

Comparative Study of Red Dot Sight Parallax

Eric Dorenbush

Green Eye Tactical

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Author Note

Eric Dorenbush, Owner/Instructor, Green Eye Tactical

Contact: eric@GreenEyeTactical.com

This study was supported by volunteer efforts and received no outside funding sources.

***** THE RESULTS IN THIS REPORT AND THE
ACCOMPYING ANALYSIS AND/OR EDITORIAL
ANALYSIS ARE SOLELY BASED ON THE SAMPLE
GROUPS TESTED. WHILE IT MAY BE POSSIBLE TO
DRAW INFERENCES TOWARDS AN OPTICS MODEL IN
GENERAL-- NO DATA, ANALYSIS, COMMENTS, OR
STATEMENTS IN THIS REPORT SHOULD BE
CONSIDERED AS A STATEMENT TOWARDS ALL
OPTICS IN GENERAL AND ARE ONLY BASED ON THE
SPECIFIC DATA COLLECTED AND THE SPECIFIC
MODELS TESTED. ALL TESTING DATA WAS DERIVED
FROM INDEPENDENT TESTERS, NOT THE AUTHOR OF
THIS REPORT *****



Abstract

This report is designed to evaluate the possible aiming dot deviation in red dot optic sights due to parallax effect, resulting from angular inclination or deflection in user view angles through the maximum possible angle of view on the horizontal and vertical planes. The report consists of two separate testing events: one held by the author of this report, and another from various independent volunteers across the country that replicated the test and submitted data from their observations. The results of the data collection reveal interesting trends that conflict with the commonly held notions that all red dot sights are equally susceptible to parallax induced Point of Aim deviation.

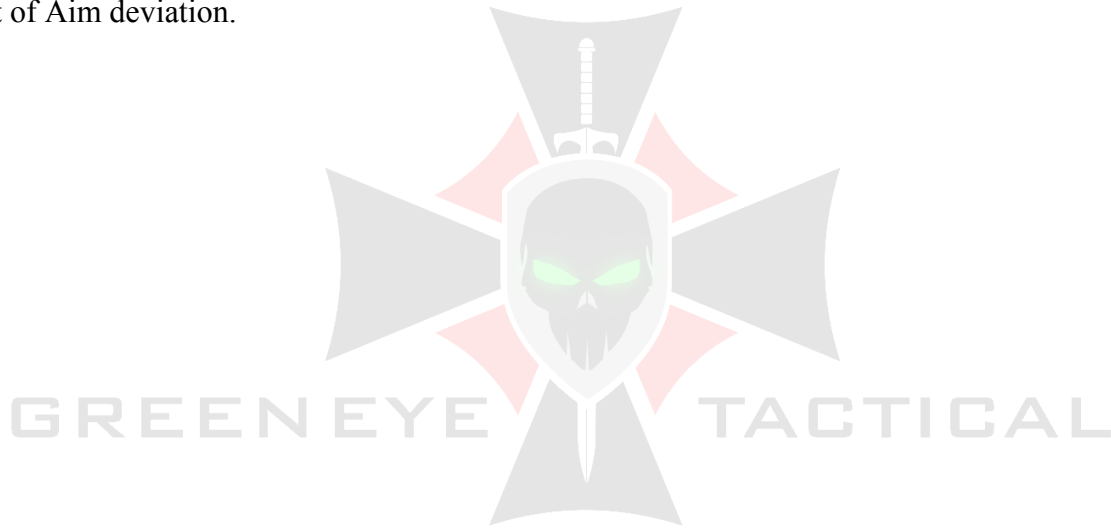


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Introduction

Editorial: *During my years as an instructor, I have noticed a variance in the sensitivity of certain optics models with regards to Point of Impact (POI) shift due to inconsistency with the shooter's head position and alignment behind the optic. This issue has arisen repeatedly in a specific course I teach called the Tactical Rifle Fundamentals Course (TRF). During this course, shooters are trained in marksmanship fundamentals by instructing them in various concepts that can affect the two firearms tasks: One-- Properly point the weapon, Two-- Fire the weapon without moving it. Obviously, there are several errors a shooter can induce that fall under one or both tasks. After data collection and custom zero development, shooters begin grouping at their custom zero distance. Depending on their barrel characteristics, measured muzzle velocity, atmospheric data, and bullet characteristics, this distance can vary generally between 24 yards to 56 yards. After initial instruction, shooters begin to fire 5 round groups at circular bullseye targets. After each group is fired, shooters move downrange to the targets, and I conduct a debrief of each target, issuing feedback and sight adjustments as necessary-- with the goal to increase the consistency of their grouping and to eliminate shooter induced error. This is often a troubleshooting process that can take consecutive groups. Shooters continue this process at 100 yards, 200 yards, and 300 yards in various standard shooting positions. At the very first TRF course I taught three years ago, I noticed difficulty in completing this process by shooters using one particular optic model. The shooters using these optics produced a POI shift each group fired that could range from a quarter inch to two inches. After exhausting all mechanical error possibilities, I attempted to fire a group with one of their weapons. While adjusting my head position and assuming the prone supported position that they had been using, I noticed some*

irregular movement with the aiming dot in the optic. I then checked the optic by moving my head directly vertically, behind the optic while keeping the weapon immobile. It was then that I noticed that the aiming dot moved in a circular arc that was not in an axis directly equal to or opposite of my view angle. Without telling the rest of the class what I saw, I asked them to perform the same check and, when satisfied- to stand up without saying anything and let each of the other students perform the check. After everyone had completed the check, I asked the class what they had seen. They all described, independently exactly what I saw. We then performed the same actions with the other student's optic of the same model with the same results-- except for one thing-- the optic moved in a completely different arc. Over the next three years I saw many of these optic models. Without exception, every user of this optic demonstrated POI shift; every optic displayed irregular and excessive aiming dot deviation when observed; every student in each class confirmed the same observations; and, every optic displayed a different arc pattern of movement. Again, this was without exception. Over these years as an instructor, I reinforced to users of these optics at the TRF course the need to keep the aiming dot in the center of the viewing tube. I proposed the option of referencing the front sight post's position relative to the aiming dot as a spatial reference when firing (not placing the dot on the front sight post, just noting the position relative to it) to increase consistency. Often this minimized the POI shifts, but it never eliminated it. After three years of observing the same issue with this sight and the effect it had on my client's ability to progress with the rest of the class, I decided to disallow its use in this one specific course. I made this announcement on my company's relevant social media pages. Shortly after sharing this equipment restriction, it was shared to an industry forum by an unknown user. My statement stirred some emotions with some in the industry. While this

announcement was not an industry press release or advice to anyone in the industry, as it pertained to just one of my courses- the reaction was that it was.

In my assessment, this misunderstanding exposed a major issue in our firearms community. We have evolved, generally, into an echo chamber where broad statements and opinions drive the validity of equipment. After extensive research, I also realized the severe lack of any independent and peer reviewed testing. To a large extent, most simply take the word of manufacturers-- or others take the word of another person or organization that say, "they saw it happen". So, while my announcement was taken out of context as industry advice, I realized that it was an opportunity to, at the very least, try to do something right. Ideally, as a community, no one should react emotionally to someone who states a point of view on a piece of equipment or on a theory that differs from one's own. One should simply request that the person substantiates their view by producing data that can be reproduced and verified. One should never discourage someone in this undertaking, for if one knows that one's point of view is correct-- then the tester's data will prove it. If the tester's resulting data or model is believed to be flawed, then one can in turn, reproduce their test and demonstrate it to be inaccurate. This is the basis of the Scientific Method. Society can then keep each other honest in what individuals say, because statements will need to be supported by evidence that can be replicated. Society would be improved if more people approached controversial topics in this manner. Therefore, I have committed to this endeavor by dedicating a portion of my time, without pay or incentive, to producing a test, the resulting data, and this report for the community to review. It is my deepest hope that it will drive others to reproduce what I have done, in order to either prove or disprove my results. I want to thank all who are reading this, and I hope that readers find this report to be interesting.

Eric Dorenbush

Green Eye Tactical



Methods

This report consists of two separate testing events:

- The first test was conducted on 11 March 2017.
- Follow up tests were performed independently by users across the country and were then submitted electronically.

The following section defines the initial test performed.

Testing Plan (Original Test, 11 MAR 2017)

Purpose:

To measure and compare data on red dot sight aiming dot deviation, due to parallax, in various models of optics at variable ranges.

Method:

Users induce angular deviation in their angle of view, from one extreme to another, in order to replicate head position inconsistency and measure the maximum possible parallax deviation.

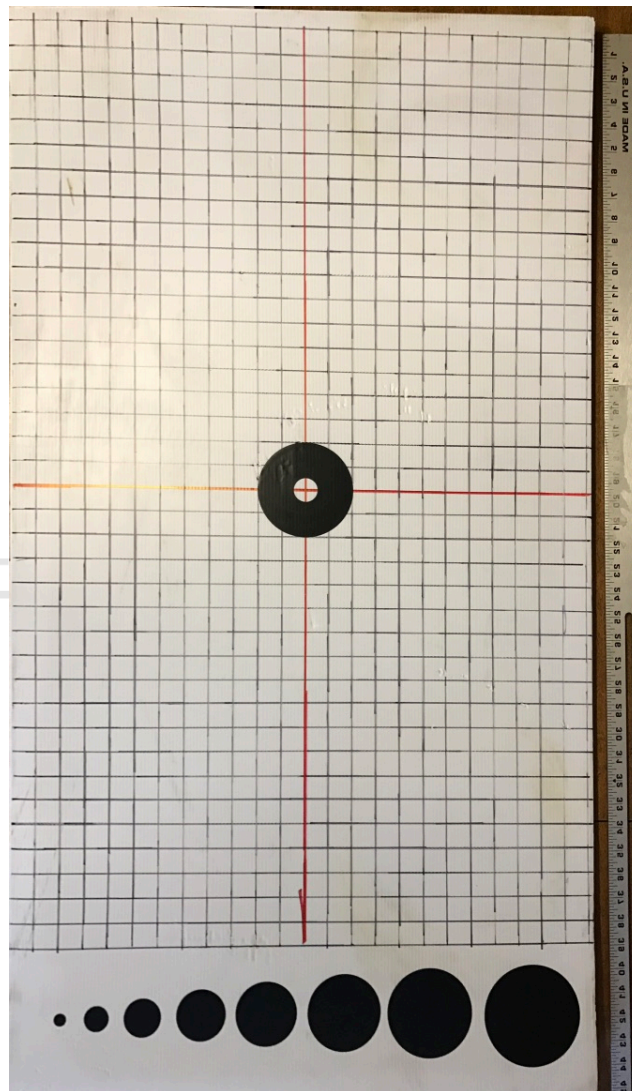
Goals:

This test is intended to:

- To objectively evaluate each device

- To establish specific controls to ensure consistency between testers and devices
- To establish clear protocols to ensure repeatability and ease of peer review
- To comment only on confirmed observations, not hypothesize as to the causes

Calibration Targets:



*** Note: The picture above was not taken at a perpendicular angle to the target face. Due to perspective, the target is not measurable in this photograph. ***

Calibration targets were constructed on white corrugated plastic target backers 24" wide x 44" tall. The lower 6" portion of the target consisted of 8 black vinyl circles that ranged from 0.5" to 4", in 0.5" increments. The upper target area measured 38" x 24" and consisted of a marked black grid line pattern with 1" line spacing. The central horizontal and vertical lines were red. At the center of the target, was a 4" black vinyl circle with a 1" circular hole in the center.

Test Sheets:

**GREEN EYE TACTICAL
RED DOT TEST AND EVALUATION FORM**

Tester ID _____

Date _____

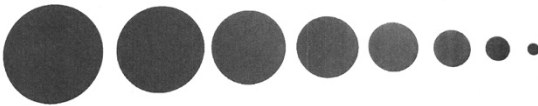
Optic Brand _____

Optic Model _____

Optic ID _____

Aiming Dot Size Evaluation
(circle one, annotate brightness setting above circled dot)

Distance _____



Color Legend

Vertical Movement Color _____

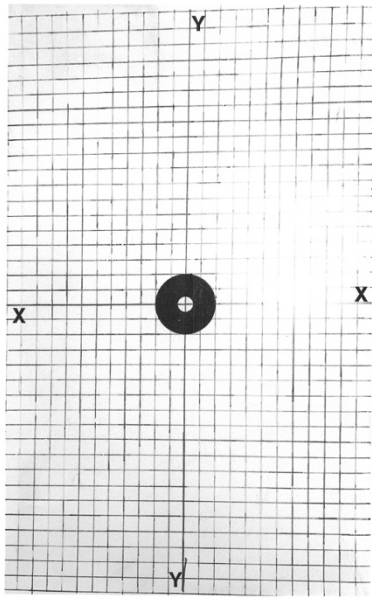
Vertical X Axis Range _____

Vertical Y Axis Range _____

Horizontal Axis Color _____

Horizontal X Axis Range _____

Horizontal Y Axis Range _____



Testers were issued a testing form to be used for each optic separately at each distance observed. The concept of the form was that the tester would fill out the relevant data fields in the top margins. The tester would then use a colored pen to draw the path he saw the aiming dot move, relative to the center of the target, on the representation of the calibration target on the test sheet. The tester would use a separate color for the vertical and horizontal movement tests, noting the color used in the color legend fields. The tester would then mark the coordinates for the end points of each line trace. Testers did express some confusion as to the Cartesian coordinate system, as well as the format for entry that separated the X axis values from the Y axis values. Testers were instructed that they could leave the coordinate fields blank and that the diagram would be used to derive the coordinates from. This format was modified in later tests.

Planned Control Measures:

- All optics used were to be assigned an ID number, labelled, photographed, and have its serial number and model recorded on a master sheet. All optics would be associated with a tester ID for the purposes of follow up for inconsistencies



- . All testers will be assigned a tester ID number, which will be used on tester evaluation forms. Testers name and personal data were to be kept on a separate roster and not used on publicly released results to protect privacy. Testers could choose to reveal their identities independently.
- If optics were weapons mounted, then they would be cleared and flagged before test use.
- Live fire shot groups would not be used for this test to record results, to rule out fundamentals errors as a factor.
- All targets used would have its measurements confirmed by the testing group before use. Any inconsistencies will be recorded. All targets will be set up and leveled by a level confirmed by the testing group. Targets will be placed at distances, utilizing a laser rangefinder.



- Weapons would be clamped to a rest and the sight will be leveled with a level and confirmed by at least two separate testers before observation.

- All testers would be observed by at least one other tester during observation to ensure consistency.
- To eliminate the potential of the test organizer inducing bias, the testing group would elect a test leader, who had the responsibility of effectively running the test.
- The testing group would elect a recorder who would manage all testing forms until the test was complete.
- All weather and atmospheric data at the time of the test would be recorded
- All optics would use a fresh lithium battery

Planned Procedures:

- Testing group would inspect and clear all weapons used during testing, under the test organizer's supervision.
- Testing group would inspect each optic, thoroughly clean all optic lenses, and check batteries.
- Testing group would inspect each optic's serial number, record the number on a master sheet, and assign an ID number to be attached to each optic for ease of reference during testing.
- Testing group would install and inspect each calibration target-- confirming the precise distance from the testing table to be 25 yards, 50 yards, and 100 yards.
- Members of the testing group, not involved in testing of the optics on the table would be sequestered in a holding area, to not be biased by observing other tester's findings.
- Testers would conduct the following tests:

- Point the aiming dot at the 0.5 inch to 4-inch sub-tension circles at the bottom of the calibration target to observe and measure the perceived aiming dot size and variable distances and record the results on the evaluation sheet.
- Point the aiming dot at the center of the calibration target.
- Confirm the dot is centered on the calibration target by a second tester.
- Without touching the weapon or optic, the tester would conduct the vertical movement test by recording the linear measurement of the aiming dot movement, measured perpendicular to the line of sight, relative to and at the intended point of aim, as observed through the maximum viewing angle of vertical inclination and declination.
- The tester would then conduct the horizontal movement test by recording the linear measurement of the aiming dot movement, measured perpendicular to the line of sight, relative to and at the intended point of aim, as observed through the maximum and minimum viewing angle of horizontal deflection.
- This process would be repeated at the 25 yard, 50 yard and 100 yard calibration targets



- A major focus of the planned procedures was to keep them as simple as possible, so that any interested party would not be discouraged to attempt to replicate the test in order to confirm the results in this report or to test their own personal equipment.

GREENEYE TACTICAL

Testing Narrative:



The test was held in Whitewright, Texas at a private range facility on 11 March 2017. 6 volunteer testers attended the event. 14 optics were donated for testing by volunteers. Testing began at 0930 and was projected to conclude before noon. The test began well and testers were motivated by the opportunity to contribute to the industry through data collection. It became apparent early in the day, that the protocols used were very time consuming. By 1130, we had only finished 4 optics evaluations by 2 testers. After consultation with the lead tester, it was identified that the red dot size evaluation portion of the test was overly time intensive, especially on the 100 yard target. I relayed to the lead tester, that while this was an interesting point of data to collect, it was not essential to the test's main purpose. We also set up an additional table to provide for two additional testing stations. The holding area was decommissioned and all testers were moved to the testing line to simultaneously conduct tests. This abbreviated the process significantly, but as we were already late in the day, many testers were moving close to deadlines to depart. After consulting with the lead tester, I communicated the priority to be the 50 yard target first, then the 25 yard target, with the 100 yard target then observed if time allowed as it consumed more time. Unfortunately, due to the unforeseen time involved in the testing, not all optics were able to be observed by all testers, at all distances. It was also found that the testing form was not well thought out and the (X, Y) coordinate fields did not make logical sense. This form was subsequently modified. Testers completed an exit survey and statement before leaving. No tester reported a lack of confidence in their findings.

Definitions:

Often the usage of terms can get in the way of explaining a concept or result. The following is a list of terms used in this report that could be misconstrued. The definitions may differ from usage in other areas, however-- this is what they are being used for and where their definitions are derived from:

*“Parallax is a displacement or difference in the apparent position of an object viewed along two different lines of sight, and is measured by the angle or semi-angle of inclination between those two lines. The term is derived from the Greek word παράλλαξις (parallaxis), meaning "alternation". Due to foreshortening, nearby objects have a larger parallax than more distant objects when observed from different positions..... In optical sights parallax refers to the apparent movement of the reticle in relationship to the target when the user moves his/her head laterally behind the sight (up/down or left/right), i.e. **it is an error where the reticle does not stay aligned with the sight's own optical axis**” – Wikipedia, Parallax.*

The key phrase in this definition is bolded. **We are using parallax movement to describe the effect of the aiming point moving from its relative point of aim on a target due to the alignment of the user's head behind the optic.**

Atmospherics:

Temperature: 68F

Humidity: 57.2%

Barometric Pressure: 30.08 inHg

Altitude: 751 ft ASL

Direction of Observation: 180deg Magnetic

Angle of Observation: 0deg

Table of Optics Tested:

Optic Brand	Optic Type	Serial #	ID #
EoTech	EXPS 3.0	A1292043	1
EoTech	EXPS 3.0	A0565568	2
EoTech	EXPS 3.2	A1276811	3
Aimpoint	T-1	W3229523	4
Aimpoint	T-1	W3118077	Not Tested
Aimpoint	Pro	K2980053	Not Tested
Trijicon	RM07	108157	Not Tested
EoTech	EXPS 3.0	A1348665	8
Primary Arms	MD-05	6182	9
Aimpoint	T-1	W3908997	10
Trijicon	MRO	041032	11
Burris	Fastfire III		12
Trijicon	MRO	0611331	13
Trijicon	MRO	010521	14

Testing Plan (Follow-On Testing)

The following section summarizes the independent follow-on tests that volunteers across the country conducted by replicating the modified form of the original testing.

Purpose:

To collect and compare data on red dot sight aiming dot deviation, due to parallax, in various models of optics at variable range for the purpose of validating the data sets and results from the original 11 March 2017 results and to expand the sample groups.

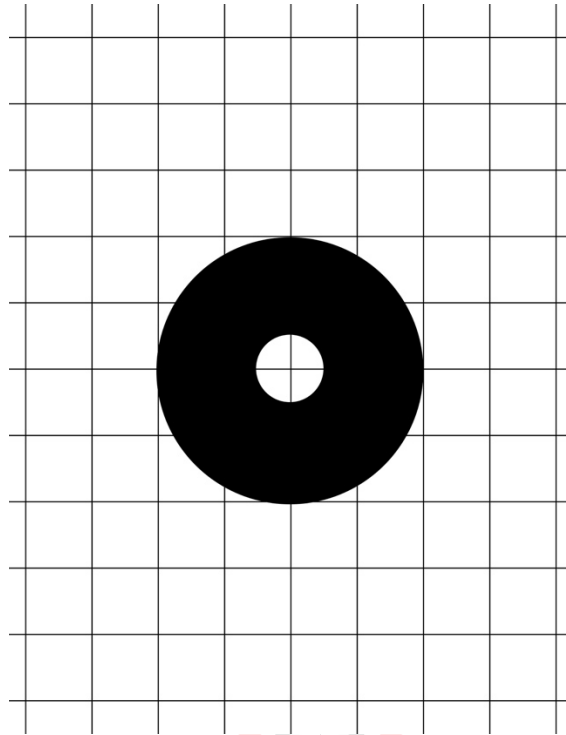
Method:

Users would induce angular deviation in their angle of view from one extreme to another, to replicate head position inconsistency and measure the maximum possible parallax deviation.

Goals:

- To objectively evaluate each device in an impartial manner.
- To establish specific controls to ensure consistency between testers and devices.
- To establish clear protocols to ensure repeatability and peer review.
- To comment only on confirmed observations, not hypothesis as to the causes.

Calibration Targets:



For the follow-on testing, a calibration target was produced that could be printed on standard printer paper. This modification was made in order to accommodate Law Enforcement units with limited time to construct the original calibration targets and military Special Operations Units that may be forward deployed. The calibration targets consist of the same 1" grid line spacing as the original, as well as the 4" black center circle, with the 1" circular cut out.

Test Sheets:

RED DOT TEST AND EVALUATION FORM

Tester ID A10
(ensure testers real name is referenced to the tester ID separately from this form)

Date 17MAR17

Optic Brand Aimpoint

Optic Model M68

Optic ID/ Serial # AB12345678
(If OPSEC/ PERSEC causes concerns with publicly releasing the optic Serial #, assign it an ID/track # and reference it to the S/N separately from this form)

Distance 50 yards
(please use a separate form for 25, 50, and 100yd observations)

The grid on the target below is comprised of 1" squares and a 4" black circle with a 1" center. If you cannot produce this target locally and are using an alternate target, ensure you reference and convert your form of target measurement to match the target scale on your drawing. You may choose to alter this picture to aid, i.e.: if you are using a 5.32" NRA bullseye, or an Army Zero target- use the grid as a scale reference and draw the target used on this sheet to aid in your sketch of movement.

Observation Legend
"If you are unable to send this form scanned in color, please annotate which line sketched belongs to which movement test"

Vertical Head Alignment Test

Movement Trace Color RED

Point A Coordinate (X,Y) (-2,4)

Point B Coordinate (X,Y) (3,-3)

Horizontal Head Alignment Test

Movement Trace Color BLUE

Point A Coordinate (X,Y) (3,3)

Point B Coordinate (X,Y) (-3,-3)

**note*- if you do not understand the cartesian coordinate system, leave point A and B fields blank. Attempt to make the drawing on the target as accurate as possible so we can plot them for you or use them as a confirmation of your recorded coordinates.*

Target Diagram: A grid with a 4" black circle in the center. Four points are plotted: Point A (red) at (-2,4), Point B (red) at (3,-3), Point A (blue) at (3,3), and Point B (blue) at (-3,-3). Arrows indicate movement from A to B for both tests.

Annotations:

- This example sheet is not an example of any measured or expected results- your observations may be different!
- This number the tester ID that you assigned on the Test Records Reference Excel Sheet. DO NOT USE YOUR REAL NAME, this is a public form
- Date your observation was conducted
- Brand name of optic (Aimpoint, Eotech, Trijicon, etc)
- Model of optic (EXPS 3.0, T-1, MRO, etc)
- This number is either the optic's serial number or the ID number assigned on the Test Records Reference Excel Sheet
- Distance this observation was conducted. (Prioritize 50yds > 25yds > 100yds if time is limited)
- Trace your observations on the chart. If you cannot scan color copies, make sure you make a notation as to which line belongs to which movement test.
- If you do not understand how to plot the end points of your line using the Cartesian system- leave the coordinate fields blank and they will be filled in for you. The line sketch you draw will be assumed to be correct, so make it as accurate as possible. You may consider tracing in pencil until you are sure it is correct and then outlining it in color.

In order to aid and encourage the independent evaluation of the test we conducted on 11 March 17, the original testing form was modified to make the evaluation process more streamlined and easier to understand. All files were then uploaded to a shared Dropbox and the link was shared various firearms forums and on social media.

Instruction Sheets (Procedures and Control Measures)

The following instruction sheet was also added to the folder. Some modifications were made to the instructions to accommodate some special operations units that wished to submit test results, but were forward deployed. Considerations for the sensitivity of releasing serial numbers of

optics for some of these units:

RED DOT TEST INSTRUCTIONS

This is a simple and standardized test to evaluate your red dot optic for possible parallax movement by using the maximum range of vertical and horizontal head alignment and observing the results at variable distances, for the purpose of: equipment capability awareness and comparison

Procedures:

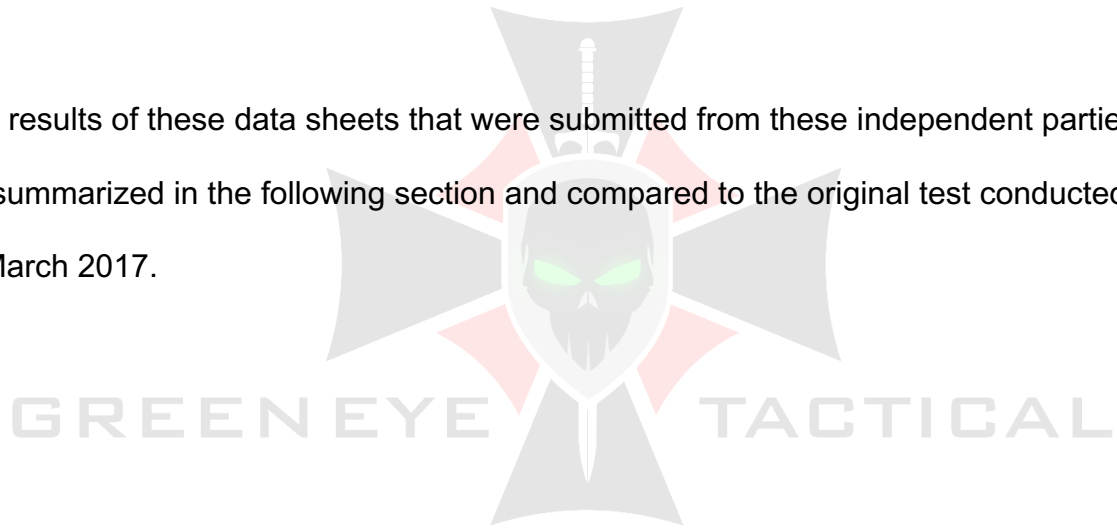
- **Record all tester names on the “Tester Name Reference” tab in the Test Record Reference Sheet excel file. Assign each tester a “Tester ID #” for use on the “Red Dot Test and Evaluation Form”.** This file will not be publicly released. (no sheets with alias or false names will be accepted unless prearranged and justified)
- **Record all Optic Brand, Model Name, and serial number information on the “optic reference” tab in the Test Reference Sheet excel file.** To make it easier for testers to identify the optic if multiple units are being tested- an ID or rack # may be assigned and recorded on the sheet. This file WILL be publicly released (only this tab). NO TEST WILL BE ACCEPTED WITHOUT VERIFIABLE SERIAL NUMBERS. (if OPSEC prevents serial number disclosure, prior coordination must be made)
- **Place calibrated targets at 25yds, 50yds, and 100yds** (ensure you use yards, not meters). Ensure distance is measured with a laser range finder, measuring tape, etc.- **DO NOT** use existing range markers, pacing or range estimation. Ensure that you measure your targets and have a method to judge vertical and horizontal deviation that you can correlate to the 1” grid on the evaluation sheet. If time does not allow testing at all three distances, please use the following priorities as time allows: 50yds > 25yds > 100yds.
- **Clean all optics lenses thoroughly and install a fresh battery.**
- **Place rifle on a stable platform that will prevent the rifle from moving during testing.** If an unmounted optic is used, place the optic on something that will accomplish the same purpose.
- **Aim the optic so that the aiming dot is in the center of your target.** Attempt to keep the aiming dot in the center of the viewing tube or window during aiming. If a second tester is available, have them confirm.
- **Conduct the vertical head movement observation.** Move your head from center alignment (dot in the center of the tube/window) upwards to the extent you can keep the target and aiming dot in your field of view and the aiming dot centered from left to right. Then move your head down to the lowest extent you can keep the dot and target in your FOV. Note the extent of dot movement (if any) and the path of movement reference the target. Ensure you do not touch/move the rifle during this process and the

Testing Narrative

The follow-on testing was an extremely important component of this testing report. Due to the nature of the testing procedures used in the original test, there was a reasonable chance that the tester induced error could create inconsistent results to the point that the data sets would not be reproducible. The concerns over this made it essential to replicate the test completely independently and by as many separate parties as possible. If results within the standard deviation for similar optic models could not be reproduced by independent testers, then it could invalidate the data sets for the purpose they were summarized. In that case, additional controls would have to be emplaced and the testing would need to be repeated until enough variables were removed until the data sets were consistent. All files and instructions required for the testing procedure were uploaded to a shared Drop Box folder and published on several industry forums and social media sites. As a result of this initiative, a significant amount of data sheets were received that have drastically expanded the type and models in this report, as well as drastically expanding the comparative data point of the original test. These reports have come from a wide array of individuals from a wide variety of backgrounds from the civilian, Law Enforcement, Federal, and Military community.



The results of these data sheets that were submitted from these independent parties are summarized in the following section and compared to the original test conducted on 11 March 2017.



Results

Summary Chart Legend

For all summary charts, the following abbreviations and terms are used:

VD A (IN)	Average of Vertical Deviations in Inches
VD A (MOA)	Average of Vertical Deviations in Minutes of Angle (shooter's)
VD SD (IN)	Standard Deviation of Vertical Deviations in Inches
VD SD (MOA)	Standard Deviation of Vertical Deviations in Minutes of Angle
HD A (IN)	Average of Horizontal Deviations in Inches
HD A (MOA)	Average of Horizontal Deviations in Minutes of Angle (shooter's)
HD SD (IN)	Standard Deviation of Horizontal Deviations in Inches
HD SD (MOA)	Standard Deviation of Horizontal Deviations in Minutes of Angle
AVG A (IN)	Average of Horizontal and Vertical Deviations in Inches
AVG A (MOA)	Average of Horizontal and Vertical Deviations in Minutes of Angle (shooter's)
AVG SD (IN)	Average of Horizontal and Vertical Standard Deviations in Inches
AVG SD (MOA)	Average of Horizontal and Vertical Standard Deviations in Minutes of Angle (shooter's)
Vertical Deviation	The linear measurement of the aiming dot movement, measured perpendicular to the line of sight, relative to and at the intended point of aim, as observed through the maximum viewing angle of vertical inclination and declination.
Horizontal Deviation	The linear measurement of the aiming dot movement, measured perpendicular to the line of sight, relative to and at the intended

	point of aim, as observed through the maximum and minimum viewing angle of horizontal deflection.
Inches	Standard linear measurement. 1/12 of a foot
Minutes of Angle	Angular form of measurement, where 1 Minute of Angle (MOA) equals 1/60th of a degree and 1 degree equals 1/360th of a circle or complete turn. True MOA subtends to 1.047 inches at 100 yards for every 1 MOA and is not used for this test. "Shooter's" MOA rounds the subtension to 1 inch at 100 yards for each 1 MOA. This is used to simplify the math involved, the results, and to reduce confusion in some of the readers.
Average	The Arithmetic Mean as found by the sum of numbers, divided by the number of the numbers.
Standard Deviation	Standard deviation is a measure that is used to quantify the amount of variation or dispersion of a set of data values. A low standard deviation indicates that the data points tend to be close to the mean of the set, while a high standard deviation indicates that the data points are spread out over a wider range of values. The STDEV.S function is used for the calculations on this sheet.

11 March 17 Test Results

Overall Results

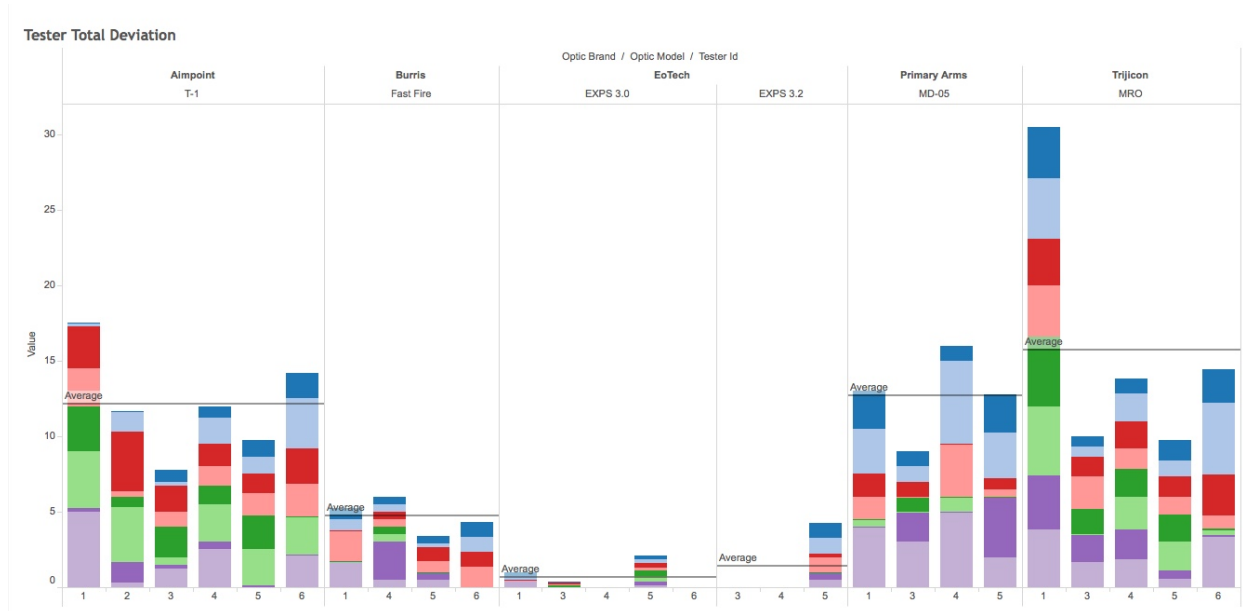
Testing Accuracy:

The premise of this test was to evaluate possible parallax error that a shooter could induce into a red dot optic through improper viewing angle, such as may occur due to inconsistent head alignment. One of the objectives of this test was to keep the manner in which the test was conducted as simple and repeatable as possible. While a more realistic way to test for possible error, would be to restrict the view angles to the center 50% of the available viewing area-- placing repeatable controls to restrict this angle would have complicated the testing protocols and/or required additional equipment. For these reasons, we chose to use the maximum viewing angles on each axis of movement, as the physical construction of the tube or window in the optic would provide a natural constant for viewing angle tolerances.

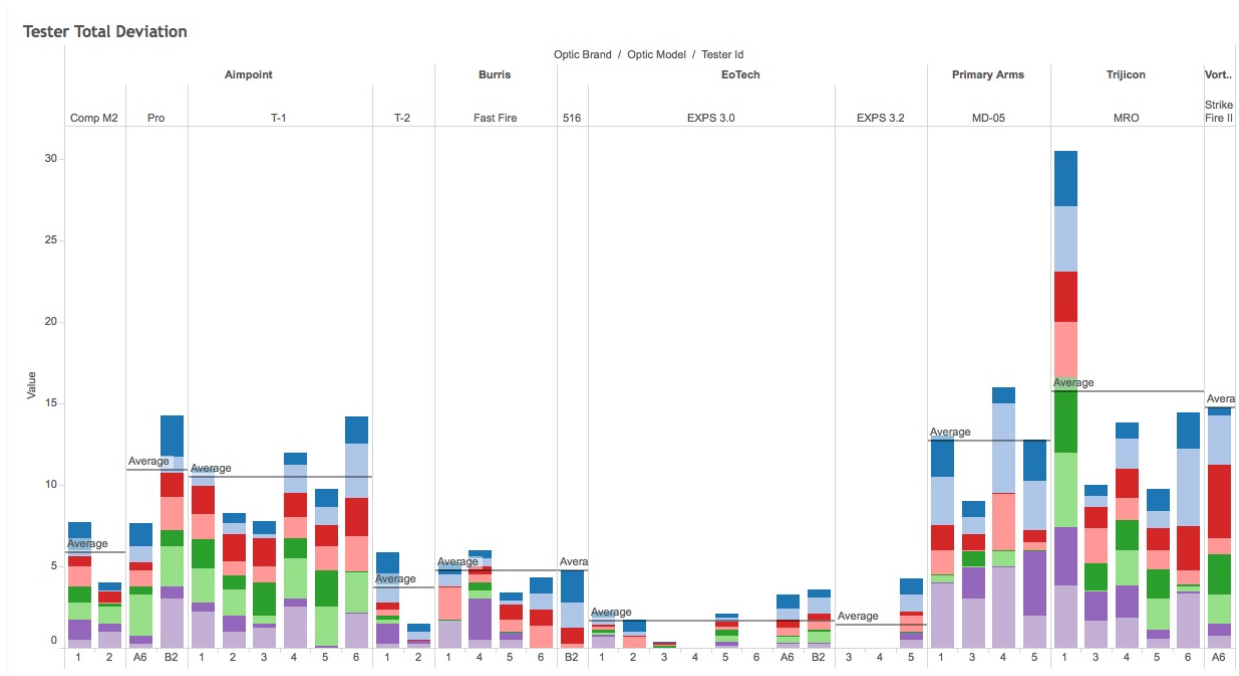
Red dot users also tend to perceive and reference the aiming dots differently. This could be due to numerous reasons, such as: how users with astigmatisms may see the EoTech red dots as an amoeba or separate dots rather than a single dot, or some Aimpoint dots may appear as an oval. Visual acuity can also affect the clarity of the target the aiming dot is being referenced to as well. Since the premise of this test is based on a user's perception and ability to use an optic, it was decided to not control this variable. We feel that this makes the test unique, in that: is provides results that may more closely represent results that would be replicated by interested parties that may attempt to recreate the test. An interesting follow up test that could be done after this test, may be to recreate this test using cameras or video equipment instead to establish a comparative data set against the user's visual acuity and perception.

Below is a table showing the differences in the tester's results from the 11 March 2017

test:



As you can see, there are variances in the results that the testers reported. What is very interesting, is that some testers reported results that were far outside the average of the other testers. However, the variance was not constant across all optics. For instance, Tester ID # 1 reported results that were far outside the average for the Trijicon MRO's, however the same tester was well within the average for the Burris Fast Fire and EoTech EXPS 3.0, and only slightly greater than average for the T-1.



When we add in the tester standard deviations from the independent testing that occurred after the 11 March 2017 test, we can see that as the test group increases, the variance in results remain fairly consistent-- tester ID # 1 on the MRO being the sole outlier. The expansion in the sample group compared against the consistency of the results seems to indicate that the original testing group's standard deviation in data point display a trend to be consistent with expected results.

One of the factors of the test that minimizes the effect of results that may fall outside of the margins is that we use multiple data points and present the results as averages. This results in a single large variance in data producing only a minimal shift in average results. Another statistic we included in the comparative charts that will be displayed is the Standard Deviation of the results. This gives the reader an idea of how much variance there is in the data points for the averages displayed. As the data is displayed at varying levels and orders, the reader can use the comparison

Chart Explanation

The overall section summarizes the testing data from all distanced (25, 50, and 100yds). Data sheets are entered a master spreadsheet, which can be found in the public files for this report, and results are calculated. Summary tables are sorted from better results to worse results and color coded for clarity.

The values in the “Data Points” column represent how many individual tester sheets were used to produce the results given. The “VD A (IN)” and “HD A (IN)” columns represent the average of all linear distance measured from their associated data points. The linear distance was measured by taking the line trace end point coordinates using the Cartesian Graph format (x1,y1), (x2,y2). The Cartesian version of Pythagoras’s Theorem was used to find the Euclidean Distance between the two points, using the formula:

$$d = \sqrt{((x_2 - x_1)^2 + (y_2 - y_1)^2)}$$

The “AVG A (IN)” and “AVG A (MOA)” Columns are a simple average of the Euclidean Distance from their corresponding deviation columns, i.e.: AVG A (IN) is the average of the VD A (IN) and HD A (IN) fields.

The Standard Deviation fields, “VD SD (IN)”, “VD SD (MOA)”, “HD SD (IN)”, and “HD SD (MOA)”, are not calculated from the summary charts pictured here. These values are calculated from the Euclidean Distance values from each individual optic. The average Standard Deviation fields, “AVG SD (IN)” and “AVG SD (MOA)” are averages of the corresponding Vertical Deviation and Horizontal Deviation results.

The color scheme on the charts represent an “above average” or “below average” measurement, based on a simple average from that column, represented in the “Total Sample Average” row.

This means, green is a smaller or more precise value and red is a larger or less precise value. The exemption is the “Data Points” column, of which a smaller number of data points is labeled as red and a larger sample size is green. Simply: green is a better result, red is a worse result.

***The movements observed are the movements of the aiming dot, reference the target, looking through the viewing window or tube. The test did not measure if parallax caused the actual perception of the targets position itself to move to changes in viewing angle. The “Vertical” or “Horizontal” descriptor to deviation describes the axis of head movement the tester used to observe the recorded results. Due to many of the optics exhibiting irregular and excessive movement, using the actual movement direction of the aiming dot was not possible. The irregular movement paths also drove the decision to use simple end points for deviation calculation, as using multiple data points along many of the optic’s curving paths would have been extremely complex. ***

The “Data Points” column indicate the total number of test sheet data that were used to produce the results shown. Since all testers were not all able to test all optics at all ranges, due to having to leave as the test took much longer to conduct, the Data Points are not evenly dispersed. Keep this in mind for the later comparisons in this report, as remote testers submitted a significant number of many of these low data point optics-- and their results will indicate as to whether the smaller sample group produced a flawed model or not.

The following sections below summarizes the results of the data recorded by user evaluations during the vertical movement test.

SUMMARY OF OVERALL RESULTS

Overall Vertical Movement Evaluation:

Sorted by Vertical Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.2	All	6	0.333333333	1	0.516397779	1.673320053
EoTech	EXPS 3.0	All	25	0.37472136	1.138885438	0.592561444	2.011151194
Burris	Fast Fire	All	10	1.18591736	3.519048316	1.381866698	4.057407348
Aimpoint	T-1	All	25	4.75140586	11.13178627	3.215221343	4.895079853
Primary Arms	MD-05	All	8	5.153006282	13.71925818	2.106866666	2.598231292
Trijicon	MRO	All	33	5.497114588	13.45476109	4.041956247	6.432316677
Total Sample Average			17.833333	2.882583131	7.327289882	1.975811696	3.611251069
Total Data Points			107				

This table summarizes the results of the data recorded by user evaluations during the vertical movement test, by optic type and at all distances. As shown, this data is derived from 107 individual test reports.

From the Vertical Deviation results, we can see a clear separation in measurements between the optic models. To further break out these results, we can compare this table to the Overall Vertical Deviation summary, sorted by individual optics tested:

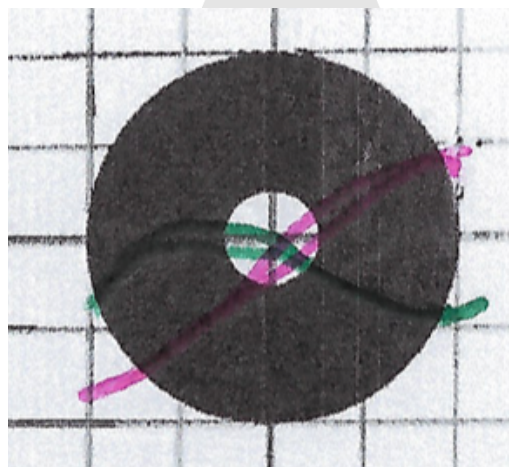
Sorted by Vertical Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.2	3	6	0.333333333	1	0.516397779	1.673320053
EoTech	EXPS 3.0	8	11	0.363636364	1.227272727	0.683407239	2.503633723
EoTech	EXPS 3.0	1	8	0.375	1	0.51754917	1.511857892
EoTech	EXPS 3.0	2	6	0.394672331	1.162022659	0.612846229	1.905162462
Burris	Fast Fire	12	10	1.18591736	3.519048316	1.381866698	4.057407348
Trijicon	MRO	13	9	3.770571892	9.59973272	1.201305982	3.546233659
Aimpoint	T-1	4	10	4.369223352	11.71725908	1.388399278	4.472861345
Aimpoint	T-1	10	15	5.006194199	10.74147106	4.038389837	5.27332906
Primary Arms	MD-05	9	8	5.153006282	13.71925818	2.106866666	2.598231292
Trijicon	MRO	14	11	5.71875277	15.10461774	2.669354498	6.575376439
Trijicon	MRO	11	13	6.504873379	14.72759434	5.769359369	7.107938892
Total Sample Average			9.727272727	3.015925569	7.59257062	1.898703886	3.747759288
Total Data Points			107				

As we can see from the chart comparison, the result within each individual optic type exhibited relatively consistent behavior when compare to the same models. The exception being

the MRO's, where we see that one of the three MRO models, Optic ID # 13, significantly outperformed Optic ID # 14 and 11. These optics, however, still performed in the bottom 50% of the group.

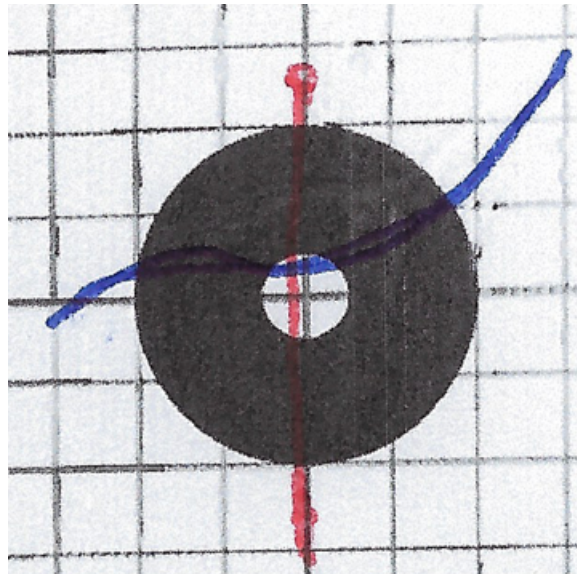
Many of the testers reported very minimal movement observed in the EXPS 3.0s tested, and if movement occurred-- it was at the very edge of the viewing window and was minimal.

The MRO was very difficult for the users to diagram what they saw. Most testers reported a diagonal deviation when moving their point of view vertically. The difficult part to describe was when the aiming dot passed back through the target as the tester crossed over the center of the viewing tube. At this center point the dot would make a sharp movement before continuing its diagonal path. Some users described a “squiggle”, some a lightning bolt, some a waveform. This behavior was observed by all testers on all MROs tested in this test. To demonstrate this, below is a picture of Optic ID #13's movement diagram at 50 yards, as drawn by Tester # 5. To remind the reader of perspective-- the black circle represents the 4” black circle on the calibration target and grid lines are 1” spacing.



Testers reported varying semicircular movement patterns in the T-1s tested. All testers reported this behavior in both T-1 optics tested. An example of the irregular movement observed

in the T-1 models is exhibited below in Optic ID #'s 50 yard test form as observed by Tester ID #1.



We also see the formation of a trend, that will continue through the varying levels of breakout detail, that the optics that exhibited less aiming dot deviation due to parallax also produced a better standard deviation of results. The decrease in movement seems to indicate that testers had the ability to more accurately observe and reference these optics.

Editorial analysis: As an instructor, I find the Standard Deviation numbers almost more interesting than the Deviation measurements, as it clearly points to which optics are more sensitive to user error. As it pertains to user error, an optic with a very low standard deviation would indicate consistent error that could be predicted and more easily accounted for, a very high standard deviation indicates inconsistent error that would be much more difficult to account for.

Overall Horizontal Movement Evaluation:

Sorted by Horizontal Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	25	0.4	1.16	0.688446318	2.055075019
EoTech	EXPS 3.2	All	6	0.814996656	2.317177583	1.285665797	3.681959486
Burris	Fast Fire	All	10	1.89650799	4.529227569	1.171185271	2.330020894
Aimpoint	T-1	All	25	4.905103764	10.53918909	3.538472639	3.725684124
Primary Arms	MD-05	All	8	5.398007472	14.76812235	2.482571324	5.226587213
Trijicon	MRO	All	33	5.979710915	13.29301614	4.668782274	4.22699223
Total Sample Average			17.833333	3.232387799	7.767788789	2.305853937	3.541053161
Total Data Points			107				

From the Overall Horizontal Deviation by model type summary chart above, it is observed that there were only changes in rankings in the upper 50% of the optics, compared to the vertical movement test. Some of the MROs appeared more sensitive to horizontal head movement, while the T-1s were more sensitive to vertical head movement, but this was not consistent.

We can also see the trend of a greater precision of results with the optics that exhibited less deviation.

Sorted by Horizontal Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	2	6	0.291666667	0.833333333	0.458711965	1.329160136
EoTech	EXPS 3.0	8	11	0.340909091	1.181818182	0.654529672	2.482667187
EoTech	EXPS 3.0	1	8	0.5625	1.375	0.903860767	2.065879266
EoTech	EXPS 3.2	3	6	0.814996656	2.317177583	1.285665797	3.681959486
Burris	Fast Fire	12	10	1.89650799	4.529227569	1.171185271	2.330020894
Aimpoint	T-1	10	15	4.542053431	9.731771818	2.353511958	3.539463833
Trijicon	MRO	14	11	4.913508762	12.33653294	1.869003696	3.858879437
Primary Arms	MD-05	9	8	5.398007472	14.76812235	2.482571324	5.226587213
Trijicon	MRO	13	9	5.441756386	11.8804971	4.340731317	2.731393807
Aimpoint	T-1	4	10	5.449679263	11.750315	4.921720107	3.848534699
Trijicon	MRO	11	13	7.254312025	15.08024586	6.295662803	4.946550997
Total Sample Average			9.727272727	3.355081613	7.79854925	2.430650425	3.27646336
Total Data Points			107				

In the same chart that shows the same summary, but broken out to individual optics tested we can see some interesting trends. For instance: Optic ID #10 displays more consistent standard

deviation result of 3.5 MOA in the horizontal test, and a less consistent standard deviation result of 5.27 MOA in the vertical testing.

Editorial analysis: *This data, combined with the tester's verbal descriptions of what they observed, demonstrate how irregular movement paths can cause difficulty with the user's ability to consistently reference the optic.*



Overall Total Deviation Summary:

Sorted by Total Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	2	6	0.343169499	0.997677996	0.535055308	1.615458797
EoTech	EXPS 3.0	8	11	0.352272727	1.204545455	0.668061987	2.492032759
EoTech	EXPS 3.0	1	8	0.46875	1.1875	0.687094036	1.730761599
EoTech	EXPS 3.2	3	6	0.574164995	1.658588792	0.897719034	2.669972886
Burris	Fast Fire	12	10	1.541212675	4.024137943	0.87427761	2.813271146
Trijicon	MRO	13	9	4.606164139	10.74011491	2.512512439	2.205958171
Aimpoint	T-1	10	15	4.774123815	10.23662144	3.023401353	3.841910989
Aimpoint	T-1	4	10	4.909451307	11.73378704	2.95937627	2.444928218
Primary Arms	MD-05	9	8	5.275506877	14.24369026	2.015103508	3.01278581
Trijicon	MRO	14	11	5.316130766	13.72057534	1.981461481	4.647606423
Trijicon	MRO	11	13	6.879592702	14.9039201	5.68003059	5.141557488
Total Sample Average			9.727272727	3.185503591	7.695559935	1.984917601	2.965113117
Total Data Points			107				

As we can see from the summary chart there is a wide range in deviations with very large increments between many of the optics models. While we generally accept that red dot optics are all subject to parallax, it is extremely clear that some optics do not succumb significantly to parallax deviation and other optics exhibit more extreme parallax deviation.

GREEN EYE TACTICAL

SUMMARY OF 25 YARD RESULTS

25 Yard Vertical Movement Evaluation:

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.2	All	25	3	0.333333333	1.333333333	0.577350269	2.309401077
EoTech	EXPS 3.0	All	25	12	0.405669499	1.622677996	0.663166446	2.652665785
Burris	Fast Fire	All	25	5	1.147213595	4.588854382	1.190536101	4.762144404
Primary Arms	MD-05	All	25	4	3.413245611	13.65298245	0.741399035	2.965596141
Aimpoint	T-1	All	25	11	3.437309147	13.74923659	1.236283305	4.945133219
Trijicon	MRO	All	25	15	4.002210046	16.00884018	1.238798993	4.955195971
SAMPLE AVERAGE				8.333333333	2.123163539	8.492654155	0.941255692	3.765022766
Total Data Points				50				

In this chart, we see that 50 data sheets were available and used to produce the summaries for the 25 yard results. While some optics types had fewer data points, they do show a level of consistency within the larger sample size of data points in the overall summaries. We also see a general consistency in the rankings of the optics tested.

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	1	25	4	0.25	1	0.5	2
EoTech	EXPS 3.2	3	25	3	0.333333333	1.333333333	0.577350269	2.309401077
EoTech	EXPS 3.0	2	25	3	0.372677996	1.490711985	0.645497224	2.581988897
EoTech	EXPS 3.0	8	25	5	0.55	2.2	0.87321246	3.492849839
Burris	Fast Fire	12	25	5	1.147213595	4.588854382	1.190536101	4.762144404
Trijicon	MRO	13	25	4	2.940912554	11.76365022	0.940590843	3.762363372
Aimpoint	T-1	10	25	6	3.285796107	13.14318443	1.429773665	5.719094658
Primary Arms	MD-05	9	25	4	3.413245611	13.65298245	0.741399035	2.965596141
Aimpoint	T-1	4	25	5	3.619124795	14.47649918	1.09083438	4.363337521
Trijicon	MRO	11	25	6	4.258478938	17.03391575	1.240334053	4.96133621
Trijicon	MRO	14	25	5	4.543725369	18.17490148	1.092336812	4.369347248
SAMPLE AVERAGE				4.545454545	2.246773482	8.987093927	0.938351349	3.753405397
Total Data Points				50				

When we break these results out by specific optics tested, also see some level of consistency compared to the overall summaries of all distances. We do see some minor changes in rankings within the rankings of optics types, as we do with the EoTechs which have changed positions in rankings within themselves-- but have retained their overall place within the group by type. We also see MRO Optic # 13 significantly outperform #14 and #11. The Burris remains

unchanged in its position, but the T-1s have changed position relative to each other and the rest of the lower 50% of the sample group.



25 Yard Horizontal Movement Evaluation:

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	25	12	0.375	1.5	0.635144937	2.540579748
EoTech	EXPS 3.2	All	25	3	0.687184271	2.748737084	1.190238071	4.760952286
Burris	Fast Fire	All	25	5	1.136211589	4.544846357	0.807405741	3.229622964
Aimpoint	T-1	All	25	11	2.780912817	11.12365127	0.996582306	3.986329223
Trijicon	MRO	All	25	15	3.624074311	14.49629725	0.944581569	3.778326277
Primary Arms	MD-05	All	25	4	3.972107409	15.88842964	1.430553613	5.722214454
SAMPLE AVERAGE				8.333333333	2.095915066	8.383660265	1.00075104	4.003004158
Total Data Points				50				

In the 25 yard summary by optic type for the horizontal deviation test, we see the same general trend towards ranking. The top 50% ranking remains unchanged from the overall results at all distances. The same optics that changed position within their respective types, changed in line with their change in the overall results. It is of note-- that the EXPS 3.2 begins to display a worsening degree of standard deviation of results at closer distances.

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	1	25	4	0.25	1	0.5	2
EoTech	EXPS 3.0	2	25	3	0.25	1	0.433012702	1.732050808
EoTech	EXPS 3.0	8	25	5	0.55	2.2	0.87321246	3.492849839
EoTech	EXPS 3.2	3	25	3	0.687184271	2.748737084	1.190238071	4.760952286
Burris	Fast Fire	12	25	5	1.136211589	4.544846357	0.807405741	3.229622964
Aimpoint	T-1	4	25	5	2.689434106	10.75773642	0.841831479	3.367325916
Aimpoint	T-1	10	25	6	2.857145077	11.42858031	1.184933082	4.739732328
Trijicon	MRO	13	25	4	3.2169892	12.8679568	0.448672838	1.79469135
Trijicon	MRO	14	25	5	3.400779383	13.60311753	1.021457042	4.085828167
Primary Arms	MD-05	9	25	4	3.972107409	15.88842964	1.430553613	5.722214454
Trijicon	MRO	11	25	6	4.081543493	16.32617397	1.05318719	4.212748758
SAMPLE AVERAGE				4.545454545	2.099217684	8.396870737	0.889500383	3.558001534
Total Data Points				50				

When broken out by specific Optic ID #, we again see the same trend for positions compared to the summary results from all positions. Again, the EXPS 3.2 displays a worsening degree of standard deviation here as well.

25 Yard Total Deviation Summary:

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	25	12	0.39033475	1.561338998	0.647130249	2.588520994
EoTech	EXPS 3.2	All	25	3	0.510258802	2.041035209	0.88379417	3.535176681
Burris	Fast Fire	All	25	5	1.141712592	4.56685037	0.962054934	3.848219738
Aimpoint	T-1	All	25	11	3.109110982	12.43644393	0.831723785	3.326895142
Primary Arms	MD-05	All	25	4	3.69267651	14.77070604	0.878595252	3.514381009
Trijicon	MRO	All	25	15	3.813142179	15.25256871	0.865474412	3.461897649
SAMPLE AVERAGE				8.333333333	2.109539303	8.43815721	0.844795467	3.379181869
Total Data Points				50				

While the average results at 25 yards, by optic type, remain consistent with the rankings in the summary results from all distances in the previous section-- the standard deviations do not.

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	1	25	4	0.25	1	0.5	2
EoTech	EXPS 3.0	2	25	3	0.311338998	1.245355992	0.539254963	2.157019853
EoTech	EXPS 3.2	3	25	3	0.510258802	2.041035209	0.88379417	3.535176681
EoTech	EXPS 3.0	8	25	5	0.55	2.2	0.87321246	3.492849839
Burris	Fast Fire	12	25	5	1.141712592	4.56685037	0.962054934	3.848219738
Aimpoint	T-1	10	25	6	3.071470592	12.28588237	1.062250413	4.249001651
Trijicon	MRO	13	25	4	3.078950877	12.31580351	0.564125603	2.256502411
Aimpoint	T-1	4	25	5	3.15427945	12.6171178	0.560594129	2.242376515
Primary Arms	MD-05	9	25	4	3.69267651	14.77070604	0.878595252	3.514381009
Trijicon	MRO	14	25	5	3.972252376	15.8890095	0.898531713	3.59412685
Trijicon	MRO	11	25	6	4.170011216	16.68004486	0.806924107	3.227696429
SAMPLE AVERAGE				4.545454545	2.172995583	8.691982332	0.77539434	3.101577361
Total Data Points				50				

We also see some changes in specific optics rankings within their respective optics types, compared to the summary chart of all distances. The constant we do see is that the optics in the top 50% and the bottom 50% of ranking, remain in their respective brackets.

25 Yard Rate of Change Summary

Change in average deviation amount from overall results to 25yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	25yd AVG (MOA)	Overall AVG (MOA)	% Change
Primary Arms	MD-05	All	14.77070604	14.24369026	3.70%
Trijicon	MRO	All	15.25256871	13.45569702	13.35%
Burris	Fast Fire	All	4.56685037	4.024137943	13.49%
Aimpoint	T-1	All	12.43644393	10.83548768	14.78%
EoTech	EXPS 3.2	All	2.041035209	1.658588792	23.06%
EoTech	EXPS 3.0	All	1.561338998	1.149442719	35.83%
Total Sample Average			8.43815721	7.56117407	17.37%

Another interesting trend is that there is no apparent constant, with regards to any general rule as to whether all red dot optics tested displayed an increasing or decreasing degree of parallax deviation at closer distances than at longer distances. It is generally assumed that red dot optics are more susceptible at closer distances than at longer distances. While we do see that that all optics displayed more angular (MOA) deviation at closer distances, there is not a constant rate of change. The optics that displayed significantly less deviation at closer ranges displayed a drastically higher rate of increase. The optics that displayed significantly higher angular deviation at closer distances displayed a significantly lower rate of increase. However, none of the optics displayed any form of a constant of change when compared with other optics models.

SUMMARY OF 50 YARD RESULTS

50 Yard Vertical Movement Evaluation:

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.2	All	50	3	0.333333333	0.666666667	0.577350269	1.154700538
EoTech	EXPS 3.0	All	50	12	0.375	0.75	0.559016994	1.118033989
Burris	Fast Fire	All	50	4	1.530776407	3.061552813	1.791358365	3.58271673
Aimpoint	T-1	All	50	10	4.607830833	9.215661664	1.287933322	2.575866642
Trijicon	MRO	All	50	14	5.893063039	11.78612608	3.175087061	6.350174125
Primary Arms	MD-05	All	50	4	6.892766953	13.78553391	1.317706964	2.635413928
SAMPLE AVERAGE				7.833333333	3.272128427	6.544256855	1.451408829	2.902817659
Total Data Points				47				

The 50 yard vertical evaluation averages, by optic type, remain consistent with the ranking positions in the similar overall results at all distances. With exception to the Primary Arms optic, which drops to the bottom slot.

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	8	50	5	0.25	0.5	0.559016994	1.118033989
EoTech	EXPS 3.2	3	50	3	0.333333333	0.666666667	0.577350269	1.154700538
EoTech	EXPS 3.0	2	50	3	0.416666667	0.833333333	0.721687836	1.443375673
EoTech	EXPS 3.0	1	50	4	0.5	1	0.577350269	1.154700538
Burris	Fast Fire	12	50	4	1.530776406	3.061552813	1.791358365	3.58271673
Trijicon	MRO	13	50	4	4.292874202	8.585748405	1.085499015	2.170998029
Aimpoint	T-1	10	50	6	4.480803837	8.961607673	1.398883974	2.797767948
Aimpoint	T-1	4	50	4	4.798371327	9.596742653	1.278349254	2.556698508
Trijicon	MRO	11	50	5	6.048550329	12.09710066	3.875409481	7.750818962
Primary Arms	MD-05	9	50	4	6.892766953	13.78553391	1.317706964	2.635413928
Trijicon	MRO	14	50	5	7.017726821	14.03545364	3.562216702	7.124433403
SAMPLE AVERAGE				4.272727273	3.323806352	6.647612705	1.522257193	3.044514386
Total Data Points				47				

The breakout detail by Optic ID # shows the same marginal changes between rankings between optic types and similar changes in the lower 50% rankings. The Burris remains at a constant position.

50 Yard Horizontal Movement Evaluation:

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	50	10	0.458333333	0.916666667	0.782139645	1.56427929
EoTech	EXPS 3.2	All	50	3	0.942809042	1.885618083	1.632993162	3.265986323
Burris	Fast Fire	All	50	4	2.321005488	4.642010976	0.753156491	1.506312981
Aimpoint	T-1	All	50	4	4.908201021	9.816402042	1.494271556	2.988543111
Trijicon	MRO	All	50	14	5.589694879	11.17938976	1.346629876	2.69325975
Primary Arms	MD-05	All	50	12	6.823907535	13.64781507	2.629140785	5.258281569
SAMPLE AVERAGE				7.833333333	3.507325216	7.014650432	1.439721919	2.879443837
Total Data Points				47				

The horizontal deviation table remains almost consistent with the changes observed in the vertical summary changes.

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	8	50	5	0.2	0.4	0.447213595	0.894427191
EoTech	EXPS 3.0	2	50	3	0.333333333	0.666666667	0.577350269	1.154700538
EoTech	EXPS 3.0	1	50	4	0.875	1.75	1.181453907	2.362907813
EoTech	EXPS 3.2	3	50	3	0.942809042	0.188561808	1.632993162	0.326598632
Burris	Fast Fire	12	50	4	2.321005488	4.642010976	0.75315649	1.506312981
Aimpoint	T-1	10	50	6	4.402860737	8.805721475	1.156624741	2.313249483
Trijicon	MRO	13	50	4	4.836199015	9.67239803	0.481219405	0.962438809
Trijicon	MRO	11	50	5	5.653871403	11.30774281	1.534494281	3.068988562
Aimpoint	T-1	4	50	4	5.666211447	11.33242289	1.786634764	3.573269528
Trijicon	MRO	14	50	5	6.128315045	12.25663009	1.558747375	3.117494751
Primary Arms	MD-05	9	50	4	6.823907535	13.64781507	2.629140785	5.25828157
SAMPLE AVERAGE				4.272727273	3.471228459	6.788179074	1.249002616	2.230788169
Total Data Points				47				

The breakout detail, by Optic ID #, again show consistent results with the previous averages with the top 50% remaining constant and the bottom 50% marginally changing rankings.

50 Yard Total Deviation Summary:

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	50	10	0.416666667	0.833333333	0.640342001	1.280684003
EoTech	EXPS 3.2	All	50	3	0.638071188	1.276142375	1.105171716	2.210343431
Burris	Fast Fire	All	50	4	1.925890948	3.851781895	0.724949741	1.449899481
Aimpoint	T-1	All	50	4	4.758015927	9.516031854	1.239338745	2.47867749
Trijicon	MRO	All	50	14	5.741378959	11.48275792	2.034725164	4.069450331
Primary Arms	MD-05	All	50	12	6.858337244	13.71667449	1.421957621	2.843915241
SAMPLE AVERAGE				7.833333333	3.389726822	6.779453644	1.194414165	2.38882833
Total Data Points				47				

The 50 yard summary data (of the 47 available data sheets), by optic type in the table above continues to display general consistency with the overall results. We do however see the Primary Arms optic fall in rankings in the vertical deviation table.

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	8	50	5	0.225	0.45	0.503115295	1.00623059
EoTech	EXPS 3.0	2	50	3	0.375	0.75	0.649519053	1.299038106
EoTech	EXPS 3.2	3	50	3	0.638071187	0.427614237	1.105171716	0.740649585
EoTech	EXPS 3.0	1	50	4	0.6875	1.375	0.850857411	1.701714821
Burris	Fast Fire	12	50	4	1.925890947	3.851781894	0.724949741	1.449899481
Aimpoint	T-1	10	50	6	4.441832287	8.883664574	1.148714426	2.297428853
Trijicon	MRO	13	50	4	4.564536609	9.129073217	0.526118267	1.052236533
Aimpoint	T-1	4	50	4	5.232291387	10.46458277	1.381585943	2.763171886
Trijicon	MRO	11	50	5	5.851210866	11.70242173	2.500915794	5.001831588
Trijicon	MRO	14	50	5	6.573020933	13.14604187	2.174533006	4.349066012
Primary Arms	MD-05	9	50	4	6.858337244	13.71667449	1.421957621	2.843915243
SAMPLE AVERAGE				4.272727273	3.397517406	6.717895889	1.180676207	2.227743882
Total Data Points				47				

The by Optic ID # breakout follows the same ranking change trend as the vertical and horizontal chart changes for the 50 yard results

50 Yard Rate of Change Summary:

OPTIC BRAND	OPTIC MODEL	OPTIC ID	50yd AVG (MOA)	Overall AVG (MOA)	% Change
EoTech	EXPS 3.0	All	0.8333333333	1.149442719	-27.50%
EoTech	EXPS 3.2	All	1.276142375	1.658588792	-23.06%
Trijicon	MRO	All	11.48275792	13.45569702	-14.66%
Aimpoint	T-1	All	9.516031854	10.83548768	-12.18%
Burris	Fast Fire	All	3.851781895	4.024137943	-4.28%
Primary Arms	MD-05	All	13.71667449	14.24369026	-3.70%
Total Sample Average			6.779453644	7.561174069	-14.23%

As before, we see the lack of a constant rate of change in deviation as we move back in distance to 50 yards, compared to the overall summary of all distances. Here, even though the deviations were minimal to begin with, we see the EoTechs drastically decrease the percent change in parallax, compared to the other model types that show a very large amount of deviation and a small rate of change. This is an interesting data set that challenges the notion that red dot optics are either parallax free beyond 40 or 50yds, or that the amount of parallax decreases with distance. It also challenges the notion that parallax affects all red dot optics in the same way or in any consistent fashion, when compared between models.

SUMMARY OF 100 YARD RESULTS

Unfortunately, the 100 yard summary has the smallest sample size. This test was done towards the end of the test day and due to the level of precision in aiming, took significantly more time to conduct.

100 Yard Vertical Movement Evaluation:

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	All	100	1	0	0	N/A	N/A
Burris	Fast Fire	All	100	1	0	0	N/A	N/A
Aimpoint	T-1	All	100	4	8.72410939	8.72410939	6.722094449	6.722094449
Trijicon	MRO	All	100	4	9.717187041	9.717187041	9.36847736	9.36847736
SAMPLE AVERAGE				2.5	4.610324108	4.610324108	8.045285905	8.045285905
Total Data Points				10				

In this chart, we see a different color. The yellow blocks result from the fact that there is only one data point for that model. A standard deviation cannot be determined from one data point. The general ranking of the optics models, with regards to the vertical deviation from the 10 data points, remain consistent with the overall results, regardless of the small sample size.

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	8	100	1	0	0	N/A	N/A
Burris	Fast Fire	12	100	1	0	0	N/A	N/A
Trijicon	MRO	13	100	1	5	5	N/A	N/A
Trijicon	MRO	14	100	1	5.099019514	5.099019514	N/A	N/A
Aimpoint	T-1	4	100	1	6.403124237	6.403124237	N/A	N/A
Aimpoint	T-1	10	100	3	9.497771108	9.497771108	8.011773583	8.011773583
Trijicon	MRO	11	100	2	14.38486433	14.38486433	13.27220241	13.27220241
Total Sample Average				1.428571429	5.769254169	5.769254169	10.641988	10.641988
Total Data Points				10				

Compared with the overall summary of all distances, the vertical deviation results at 100 yards remain relatively consistent. It is interesting that there was not consistency between the MRO models. From the data we collected, the MRO optic type displayed the least consistent observation results when compared to the other models. The extreme shift that was observed in

Optic ID # 11 was confirmed by two separate observers as represented in the data points and the relating movement diagram drawn by the observers. While we do not have an even number of data points with all the optics on this chart, there is an extreme difference between the top optics and the bottom optics. The results of the MROs and T-1s were a great surprise to the testing group, who expected parallax to decrease significantly at farther distances as the EoTech did.



100 Yard Horizontal Movement Evaluation:

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	100	1	0	0	N/A	N/A
Burris	Fast Fire	All	100	1	4	4	N/A	N/A
Aimpoint	T-1	All	100	4	10.73888572	10.73888572	5.313672111	5.313672111
Trijicon	MRO	All	100	4	16.1784043	16.1784043	7.303810355	7.303810355
SAMPLE AVERAGE				2.5	7.729322506	7.729322506	6.308741233	6.308741233
Total Data Points				10				

Again, we see consistency in the relative rankings compared to the overall summary charts.

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	8	100	1	0	0	N/A	N/A
Burris	Fast Fire	12	100	1	4	4	N/A	N/A
Trijicon	MRO	14	100	1	6.403124237	6.403124237	N/A	N/A
Aimpoint	T-1	10	100	3	8.190255524	8.190255524	1.83836114	1.83836114
Trijicon	MRO	13	100	1	16.76305461	16.76305461	N/A	N/A
Aimpoint	T-1	4	100	1	18.38477631	18.38477631	N/A	N/A
Trijicon	MRO	11	100	2	20.77371918	20.77371918	4.68029733	4.68029733
Total Sample Average				1.428571429	10.64498998	10.64498998	3.259329235	3.259329235
Total Data Points				10				

As we break out the results here by Optic ID number, we see that some of these optics showed a very large increase in deviation when the testers observed for movement while adjusting their horizontal viewing deflection as opposed to the previous chart that displayed the results from the users adjusting their vertical viewing angle. Specifically startling were the observations from Optic # 11, which testers reported that the aiming dot nearly moved completely outside of the 24" wide calibration target at 100 yards.

100 Yard Total Deviation Summary:

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	100	1	0	0	N/A	N/A
Burris	Fast Fire	All	100	1	2	2	N/A	N/A
Aimpoint	T-1	All	100	4	9.731497556	9.731497556	4.375562448	4.375562448
Trijicon	MRO	All	100	4	12.94779567	12.94779567	7.735995348	7.735995348
SAMPLE AVERAGE				2.5	6.169823307	6.169823307	6.055778898	6.055778898
Total Data Points				10				

The average table for 100 yards, by optic type shows a very clear separation in deviation amount between the four optic types. Testers were very surprised by the Burris during the whole of this test, but especially at 100yds-- considering it is a micro red dot and not generally considered in the same class as the larger optics in the test that are more commonly employed at this distance.

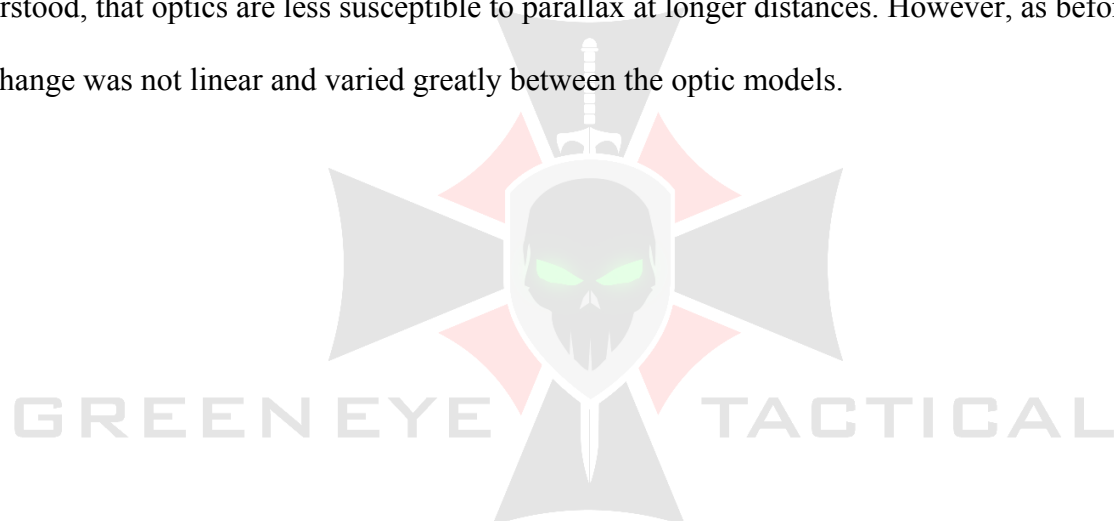
Sorted by Total Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	8	100	1	0	0	N/A	N/A
Burris	Fast Fire	12	100	1	2	2	N/A	N/A
Trijicon	MRO	14	100	1	5.751071876	5.751071876	N/A	N/A
Aimpoint	T-1	10	100	3	8.844013318	8.844013318	4.898219112	4.898219112
Trijicon	MRO	13	100	1	10.88152731	10.88152731	N/A	N/A
Aimpoint	T-1	4	100	1	12.39395027	12.39395027	N/A	N/A
Trijicon	MRO	11	100	2	17.57929176	17.57929176	8.976249873	8.976249873
Total Sample Average				1.428571429	8.207122076	8.207122076	6.937234493	6.937234493
Total Data Points				10				

The by-Optic ID # breakout continues to fall in line with the ranking trends of the overall summary of all distances, with the same effect of the lower ranking optics changing position.

100 Yard Rate of Change Summary:

Change in average deviation amount from overall results to 100yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	100yd AVG (MOA)	Overall AVG (MOA)	% Change
EoTech	EXPS 3.0	All	0	1.149442719	-100.00%
Burris	Fast Fire	All	2	4.024137943	-50.30%
Aimpoint	T-1	All	9.731497556	10.83548768	-10.19%
Trijicon	MRO	All	12.94779567	13.45569702	-3.77%
Total Sample Average			6.169823307	7.366191341	-41.07%

The percentage change in angular deviation generally falls into what is commonly understood, that optics are less susceptible to parallax at longer distances. However, as before, the change was not linear and varied greatly between the optic models.



Original Test Summary

The results of this test are representative of independent tester evaluations, solely of the specific optics that were tested, under the conditions tested. They cannot be construed to represent all optics produced under these model lines. While the various optics of the same model type have large differences in the sequential numbering of their serial numbers, and most probably indicate a significant difference in production dates-- there is insufficient data to draw conclusions or comparisons between production years.

There is one interesting fact of this test that has not been addressed during this test report. That is, whether the optics that were tested-- that have excessive and irregular parallax deviation could be sent back to the manufacturer for repair. That brings us to one specific optic in this test. This optic was donated for testing by a volunteer that could not attend the testing. The owner of this optic had noticed first-hand, irregular and excessive aiming dot movement. These errors presented both visually, and through POI shift during consecutive groups. This owner contacted the manufacturer directly about this issue and requested resolution. The manufacturer agreed to a RMA and the owner sent the optic to the manufacturer. The owner received an email confirmation that the optic was received and then later that it had been fixed. The owner then received the optic in the mail. This optic was ID #10, and Aimpoint T-1. Unfortunately, Aimpoint would not disclose to the owner what parts were repaired, altered, or replace. It was not disclosed to the client what, if any, physical defect was present.



This specific optic's deviation was measured, overall, by 15 separate data points as opposed to 10 data points to the other T-1 tested with 10 separate data points. The overall results of this optic that had been repaired by Aimpoint differed to the non-repaired T-1 by 0.135327493 inches of Average Overall Deviation and 0.064025083 inches of difference in Standard Deviation in inches in the overall summary results.

Both the testing group and myself are confident in the results we have recorded and we are releasing all raw data and calculations, to include: tester sheets, photographs of optics and serial numbers, testing conditions, protocols, and procedures used. The intent is to be as transparent as possible and afford the ability to independent and interested parties to not only confirm the summaries represented in this report, but also so that the test can be replicated independently with other optics of the same type and model so that the results here can either be

confirmed, corrected, or disputed. We encourage others to do so and welcome the results of their outcomes.



Follow-on Test Results and Comparison

SUMMARY OF OVERALL RESULTS

After the initial testing that we hosted, we published the testing procedures and invited anyone who was willing to replicate the testing with their own optics. The independent remote testers then submitted their testing forms and they were added to the results. The following section summarizes the data that was submitted and compares it to the original testing.

Overall Vertical Movement Evaluation:

Vertical Deviation, Follow-On Test

Sorted by Vertical Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	516	All	2	0	0	0	0
EoTech	EXPS 3.0	All	16	0.917213894	1.738184763	0.90937703	1.420080271
Aimpoint	T-2	All	4	1	3	0.816496581	2
Aimpoint	Comp M2	All	6	2.380457781	7.13798315	0.447330864	2.976413254
Aimpoint	Comp M4	All	3	2.405125399	4.319338961	1.642576551	1.328520384
Vortex	StrikeFire II	All	2	2.515564437	5.031128874	2.143331782	4.286663563
Aimpoint	Pro	All	7	3.007405139	5.877549139	1.168232306	1.965575098
Aimpoint	T-1	All	23	3.879076442	9.112766963	2.486473562	4.986217369
Trijicon	SRS	All	1	4.123105626	16.4924225	N/A	N/A
Vortex	Razor	All	2	5.192582404	10.38516481	0.272352647	0.544705294
Leopold	LCO	All	6	5.646321146	12.05415571	1.765748857	5.063279194
Total Sample Average			6.5454545	2.824259297	6.831699534	1.165192018	2.457145443
Total Data Points			72				

This table summarizes the results of the data recorded by user evaluations during the vertical movement test, by optic type and at all distances. As shown, this data is derived from 72 individual test reports.

Vertical Deviation, All Tests

Sorted by Vertical Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	516	All	2	0	0	0	0
EoTech	EXPS 3.2	All	6	0.333333333	1	0.516397779	1.673320053
EoTech	EXPS 3.0	All	41	0.586425763	1.372758346	0.769785649	1.808500176
Aimpoint	T-2	All	4	1	3	0.816496581	2
Burris	Fast Fire	All	10	1.18591736	3.519048316	1.381866698	4.057407348
Aimpoint	Comp M2	All	6	2.380457781	7.13798315	0.447330864	2.976413254
Aimpoint	Comp M4	All	3	2.405125399	4.319338961	1.642576551	1.328520384
Vortex	StrikeFire II	All	2	2.515564437	5.031128874	2.143331782	4.286663563
Aimpoint	Pro	All	7	3.007405139	5.877549139	1.168232306	1.965575098
Trijicon	SRS	All	1	4.123105626	16.4924225	N/A	N/A
Aimpoint	T-1	All	48	4.333414681	10.16433952	2.892526415	4.991242766
Primary Arms	MD-05	All	8	5.153006282	13.71925818	2.106866666	2.598231292
Vortex	Razor	All	2	5.192582404	10.38516481	0.272352647	0.544705294
Trijicon	MRO	All	33	5.497114588	13.45476109	4.041956247	6.432316677
Leopold	LCO	All	6	5.646321146	12.05415571	1.765748857	5.063279194
Total Sample Average			11.93333333	2.890651596	7.168527239	1.426104932	2.837583936
Total Data Points			179				

This table represents the combined data from the Original and Follow-On tests, and is comprised of 179 data points. The only two optics that are common between the Original tests and the Follow-On tests are the EoTech EXPS 3.0 and the AimPoint T-1, which both show fairly consistent results between the respective tests. We also see that there is a drastic performance difference between the AimPoint T-1 and T-2, with the T-2 performing almost as well as the EXPS 3.0.

From the Vertical Deviation results, we continue to see a clear and consistent separation in measurements between the optic models.

Overall Horizontal Movement Evaluation:**Horizontal Movement, Follow-On Test**

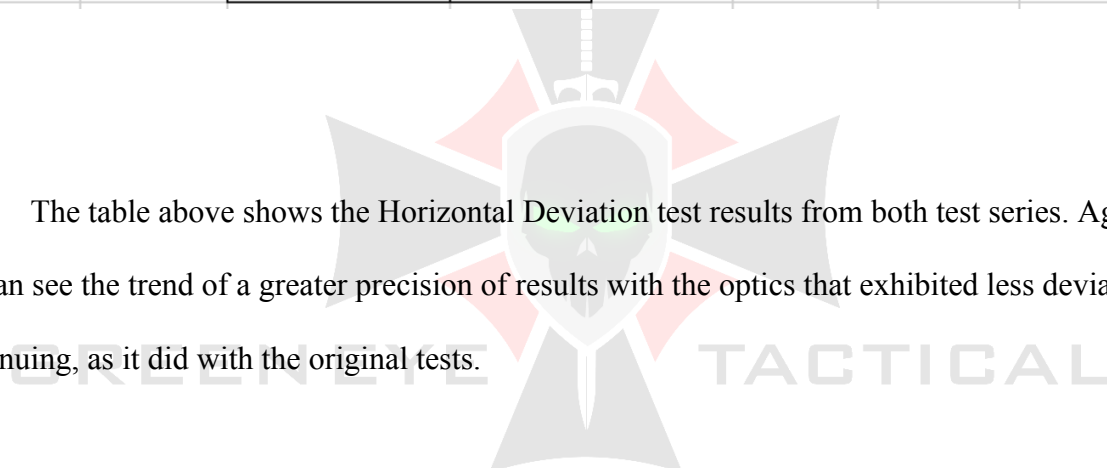
Sorted by Horizontal Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	16	1.696566443	3.50333563	1.125732261	2.293123509
Aimpoint	Comp M2	All	6	1.932854343	5.441715415	0.952569635	2.741036301
Aimpoint	T-2	All	4	2.0625	6	1.264499242	3.915780041
Aimpoint	Pro	All	7	3.238286582	6.675780125	0.725373476	2.246765009
Aimpoint	T-1	All	23	3.324583867	7.729011202	2.084785454	3.225571649
EoTech	516	All	2	3.400581317	6.801162634	1.273614312	2.547228624
Trijicon	SRS	All	1	4.007804885	16.03121954	N/A	N/A
Aimpoint	Comp M4	All	3	4.577469643	10.4218017	0.264872614	6.231297927
Vortex	StrikeFire II	All	2	5.186690106	10.37338021	2.862951536	5.725903072
Leopold	LCO	All	6	7.583333333	13.66666667	4.386532419	3.444802849
Vortex	Razor	All	2	10.40444044	20.80888088	2.548575721	5.097151441
Total Sample Average			6.5454545	4.310464633	9.768450365	1.748950667	3.746866042
Total Data Points			72				

From the Overall Horizontal Deviation by model type summary chart above, it is observed that there are changes in rankings with many of the optics, however the EXPS 3.0 and the T-2 remain in the top of the rankings. The EoTech 516 tested showed significantly more sensitivity to horizontal head movement than vertical head movement, as did the AimPoint Comp M4 and the Vortex StrikeFire II.

Horizontal Movement, All Tests

Sorted by Horizontal Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.2	All	6	0.814996656	2.317177583	1.285665797	3.681959486
EoTech	EXPS 3.0	All	41	0.905977149	2.074472441	1.081491119	2.417690674
Burris	Fast Fire	All	10	1.89650799	4.529227569	1.171185271	2.330020894
Aimpoint	Comp M2	All	6	1.932854343	5.441715415	0.952569635	2.741036301
Aimpoint	T-2	All	4	2.0625	6	1.264499242	3.915780041
Aimpoint	Pro	All	7	3.238286582	6.675780125	0.725373476	2.246765009
EoTech	516	All	2	3.400581317	6.801162634	1.273614312	2.547228624
Trijicon	SRS	All	1	4.007804885	16.03121954	N/A	N/A
Aimpoint	T-1	All	48	4.147771313	9.192645519	3.010770278	3.737768367
Aimpoint	Comp M4	All	3	4.577469643	10.4218017	0.264872614	6.231297927
Vortex	StrikeFire II	All	2	5.186690106	10.37338021	2.862951536	5.725903072
Primary Arms	MD-05	All	8	5.398007472	14.76812235	2.482571324	5.226587213
Trijicon	MRO	All	33	5.979710915	13.29301614	4.668782274	4.22699223
Leopold	LCO	All	6	7.583333333	13.66666667	4.386532419	3.444802849
Vortex	Razor	All	2	10.40444044	20.80888088	2.548575721	5.097151441
Total Sample Average			11.93333333	4.102462143	9.493017919	1.998532501	3.826498866
Total Data Points			179				

The table above shows the Horizontal Deviation test results from both test series. Again, we can see the trend of a greater precision of results with the optics that exhibited less deviation continuing, as it did with the original tests.



Overall Total Deviation Summary:**Total Average Deviation, All Tests**

Sorted by Total Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.2	All	6	0.574164995	1.658588792	0.897719034	2.669972886
EoTech	EXPS 3.0	All	41	0.746201456	1.723615393	0.849948115	1.97480781
Aimpoint	T-2	All	4	1.53125	4.5	0.991500336	2.738612788
Burris	Fast Fire	All	10	1.541212675	4.024137943	0.87427761	2.813271146
EoTech	516	All	2	1.700290658	3.400581317	0.636807156	1.273614312
Aimpoint	Comp M2	All	6	2.156656062	6.289849283	0.627828776	2.552394484
Aimpoint	Pro	All	7	3.12284586	6.276664632	0.889517514	1.890449518
Aimpoint	Comp M4	All	3	3.491297521	7.370570333	0.902671636	3.567796056
Vortex	StrikeFire II	All	2	3.851127271	7.702254543	0.359809877	0.719619755
Trijicon	SRS	All	1	4.065455256	16.26182102	N/A	N/A
Aimpoint	T-1	All	48	4.240592997	9.678492518	2.664383583	3.682560628
Primary Arms	MD-05	All	8	5.275506877	14.24369026	2.015103508	3.01278581
Trijicon	MRO	All	33	5.738412751	13.37388861	3.981778156	4.563255977
Leopold	LCO	All	6	6.614827239	12.86041119	2.493167286	3.532607522
Vortex	Razor	All	2	7.798511422	15.59702284	1.410464184	2.820928368
Total Sample Average			11.93333333	3.496556869	8.330772579	1.399641198	2.700905504
Total Data Points			179				

Total Average Deviation, Follow-On Test

Sorted by Total Deviation Averages							
OPTIC BRAND	OPTIC MODEL	OPTIC ID	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	16	1.306890169	2.620760197	0.870629072	1.603582206
Aimpoint	T-2	All	4	1.53125	4.5	0.991500336	2.738612788
EoTech	516	All	2	1.700290658	3.400581317	0.636807156	1.273614312
Aimpoint	Comp M2	All	6	2.156656062	6.289849283	0.627828776	2.552394484
Aimpoint	Pro	All	7	3.12284586	6.276664632	0.889517514	1.890449518
Aimpoint	Comp M4	All	3	3.491297521	7.370570333	0.902671636	3.567796056
Aimpoint	T-1	All	23	3.601830154	8.420889083	2.223098452	3.653422386
Vortex	StrikeFire II	All	2	3.851127271	7.702254543	0.359809877	0.719619755
Trijicon	SRS	All	1	4.065455256	16.26182102	N/A	N/A
Leopold	LCO	All	6	6.614827239	12.86041119	2.493167286	3.532607522
Vortex	Razor	All	2	7.798511422	15.59702284	1.410464184	2.820928368
Total Sample Average			6.5454545	3.567361965	8.300074949	1.140549429	2.435302739
Total Data Points			72				

The two charts above compare the overall results of both tests (above), and the follow-on test (below). Comparing the two charts, using the data from the two common optics models (EXPS 3.0 and T-1)-- we can see a measure of consistency between the tests. In the follow-on tests, the EXPS 3.0's results only differed by 0.020680957 inches in standard deviation. The

AimPoint T-1 only differed by 0.441285131 inches in standard deviation between the results. The Leopold LCO surprised all testers involved with its large degree of diagonal movement.

SUMMARY OF 25 YARD RESULTS

25 Yard Vertical Movement Evaluation:

25 Yard Vertical Deviation, Follow-On Test

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	All	25	4	0.351776695	1.407106781	0.406207101	1.624828404
Aimpoint	T-2	All	25	2	1	4	0	0
Aimpoint	Comp M4	All	25	1	1.414213562	5.656854249	N/A	N/A
Aimpoint	Pro	All	25	1	1.58113883	6.32455532	N/A	N/A
Aimpoint	Comp M2	All	25	3	2.377067588	9.50827035	0.52375999	2.095039959
Aimpoint	T-1	All	25	9	2.780285269	11.12114107	1.758021773	7.032087091
Trijicon	SRS	All	25	1	4.123105626	16.4924225	N/A	N/A
Leopold	LCO	All	25	2	4.157834563	16.63133825	0.223211779	0.892847116
SAMPLE AVERAGE				2.875	2.223177766	8.892711066	0.582240128	2.328960514
Total Data Points				23				

In this chart, we see that 23 data sheets were available and used to produce the summaries for the 25 yard results. Unfortunately, there were a few optics models that only have one data point, that were submitted by remote testers. These are evident by the “N/A” in the Standard Deviation fields, as a standard deviation cannot be derived from one result.

25 Yard Vertical Deviation, All Tests

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.2	All	25	3	0.333333333	1.333333333	0.577350269	2.309401077
EoTech	EXPS 3.0	All	25	16	0.392196298	1.568785192	0.596736291	2.386945165
Aimpoint	T-2	All	25	2	1	4	0	0
Burris	Fast Fire	All	25	5	1.147213595	4.588854382	1.190536101	4.762144404
Aimpoint	Comp M4	All	25	1	1.414213562	5.656854249	N/A	N/A
Aimpoint	Pro	All	25	1	1.58113883	6.32455532	N/A	N/A
Aimpoint	Comp M2	All	25	3	2.377067587	9.50827035	0.52375999	2.095039959
Aimpoint	T-1	All	25	20	3.141648402	12.56659361	1.489364159	5.957456638
Primary Arms	MD-05	All	25	4	3.413245611	13.65298245	0.741399035	2.965596141
Trijicon	MRO	All	25	15	4.002210046	16.00884018	1.238798993	4.955195971
Trijicon	SRS	All	25	1	4.123105626	16.4924225	N/A	N/A
Leopold	LCO	All	25	2	4.157834563	16.63133825	0.223211779	0.892847117
SAMPLE AVERAGE				6.083333333	2.256933955	9.027735818	0.731239624	2.924958497
Total Data Points				73				

Regardless, the chart above of the overall test results remain consistent with model ranking. The Trijicon and Leopold models tested showed a significant amount of movement at 25 yards, exceeding 4 inches (>16MOA). This may be a concern for end users that may not be able to precisely keep the aiming dot in the center of the viewing window consistently due to CQB environments, NVG use, or Protective Mask use. On the other hand, the EXPS series and the T-2 show a level of viewing angle forgiveness that is measurably superior to the lower ranked models.



25 Yard Horizontal Movement Evaluation:

25 Yard Horizontal Movement, Follow-On Test

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	25	4	0.98579369	3.943174759	0.933245806	3.732983226
Aimpoint	Comp M2	All	25	3	1.57600673	6.304026921	0.8663453	3.4653812
Aimpoint	T-2	All	25	2	1.875	7.5	1.237436867	4.949747468
Aimpoint	T-1	All	25	9	2.273433461	9.093733842	0.901803935	3.60721574
Aimpoint	Pro	All	25	1	2.5	10	N/A	N/A
Trijicon	SRS	All	25	1	4.007804885	16.03121954	N/A	N/A
Leopold	LCO	All	25	2	4.25	17	0.353553391	1.414213562
Aimpoint	Comp M4	All	25	1	4.272001873	17.08800749	N/A	N/A
SAMPLE AVERAGE				2.875	2.71750508	10.87002032	0.85847706	3.433908239
Total Data Points				23				

In the 25 yard summary by optic type for the horizontal deviation test (above), we see various changes in position. The only two optics that performed slightly better in the horizontal viewing angle test were the T-1 and SRS, the rest performed a bit worse- to varying degrees.

25 Yard Horizontal Movement, All Tests

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	25	16	0.527698422	2.11079369	0.737995032	2.951980126
EoTech	EXPS 3.2	All	25	3	0.687184271	2.748737084	1.190238071	4.760952286
Burris	Fast Fire	All	25	5	1.136211589	4.544846357	0.807405741	3.229622964
Aimpoint	Comp M2	All	25	3	1.57600673	6.304026921	0.8663453	3.4653812
Aimpoint	T-2	All	25	2	1.875	7.5	1.237436867	4.949747468
Aimpoint	Pro	All	25	1	2.5	10	N/A	N/A
Aimpoint	T-1	All	25	20	2.552547107	10.21018843	0.965525909	3.862103637
Trijicon	MRO	All	25	15	3.624074311	14.49629725	0.944581569	3.778326277
Primary Arms	MD-05	All	25	4	3.972107409	15.88842964	1.430553613	5.722214454
Trijicon	SRS	All	25	1	4.007804885	16.03121954	N/A	N/A
Leopold	LCO	All	25	2	4.25	17	0.353553391	1.414213562
Aimpoint	Comp M4	All	25	1	4.272001873	17.08800749	N/A	N/A
SAMPLE AVERAGE				6.083333333	2.581719717	10.32687887	0.948181721	3.792726886
Total Data Points				73				

When the horizontal deviation results from the follow-on tests and the original tests are combined in the chart above, we continue to see the previous trends of rankings.

25 Yard Total Deviation Summary:**25 Yard Total Average Deviation, Follow-On Test**

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	25	4	0.668785192	2.67514077	0.609926022	2.439704088
Aimpoint	T-2	All	25	2	1.4375	5.75	0.618718434	2.474873734
Aimpoint	Comp M2	All	25	3	1.976537159	7.906148636	0.638823614	2.555294456
Aimpoint	Pro	All	25	1	2.040569415	8.16227766	N/A	N/A
Aimpoint	T-1	All	25	9	2.526859365	10.10743746	1.122244267	4.488977067
Aimpoint	Comp M4	All	25	1	2.843107718	11.37243087	N/A	N/A
Trijicon	SRS	All	25	1	4.065455256	16.26182102	N/A	N/A
Leopold	LCO	All	25	2	4.203917281	16.81566913	0.288382585	1.153530339
SAMPLE AVERAGE				2.875	2.470341423	9.881365692	0.655618984	2.622475937
Total Data Points				23				

Above we see the total averages for the Follow-On tests, which show a level of consistency in rankings for most optics-- except for the Comp M2 and Comp M4 which move around depending on how the data is broken out-- as they showed more or less degrees of sensitivity to horizontal head movement.

25 Yard Total Average Deviation, All Tests

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	25	16	0.45994736	1.839789441	0.630089219	2.520356874
EoTech	EXPS 3.2	All	25	3	0.510258802	2.041035209	0.88379417	3.535176681
Burris	Fast Fire	All	25	5	1.141712592	4.56685037	0.962054934	3.848219738
Aimpoint	T-2	All	25	2	1.4375	5.75	0.618718434	2.474873734
Aimpoint	Comp M2	All	25	3	1.976537159	7.906148636	0.638823614	2.555294456
Aimpoint	Pro	All	25	1	2.040569415	8.16227766	N/A	N/A
Aimpoint	Comp M4	All	25	1	2.843107718	11.37243087	N/A	N/A
Aimpoint	T-1	All	25	20	2.847097754	11.38839102	0.991310562	3.965242249
Primary Arms	MD-05	All	25	4	3.69267651	14.77070604	0.878595252	3.514381009
Trijicon	MRO	All	25	15	3.813142179	15.25256871	0.865474412	3.461897649
Trijicon	SRS	All	25	1	4.065455256	16.26182102	N/A	N/A
Leopold	LCO	All	25	2	4.203917281	16.81566913	0.288382585	1.153530334
SAMPLE AVERAGE				6.083333333	2.419326836	9.677307342	0.750804798	3.003219192
Total Data Points				73				

The combined testing results above, compared with the combined results of the vertical and horizontal testing show that there were only four optics models that maintained an amount of

movement that was less than 2 inches at 25 yards: the EXPS 3.0, EXPS 3.2, T-2, and the Fast Fire.



25 Yard Rate of Change Summary

However, we do see that there is no consistency between the models with the generally perceived “rules” with regard to parallax at closer distances. The charts below demonstrate this:

25 Yard % Change, Follow-On Test

Change in average deviation amount from overall results to 25yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	25yd AVG (MOA)	Overall AVG (MOA)	% Change
Trijicon	SRS	All	16.26182102	16.26182102	0.00%
EoTech	EXPS 3.0	All	2.67514077	2.620760197	2.07%
Aimpoint	T-1	All	10.10743746	8.420889083	20.03%
Aimpoint	Comp M2	All	7.906148636	6.289849283	25.70%
Aimpoint	T-2	All	5.75	4.5	27.78%
Aimpoint	Pro	All	8.16227766	6.276664632	30.04%
Leopold	LCO	All	16.81566913	12.86041119	30.76%
Aimpoint	Comp M4	All	11.37243087	7.370570333	54.30%
Total Sample Average			9.881365692	8.075120717	23.83%

25 Yard % Change, All Tests

Change in average deviation amount from overall results to 25yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	25yd AVG (MOA)	Overall AVG (MOA)	% Change
Trijicon	SRS	All	16.26182102	16.26182102	0.00%
Primary Arms	MD-05	All	14.77070604	14.24369026	3.70%
EoTech	EXPS 3.0	All	1.839789441	1.723615393	6.74%
Burris	Fast Fire	All	4.56685037	4.024137943	13.49%
Trijicon	MRO	All	15.25256871	13.37388861	14.05%
Aimpoint	T-1	All	11.38839102	9.678492518	17.67%
EoTech	EXPS 3.2	All	2.041035209	1.658588792	23.06%
Aimpoint	Comp M2	All	7.906148636	6.289849283	25.70%
Aimpoint	T-2	All	5.75	4.5	27.78%
Aimpoint	Pro	All	8.16227766	6.276664632	30.04%
Leopold	LCO	All	16.81566913	12.86041119	30.76%
Aimpoint	Comp M4	All	11.37243087	7.370570333	54.30%
Total Sample Average			9.677307342	8.188477499	20.61%

The chart above displays the % change in deviation at 25 yards, as compared to the average results at all distances-- while the chart below it shows the same for the combined results of the original and follow-on tests. We do see that no optic model displayed less parallax at closer range. However, we also see that the amount of change between the optics models show drastically differing increases in parallax. Some optics models showed negligible increases in movement, while others increased by more than 50%.

Another interesting trend is that there is no apparent constant, with regards to any general rule as to whether all red dot optics tested displayed an increasing or decreasing degree of parallax deviation at closer distances than at longer distances. It is generally assumed that red dot optics are more susceptible at closer distances than at longer distances. While we do see that that all optics displayed more angular (MOA) deviation at closer distances, there is not a constant rate of change. The optics that displayed significantly less deviation at closer ranges displayed a drastically higher rate of increase. The optics that displayed significantly higher angular deviation at closer distances displayed a significantly lower rate of increase. However, none of the optics displayed any form of a constant of change when compared with other optics models.

SUMMARY OF 50 YARD RESULTS

50 Yard Vertical Movement Evaluation:

50 Yard Vertical Deviation, Follow-On Test

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	516	All	50	2	0	0	0	0
EoTech	EXPS 3.0	All	50	10	0.891421356	1.782842712	0.721008526	1.442017053
Aimpoint	T-2	All	50	2	1	2	1.414213562	2.828427125
Aimpoint	Comp M4	All	50	1	1.5	3	N/A	N/A
Aimpoint	Comp M2	All	50	3	2.383847975	4.76769595	0.475292803	0.950585605
Vortex	StrikeFire II	All	50	2	2.515564437	5.031128874	2.143331782	4.286663563
Aimpoint Pro	Pro	All	50	5	3.069518303	6.139036606	1.105699658	2.211399317
Aimpoint	T-1	All	50	12	3.775598312	7.551196623	1.196426067	2.392852135
Vortex	Razor	All	50	2	5.192582404	10.38516481	0.272352647	0.544705294
Leopold	LCO	All	50	2	6.031128874	6.031128874	2.872450001	2.872450001
SAMPLE AVERAGE				4.1	2.635966166	4.668819445	1.13341945	1.947677788
Total Data Points				41				

The 50-yard vertical evaluation averages, by optic type, for the Follow-On tests have almost twice the data points as the 25 yards results do. This gives us the ability to have a standard deviation value for all but one optic.

50 Yard Vertical Deviation, All Tests

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	516	All	50	2	0	0	0	0
EoTech	EXPS 3.2	All	50	3	0.333333333	0.666666667	0.577350269	1.154700538
EoTech	EXPS 3.0	All	50	22	0.60973698	1.21947396	0.675096393	1.350192786
Aimpoint	T-2	All	50	2	1	2	1.414213562	2.828427125
Aimpoint	Comp M4	All	50	1	1.5	3	N/A	N/A
Burris	Fast Fire	All	50	4	1.530776406	3.061552813	1.791358365	3.58271673
Aimpoint	Comp M2	All	50	3	2.383847975	4.76769595	0.475292803	0.950585605
Vortex	StrikeFire II	All	50	2	2.515564437	5.031128874	2.143331782	4.286663563
Aimpoint	Pro	All	50	5	3.069518303	6.139036606	1.105699658	2.211399317
Aimpoint	T-1	All	50	22	4.153885821	8.307771642	1.2808594	2.561718801
Vortex	Razor	All	50	2	5.192582404	10.38516481	0.272352647	0.544705294
Trijicon	MRO	All	50	14	5.89306304	11.78612608	3.175087062	6.350174125
Leopold	LCO	All	50	2	6.75	13.5	0.353553391	0.707106781
Primary Arms	MD-05	All	50	4	6.892766953	13.78553391	1.317706964	2.635413928
SAMPLE AVERAGE				6.285714286	2.987505404	5.975010808	1.121684792	2.243369584
Total Data Points				88				

The chart above, showing the combined results, begins to show a trend in rankings-- with the EXPS series and the T-2 consistently towards the top and the MRO and LCO towards the bottom. The T-1 remains in the bottom half.



50 Yard Horizontal Movement Evaluation:**50 Yard Horizontal Movement, Follow-On Test**

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	50	10	1.707878271	3.415756542	0.965747731	1.931495462
Aimpoint	T-2	All	50	2	2.25	4.5	1.767766953	3.535533906
Aimpoint	Comp M2	All	50	3	2.289701955	4.57940391	1.065784893	2.131569785
Aimpoint Pro	Pro	All	50	5	3.31249096	6.62498192	0.782546835	1.56509367
Aimpoint	T-1	All	50	12	3.326593773	6.653187546	1.340548953	2.681097906
EoTech	516	All	50	2	3.400581317	6.801162634	1.273614312	2.547228624
Aimpoint	Comp M4	All	50	1	4.716990566	9.433981132	N/A	N/A
Vortex	StrikeFire II	All	50	2	5.186690106	10.37338021	2.862951536	5.725903072
Vortex	Razor	All	50	2	10.40444044	20.80888088	2.548575721	5.097151441
Leopold	LCO	All	50	2	13	13	1.414213562	1.414213562
			SAMPLE AVERAGE	4.1	4.959536739	8.619073478	1.557972277	2.958809714
			Total Data Points	41				

The horizontal deviation table for the Follow-On tests show that the EoTech 516 remains more sensitive to horizontal head placement than the other EoTech models, as does the AimPoint Comp M4. The Leopold LCO and the Vortex Razor both more than double their amount of deviation at 50 yards, compared to 25 yards.

50 Yard Horizontal Movement, All Tests

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.2	All	50	3	0.942809042	1.885618083	1.632993162	3.265986324
EoTech	EXPS 3.0	All	50	22	1.026308305	2.05261661	1.060990278	2.121980557
Aimpoint	T-2	All	50	2	2.25	4.5	1.767766953	3.535533906
Aimpoint	Comp M2	All	50	3	2.289701955	4.57940391	1.065784893	2.131569785
Burris	Fast Fire	All	50	4	2.321005488	4.642010976	0.75315649	1.506312981
Aimpoint	Pro	All	50	5	3.31249096	6.62498192	0.782546835	1.56509367
EoTech	516	All	50	2	3.400581317	6.801162634	1.273614312	2.547228624
Aimpoint	T-1	All	50	22	4.045506158	8.091012317	1.596243481	3.192486962
Aimpoint	Comp M4	All	50	1	4.716990566	9.433981132	N/A	N/A
Vortex	StrikeFire II	All	50	2	5.186690106	10.37338021	2.862951536	5.725903072
Leopold	LCO	All	50	2	5.5	11	2.121320344	4.242640687
Trijicon	MRO	All	50	14	5.589694879	11.17938976	1.346629875	2.693259751
Primary Arms	MD-05	All	50	4	6.823907535	13.64781507	2.629140785	5.25828157
Vortex	Razor	All	50	2	10.40444044	20.80888088	2.548575721	5.097151441
			SAMPLE AVERAGE	6.285714286	4.129294768	8.258589536	1.649362667	3.298725333
			Total Data Points	88				

The overall horizontal deviation results continue to show a consistency of rankings with some of the optics. We also see that the Primary Arms optic almost doubled its movement from 25 yards to 50 yards. We also see the trend of that most of the optics display more parallax movement when the viewing angle changes horizontally, as opposed to vertically.



50 Yard Total Deviation Summary:**50 Yard Total Average Deviation, Follow-On Test**

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	50	10	1.299649814	2.599299627	0.758151288	1.516302577
Aimpoint	T-2	All	50	2	1.625	3.25	1.590990258	3.181980515
EoTech	516	All	50	2	1.700290658	3.400581317	0.636807156	1.273614312
Aimpoint	Comp M2	All	50	3	2.336774965	4.67354993	0.692819141	1.385638281
Aimpoint	Comp M4	All	50	1	3.108495283	6.216990566	N/A	N/A
Aimpoint Pro	Pro	All	50	5	3.191004632	6.382009263	0.866472968	1.732945937
Aimpoint	T-1	All	50	12	3.551096042	7.102192084	1.236026546	2.472053092
Vortex	StrikeFire II	All	50	2	3.851127271	7.702254543	0.359809877	0.719619755
Vortex	Razor	All	50	2	7.798511422	15.59702284	1.410464184	2.820928368
Leopold	LCO	All	50	2	9.515564437	9.515564437	0.729118219	0.729118219
SAMPLE AVERAGE				4.1	3.797751452	6.643946461	0.920073293	1.759133451
Total Data Points				41				

The 50 yard summary data (of the 41 available data sheets), by optic type, of the Follow-On testing in the table above continues to display the relative stable top positions in rankings of the EXPS 3.0 and the T-2. The T-1 continues to be in the bottom 50% of the rankings with over twice of the movement of the top optics.

50 Yard Total Average Deviation, All Tests

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.2	All	50	3	0.638071187	1.276142375	1.105171716	2.210343431
EoTech	EXPS 3.0	All	50	22	0.818022643	1.636045285	0.814635291	1.629270582
Aimpoint	T-2	All	50	2	1.625	3.25	1.590990258	3.181980515
EoTech	516	All	50	2	1.700290658	3.400581317	0.636807156	1.273614312
Burris	Fast Fire	All	50	4	1.925890947	3.851781894	0.724949741	1.449899481
Aimpoint	Comp M2	All	50	3	2.336774965	4.67354993	0.692819141	1.385638281
Aimpoint	Comp M4	All	50	1	3.108495283	6.216990566	N/A	N/A
Aimpoint	Pro	All	50	5	3.191004632	6.382009263	0.866472968	1.732945937
Vortex	StrikeFire II	All	50	2	3.851127271	7.702254543	0.359809877	0.719619755
Aimpoint	T-1	All	50	22	4.09969599	8.19939198	1.355314351	2.710628703
Trijicon	MRO	All	50	14	5.741378959	11.48275792	2.034725165	4.069450331
Leopold	LCO	All	50	2	6.125	12.25	1.237436867	2.474873734
Primary Arms	MD-05	All	50	4	6.858337244	13.71667449	1.421957621	2.843915243
Vortex	Razor	All	50	2	7.798511422	15.59702284	1.410464184	2.820928368
SAMPLE AVERAGE				6.285714286	3.558400086	7.116800172	1.09627341	2.192546821
Total Data Points				88				

The 50 yard summary of both test groups outlines the misconception that most red dot optics are “parallax-free” at 40- 50 yards (depending on manufacturer’s claims). The Trijicon, Primary Arms, and Leopold models tested show the capability of almost to more than 6 inches of aiming error at 50 yards due to head position misalignment. These errors stand in stark contrast to the EXPS series and the T-2, which both present much less error-- even with the extreme range in viewing angles used for testing.



50 Yard Rate of Change Summary:**50 Yard % Change, All Tests**

<u>Change in average deviation amount from overall results to 50yd results, by optic type, sorted by % change</u>					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	50yd AVG (MOA)	Overall AVG (MOA)	% Change
Aimpoint	T-2	All	3.25	4.5	-27.78%
Aimpoint	Comp M2	All	4.67354993	6.289849283	-25.70%
EoTech	EXPS 3.2	All	1.276142375	1.658588792	-23.06%
Aimpoint	Comp M4	All	6.216990566	7.370570333	-15.65%
Aimpoint	T-1	All	8.19939198	9.678492518	-15.28%
Trijicon	MRO	All	11.48275792	13.37388861	-14.14%
EoTech	EXPS 3.0	All	1.636045285	1.723615393	-5.08%
Leopold	LCO	All	12.25	12.86041119	-4.75%
Burris	Fast Fire	All	3.851781894	4.024137943	-4.28%
Primary Arms	MD-05	All	13.71667449	14.24369026	-3.70%
EoTech	516	All	3.400581317	3.400581317	0.00%
Vortex	Razor	All	15.59702284	15.59702284	0.00%
Vortex	StrikeFire II	All	7.702254543	7.702254543	0.00%
Aimpoint	Pro	All	6.382009263	6.276664632	1.68%
Total Sample Average			7.116800172	7.764269119	-9.84%

50 Yard % Change, Follow-On Test

<u>Change in average deviation amount from overall results to 50yd results, by optic type, sorted by % change</u>					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	50yd AVG (MOA)	Overall AVG (MOA)	% Change
Aimpoint	T-2	All	3.25	4.5	-27.78%
Leopold	LCO	All	9.515564437	12.86041119	-26.01%
Aimpoint	Comp M2	All	4.67354993	6.289849283	-25.70%
Aimpoint	T-1	All	7.102192084	8.420889083	-15.66%
Aimpoint	Comp M4	All	6.216990566	7.370570333	-15.65%
EoTech	EXPS 3.0	All	2.599299627	2.620760197	-0.82%
EoTech	516	All	3.400581317	3.400581317	0.00%
Vortex	Razor	All	15.59702284	15.59702284	0.00%
Vortex	StrikeFire II	All	7.702254543	7.702254543	0.00%
Aimpoint Pro	Pro	All	6.382009263	6.276664632	1.68%
Total Sample Average			6.643946461	7.503900342	-10.99%

As before, we see the same lack of a constant rate of change in deviation for the Follow-On tests as we move back in distance to 50 yards, compared to the overall summary of all distances. We do see the trend for all of the optics to generally display less movement at 50 yards, as opposed to at 25 yards, but again-- the rate of increase/decrease is not consistent between models. One correlation is that the optics that display less overall movement, also display much more of a consistent amount of change in movement at variable distances.



SUMMARY OF 100 YARD RESULTS

Unfortunately, again, the 100 yard summary has the smallest sample size. This test continues to be the most tedious to conduct due to the precision of aiming required. The results are, nonetheless, interesting.

100 Yard Vertical Movement Evaluation:

100 Yard Vertical Deviation, Follow-On Test

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
EoTech	EXPS 3.0	All	100	2	2.177050983	2.177050983	1.664601464	1.664601464
Aimpoint	Pro	All	100	1	4.123105626	4.123105626	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.301162634	4.301162634	N/A	N/A
Leopold	LCO	All	100	2	6.031128874	6.031128874	2.872450001	2.872450001
Aimpoint	T-1	All	100	2	9.444505503	9.444505503	4.754222505	4.754222505
SAMPLE AVERAGE				1.6	5.215390724	5.215390724	3.097091323	3.097091323
Total Data Points				8				

In this chart we see the EoTech EXPS 3.0 display very little movement at 100 yards. The T-1 and LCO display a significant amount of error.

100 Yard Vertical Deviation, All Tests

Sorted by Vertical Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	VD A (IN)	VD A (MOA)	VD SD (IN)	VD SD (MOA)
Burris	Fast Fire	All	100	1	0	0	N/A	N/A
EoTech	EXPS 3.0	All	100	3	1.451367322	1.451367322	1.722004455	1.722004455
Aimpoint	Pro	All	100	1	4.123105626	4.123105626	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.301162634	4.301162634	N/A	N/A
Leopold	LCO	All	100	2	6.031128874	6.031128874	2.872450001	2.872450001
Aimpoint	T-1	All	100	6	8.964241428	8.964241428	5.636563736	5.636563736
Trijicon	MRO	All	100	4	9.71718704	9.71718704	9.368477359	9.368477359
Total Sample Average				2.571428571	4.941170418	4.941170418	4.899873888	4.899873888
Total Data Points				18				

Compared with the overall summary of all distances, the vertical deviation results at 100 yards are surprising. Although there is only one testing data point for the Fast Fire, the tester reported no movement, whatsoever. The LCO exceeded 6 inches of movement, the T-1 exceeded 8 inches and the MRO exceeded 9 inches.

100 Yard Horizontal Movement Evaluation:

100 Yard Horizontal Movement, Follow-On Test

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	100	2	3.061552813	3.061552813	1.501262385	1.501262385
Aimpoint	Pro	All	100	1	3.605551275	3.605551275	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.74341649	4.74341649	N/A	N/A
Aimpoint	T-1	All	100	2	8.04270126	8.04270126	3.857449011	3.857449011
Leopold	LCO	All	100	2	13	13	1.414213562	1.414213562
SAMPLE AVERAGE				1.6	6.490644368	6.490644368	2.257641653	2.257641653
Total Data Points				8				

Again, at 100 yards, we see the tendency of all the optics tested to be more sensitive to horizontal head position than the vertical head position.

100 Yard Horizontal Movement, All Tests

Sorted by Horizontal Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	HD A (IN)	HD A (MOA)	HD SD (IN)	HD SD (MOA)
EoTech	EXPS 3.0	All	100	3	2.041035209	2.041035209	2.061859092	2.061859092
Aimpoint	Pro	All	100	1	3.605551275	3.605551275	N/A	N/A
Burris	Fast Fire	All	100	1	4	4	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.74341649	4.74341649	N/A	N/A
Aimpoint	T-1	All	100	6	9.840157567	9.840157567	4.674992927	4.674992927
Leopold	LCO	All	100	2	13	13	1.414213562	1.414213562
Trijicon	MRO	All	100	4	16.1784043	16.1784043	7.303810353	7.303810353
Total Sample Average				2.571428571	7.629794978	7.629794978	3.863718984	3.863718984
Total Data Points				18				

The sensitivity of the horizontal head position that we see in the optics tested show that the MRO tested is capable of inducing enough aiming error, due to head alignment issues, to miss an IPSC target “A” zone (15”) at 100 yards.

100 Yard Total Deviation Summary:**100 Yard Total Average Deviation, Follow-On Test**

Sorted by Total Average Deviation								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	100	2	2.619301898	2.619301898	0.081669539	0.081669539
Aimpoint	Pro	All	100	1	3.864328451	3.864328451	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.522289562	4.522289562	N/A	N/A
Aimpoint	T-1	All	100	2	8.743603381	8.743603381	4.305835758	4.305835758
Leopold	LCO	All	100	2	9.515564437	9.515564437	0.729118219	0.729118219
SAMPLE AVERAGE				1.6	5.853017546	5.853017546	1.705541172	1.705541172
Total Data Points				8				

The average table for 100 yards, for the Follow-On tests, shows a good level of precision in measurements for the top and bottom optic-- meaning both testers saw nearly the same result. As with previous results, the rankings remain relatively constant.

100 Yard Total Average Deviation, All Tests

Sorted by Total Deviation Averages								
OPTIC BRAND	OPTIC MODEL	OPTIC ID	DISTANCE	Data Points	AVG A (IN)	AVG A (MOA)	AVG SD (IN)	AVG SD (MOA)
EoTech	EXPS 3.0	All	100	3	1.746201265	1.746201265	1.513356898	1.513356898
Burris	Fast Fire	All	100	1	2	2	N/A	N/A
Aimpoint	Pro	All	100	1	3.864328451	3.864328451	N/A	N/A
Aimpoint	Comp M4	All	100	1	4.522289562	4.522289562	N/A	N/A
Aimpoint	T-1	All	100	6	9.402199498	9.402199498	3.931363843	3.931363843
Leopold	LCO	All	100	2	9.515564437	9.515564437	0.729118219	0.729118219
Trijicon	MRO	All	100	4	12.94779567	12.94779567	7.735995345	7.735995345
Total Sample Average				2.571428571	6.285482698	6.285482698	3.477458576	3.477458576
Total Data Points				18				

Looking at the combined test result table-- we see the vast difference in possible aiming error between the optics models. However-- rankings do remain relatively constant.

100 Yard Rate of Change Summary:**100 Yard % Change, Follow-On Test**

Change in average deviation amount from overall results to 100yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	100yd AVG (MOA)	Overall AVG (MOA)	% Change
Aimpoint	Comp M4	All	4.522289562	7.370570333	-38.64%
Aimpoint	Pro	All	3.864328451	6.276664632	-38.43%
Leopold	LCO	All	9.515564437	12.86041119	-26.01%
EoTech	EXPS 3.0	All	2.619301898	2.620760197	-0.06%
Aimpoint	T-1	All	8.743603381	8.420889083	3.83%
Total Sample Average			5.853017546	7.509859086	-19.86%

100 Yard % Change, All Tests

Change in average deviation amount from overall results to 100yd results, by optic type, sorted by % change					
OPTIC BRAND	OPTIC MODEL	OPTIC ID	100yd AVG (MOA)	Overall AVG (MOA)	% Change
Burris	Fast Fire	All	2	4.024137943	-50.30%
Aimpoint	Comp M4	All	4.522289562	7.370570333	-38.64%
Aimpoint	Pro	All	3.864328451	6.276664632	-38.43%
Leopold	LCO	All	9.515564437	12.86041119	-26.01%
Trijicon	MRO	All	12.94779567	13.37388861	-3.19%
Aimpoint	T-1	All	9.402199498	9.678492518	-2.85%
EoTech	EXPS 3.0	All	1.746201265	1.723615393	1.31%
Total Sample Average			6.285482698	7.901111517	-22.59%

The 100 yard % change table is where we see a continuation of the general perceived notion that optics display less parallax at distance than at close range. With one exception-- the AimPoint T-1 (in the Follow-On test table) and the EXPS 3.0 (in the combined result table), however the EXPS 3.0's error amount was significantly less than the T-1's.

Manufacturer's Claims

One of the most significant aspects of the test is the comparison of the observed results, compared to the specific manufacturer's claims as to the parallax characteristics of the optics. It should be noted that it is not made clear what aspect of parallax the manufacturer refers to in their product data. As parallax is defined as the apparent change of position of an object, viewed upon two different angles-- it could refer to (in the case of this test) as to red dot movement or the actual target (viewing area) movement:

- Aimpoint claims that the T-1 is a "1X (non-magnifying) parallax free optic" (Aimpoint, 2017), while the overall results showed an average deviation of 9.678492518 MOA from all distances and tests.
- Aimpoint claims that the T-2 is a "1X (non-magnifying) parallax free optic" (Aimpoint, 2017), however the average deviation observed across all distances and tests was 4.5 MOA.
- Aimpoint claims that the Comp M2 is "Absence of parallax - No centering required" (Aimpoint, 2017), however the average deviation observed across all distances and tests was 6.289849283 MOA.
- Aimpoint lists no parallax claims on their website, that could be found at the time of publication, about the Comp M4 or the PRO.
- Vortex claims that the StrikeFire II is "Parallax Free" (Vortex Optics, 2017), however the average deviation observed across all distances and tests was 7.702254543 MOA.
- Vortex claims that the Razor is "Parallax free" (Vortex Optics, 2017), however the average deviation observed across all distances and tests was 15.59702284 MOA.

- Trijicon claims the SRS is “PARALLAX-FREE” (Trijicon, 2017), however the average deviation observed across all distances and tests was 16.26182102 MOA.
- Trijicon claims the MRO is “PARALLAX-FREE” (Trijicon, 2017), however the average deviation observed across all distances and tests was 13.37388861 MOA.
- Leupold claims “The Leupold Carbine Optic (LCO) is parallax free” in an answer in the product questions (Service, 2017), however the average deviation observed across all distances and tests was 12.86041119 MOA.
- EoTech claims that their optic is subject to parallax error of up to 14 MOA (EoTech, 2017). This claim is made generally on their FAQ page, without being model specific, however the averages of the models tested across all distances and tests were:
1.658588792 MOA for the EXPS 3.2, 1.723615393 MOA for the EXPS 3.0, and 3.400581317 for the 516.
- Burris claims that the Fast Fire 3 is “parallax free” (Burris Optics, 2017), however users noted an average of 4.024137943 MOA of movement.
- At the time of this testing, we could find no public claims by Primary Arms as to the parallax characteristics of the optic tested.

As we can see, there is a wide variance in what is claimed by the manufacturers and what is observed. All but Eotech, who over estimated error, failed to produce results that match the claims.

Closing:

The intent of this testing effort was to raise the bar for what is expected by consumers in the industry. This by no means should be considered an exhaustive, complete, or irrefutable work. On the contrary, readers should endeavor to test their own equipment in this form (or a better way) to produce some form of reproducible data. Too often do we engage in hero worship, group think, of product fandom to drive our equipment selection or opinions. We should have a data driven approach to equipment analysis, this way our conversations and debates can be centered in fact-- instead of emotion. Emotional attachments to equipment the blind following of fan groups breeds a toxic environment where substandard equipment is allowed to persist. It also diminishes our ability to demand performance from the equipment we purchase with our hard-earned money and prevents us, as a community, from progressing technology. My challenge to you: Get out and prove this test wrong, prove it right, I don't care-- just get out and collect data. Be part of the solution.



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