (or similar device) DEV-3 with video processing/background removal software integrated with a biometric matcher to produce a superior product.

## CONCLUSIONS

In general, six key issues/observations were identified during the evaluation:

- 1.) **The Disparity Calculator failed to produce occluded images that were acceptable in quality to the L1 matcher.** In all subject cases, left and/or right standard images were determined to be the best quality by L1 and used as probes into the gallery. This is evidenced in the True Match Rates in Run 3 (0.8%) as compared to Runs 4 (1.0%) and 5 (0.7%). The subprocess that selects images for submission as probes is not working.
- 2.) **The change in match performance between SVI images collected at 50 meters using the preset 1 and preset 3 is not statistically significant.** This leads the test team to believe that the SVI binocular images are not correctly focused. However contrary to this finding the Run 7 matching performance was improved at 50 meters over the match performance at 48 meters. Both the 48 and 50 meter image collections were using the SVI binocular preset 1 which is supposed to be optimized for 50 meters.
- 3.) **There is a stark improvement in match performance produced by matching all occluded (Run 6, 27.4%) as compared to running all left (Run 4, 1.0%) and right (Run 5, 0.7%) images produced by the Disparity Calculator.** The background removal does improve match performance in this system.
- 4.) **The significantly improved match performance of the MegaMatcher over the L1 matcher in Runs 3, 4, and 5 leads the test team to believe that some parameter(s) of the L1 matcher are incorrectly set.** The results of Runs 1, 2, 6, and 7 shows that the L1 and MegaMatcher are about equal in rank 1 True Accept Rates. In fact, the L1 is slightly better.
- 5.) **The Disparity Calculator produces occluded images that often contain partially or fully obscured faces.** This is observed qualitatively in examining resulting images, and is confirmed in the improvement in match performance when face finding is used as a filter. The match performance between Runs 6 and 7 almost doubled, from 27.41% to 50.52%. The Disparity Calculator settings for automated processing require further adjustment or improvements.
- 6.) **The Sony DEV-3 binocular was not up to the challenge of collecting face images at 50 meters or greater distances for the purpose of automated face matching.**

**APPENDIX A - ACRONYMS AND ABBREVIATIONS**

<b>Acronym</b>	<b>Definition</b>
AFIS	Automated Fingerprint Identification System
AIS	Automated Information Systems
ANSI	American National Standards Institute
CJIS	Criminal Justice Information Services
CoE	Center of Excellence
COTS	Commercial Off-The-Shelf
DOC	Department of Commerce
DOJ	Department of Justice
Dpi	Dots per inch
EBTS	Electronic Biometric Transmission Specification
EFS	Extended Feature Set
EFTS	Electronic Fingerprint Transmission Specification
FAR	False Acceptance Rate
FBI	Federal Bureau of Investigation
FRR	False Rejection Rate
FTA	Failure to Acquire
FTE	Failure to Enroll
GOTS	Government Off-The-Shelf
GUI	Graphical User Interface
IAFIS	Integrated Automated Fingerprint Identification System
JPEG	Joint Photographic Experts Group
MM	Neurotechnology's MegaMatcher
NIJ	National Institute of Justice
NIST	National Institute of Standards and Technology
NISTIR	NIST Interagency Reports
Ppi	Pixels per inch
R&D	Research and Development
S&T	Science and Technology
SSBT	Sensor, Surveillance, and Biometric Technologies
SVI	StereoVision Imaging Incorporated
T&E	Test and Evaluation
TAR	True Accept Rate
WVU	West Virginia University