FINAL REPORT

FOR THE

MOUSE-OPTICS BASED POSITION MEASUREMENT AND DISPLAY SYSTEM (MOS)

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(ADA)

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

Arizona Design Associates (ADA) was approached by Mark Mittelstaedt of Siskiyou Corporation in early September 2007. Siskiyou contracted ADA to construct a Mouse-Optics Based Position Measurement and Display System with a starting budget of $2000 and a timetable of 9 months.

The system was to use LED based optical mice technology to track the position of a microscope stage. Also, ADA was to use a microscope camera to make distance measurements on the viewable area of the microscope slide. The two systems were to be integrated in one application using a graphical user interface (GUI).

After performing trade studies and conducting analyses ADA decided to go with a two mouse design. Components were selected based on the trade studies and a prototype was constructed. Due to time constraints, a mock microscope was constructed as opposed to integrating the system into a commercial microscope and microscope stage.

The prototype was thoroughly tested and met the requirements set by Siskiyou. The prototype hardware, application, and supporting documentation were delivered to Siskiyou in May of 2008.

2. PROBLEM STATEMENT

The MOS was constructed to perform two major tasks:

1) Track the position of a microscope stage using LED based optical mice.
2) Make distance measurements within the viewable area of a microscope slide using a microscope camera.

3. TECHNICAL REQUIREMENTS

The MOS was constructed to meet the following requirements:

1) Track the position of a microscope stage to within 250µm.
2) Make distance measurements within the viewable area of a microscope slide within 10µm.
3) Integrate the two major functionalities with an application supporting a GUI and the following functionalities:
    a. Display the video feed from the microscope camera with a cursor overlay.
    b. Display the microscope stage position.
    c. Allow the user to make distance measurements on the video feed.
    d. Allow the user to save an image with the stage position coordinates.
    e. Allow the user to calibrate the system.

4. CONCEPTS CONSIDERED

The initial concepts considered revolved around the idea of integrating the mouse-optics into an existing commercial stage as seen below in Figure 1. However, after much consideration, the scope of the project was changed to allow for the mounting of the mouse-optics to a stage externally in order to provide a proof-of-concept for the design.

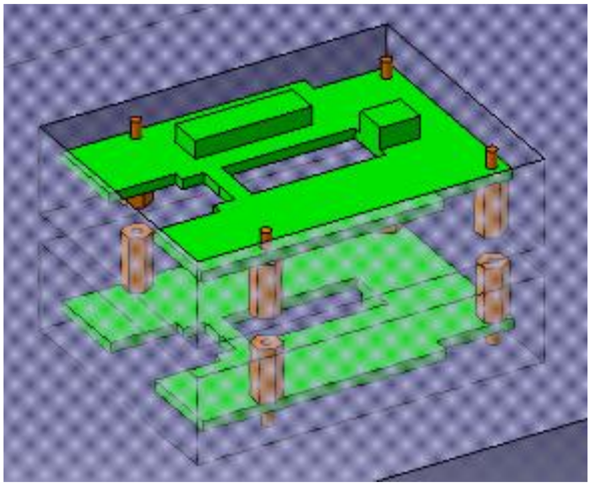

Figure 1: Initial concept integrating mouse-optics into commercial stage

After deciding to mount and test the mouse-optics externally (see Figure 2) analyses (please see MOS Trade Studies Appendix) were performed that led to two mice being used. The analyses revealed that by using two mice, one to measure movement in each orthogonal axis, crosstalk to do mechanical misalignment could be minimized.

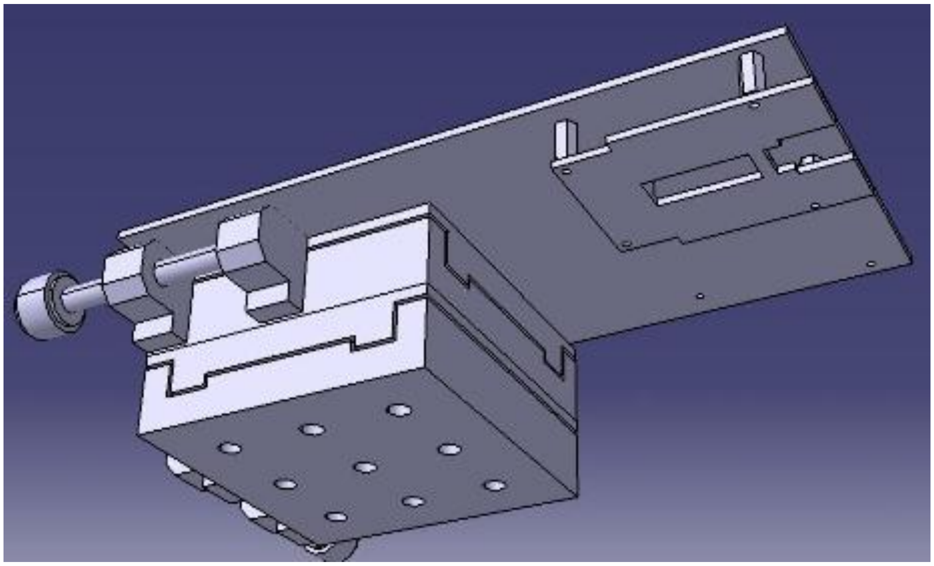

Figure 2: Time constraints led to the mouse-optics being mounted externally

5. FINAL DESIGN

The final design can be seen below in Figure 3. The optical path of the final design starts with an LED providing illumination of the microscope slide. The microscope slide is then viewed by a microscope objective which images onto a CCD camera which passes information to a computer running the integrating application.

The mechanical portion consists of two linear translation stages mounted orthogonally. The mouse-optics are connected to the stages via a custom mounting plate. The mouse-optics view a mousing surface whose height is controlled by a precision lab jack.

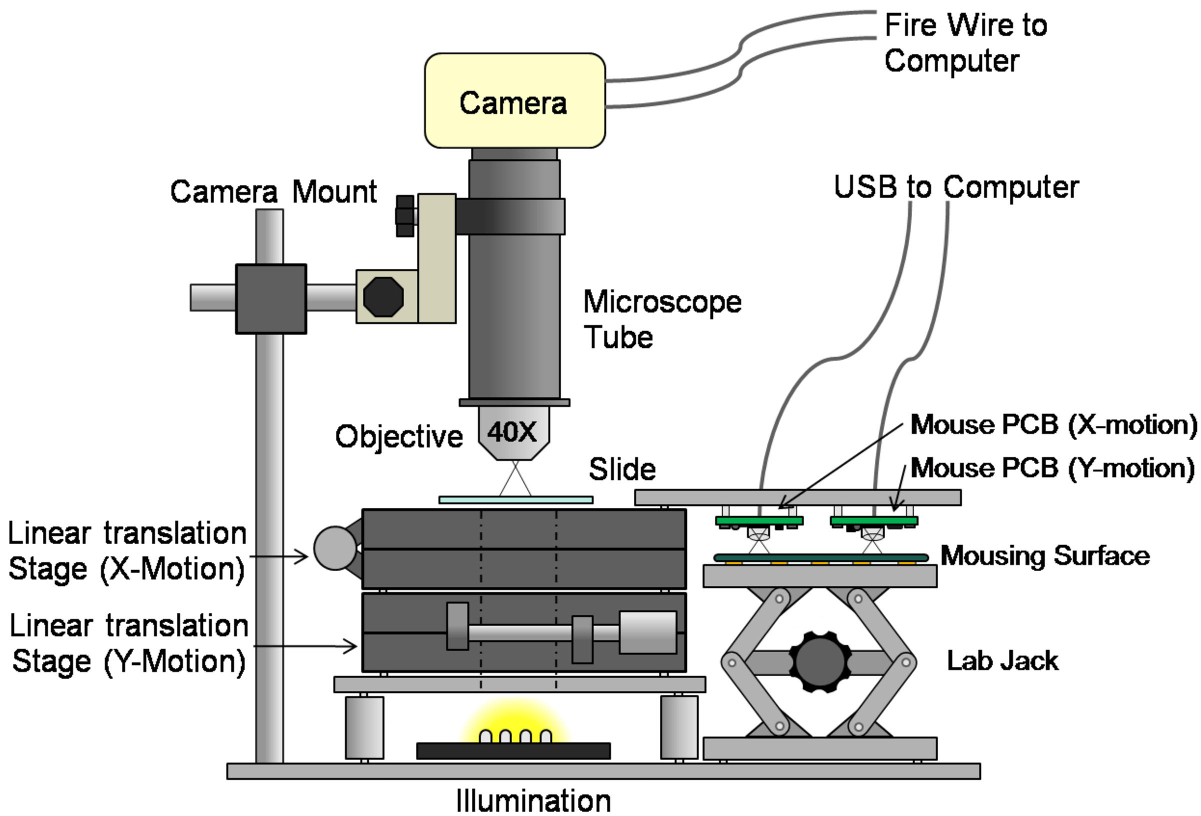

Figure 3: Final design

The final component selections can be found in Figure 4. Detailed accounts to justify component selection can be found in the MOS Analyses and MOS Trade Studies.

Label	Description	Manufacturer	Part Number	Quantity	Price Each
1	Camera	QImaging	MP5.0-RTV-CLR-10	1	Customer Furnished
2	Microscope Tube with C-Mount	Edmund Optics	NT54-868	1	$95.00
3	40X Micrsocope Objective	Olympus		1	Customer Furnished
4	Fire Wire Cables	Link Depot	1394-6-6p6p	2	$2.99
5	Microscope Tube Mounting Clamp	Edmund Optics	NT52-930	1	$60.00
6	Microscope Tube Focusing Mount	Edmund Optics	NT54-794	1	$345.00
7	90° Mount	Edmund Optics	NT39-355	1	$48.00
8	9" Horizontal Arm	Edmund Optics	NT52-220	1	$38.00
9	18" Horizontal Arm	Edmund Optics	NT39-354	1	$54.00
10	Stage Micrometer	Klarmann Rulings	KR-851	1	$142.00
11	Micrometer Adjustment Screw	Siskiyou	FAM-2.0	2	Customer Furnished
12	Linear Stage with Aperture	Siskiyou	100cr-A	2	Customer Furnished
13	Lab Jack	Siskiyou	540	1	Customer Furnished
14	5" x 5" Breadboard with Aperture	Siskiyou	MX512P-T	1	Customer Furnished
15	12" x 24" Breadboard	Siskiyou	12240	1	Customer Furnished
16	Mouse PCB Mounting Board	Custom Part		1	Customer Furnished
17	1/4 - 20 Hex Cap Screws	Siskiyou		12	Customer Furnished
18	1/4 - 20 Connecting Screws	Siskiyou		4	Customer Furnished
19	Aluminum Spacers	Siskiyou	AS-2.00	4	Customer Furnished
20	Steel Standoff	McMaster-Carr	93620A515	10	$1.23/each
21	Socket Cap Screws	McMaster-Carr	92200A077	2	$3.39/pack
22	Mouse Surface Adhesive	3M		1	$3.05/Sheet
23	Mouse Surface	SteelSeries	4D	1	$24.99
24	LED Based Optical Mouse	Microsoft	D1T-00002	3	$24.99
25	Illumination System			1	Customer Furnished

Figure 4: Final component list

One of the most difficult components to select was the mouse-optics. The most desirable mouse-optics came from a mouse with s simple printed circuit (PC) with high resolution and low cost. The initial mouse selected severely suffered from the resolution being lowered when the mouse was moved very slowly. However, even the mouse that was finally used showed this undesirable property as seen below in Figure 5.

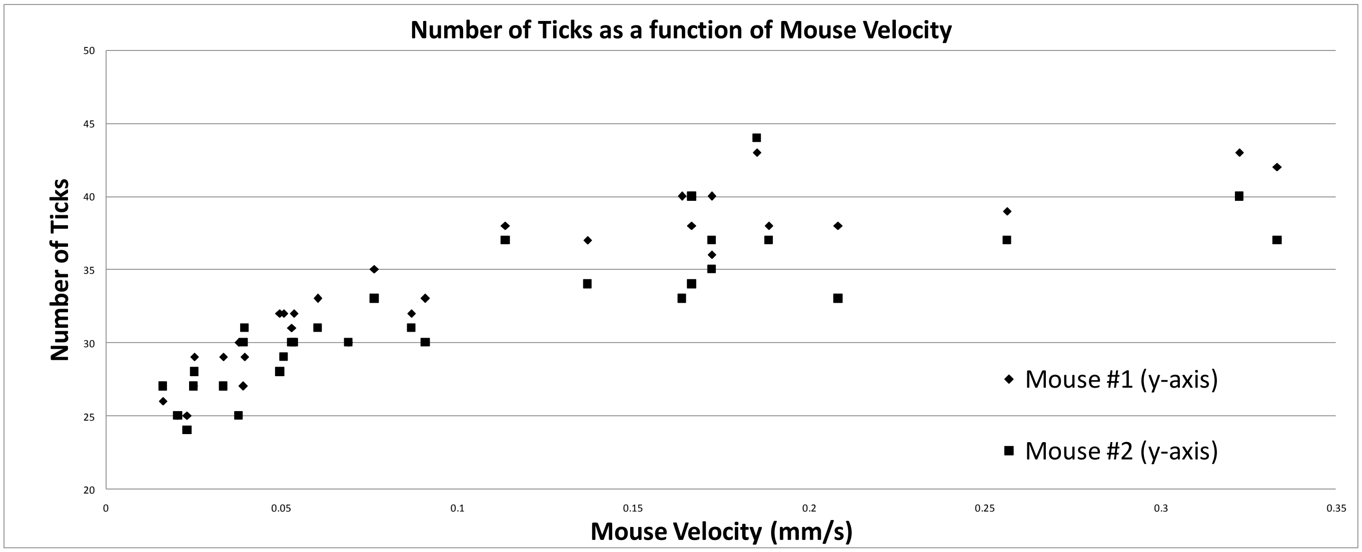

Figure 5: Graph showing that mouse-optics resolution varies with velocity

6. TESTING

For a complete description of the testing procedure and schedule one should reference the MOS Master Test Plan.

The stage position function of the MOS was calibrated using a 1mm stage micrometer with hash marks every 10µm with 5µm of accuracy. The accuracy of the stage position function was tested by using the microscope and camera feed to move the stage different distances based on the stage micrometer. The stage position output from the application was then compared to the distance moved on the stage micrometer. This test was performed for a horizontal and vertical axis as well as an axis near 45º. The system passed on all accounts as seen in Figures 6-8 below.

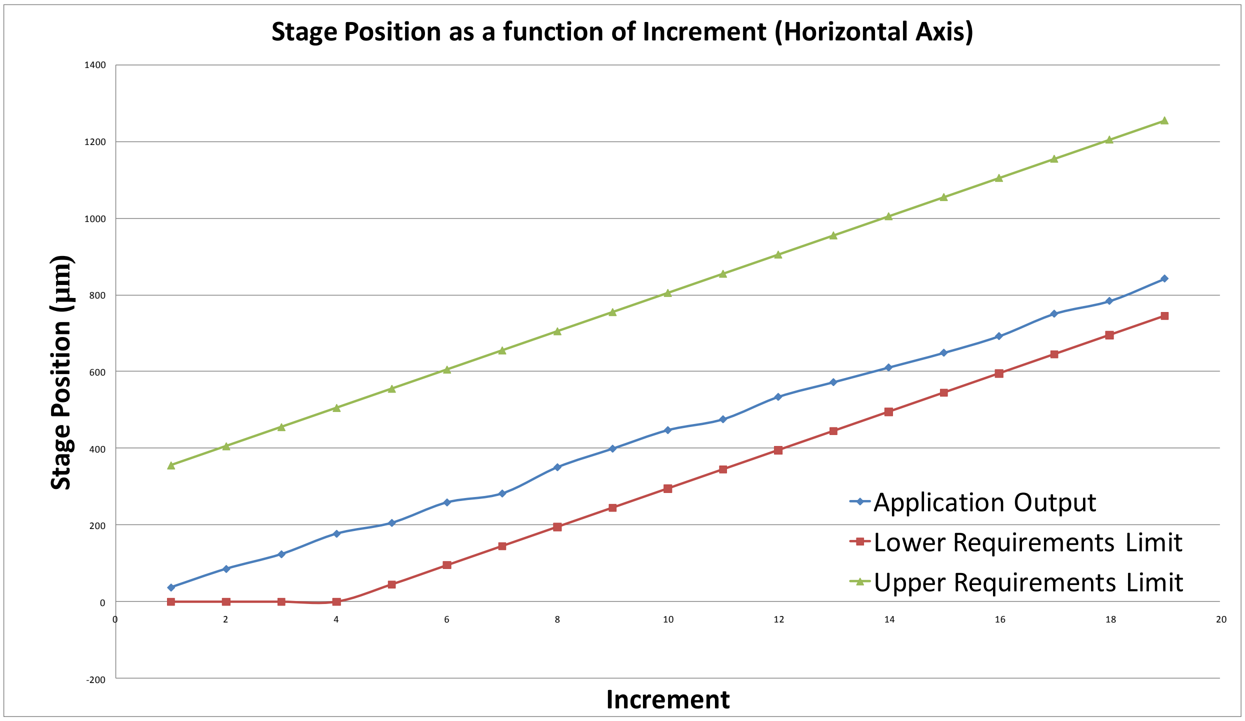

Figure 6: Stage position testing results for horizontal axis

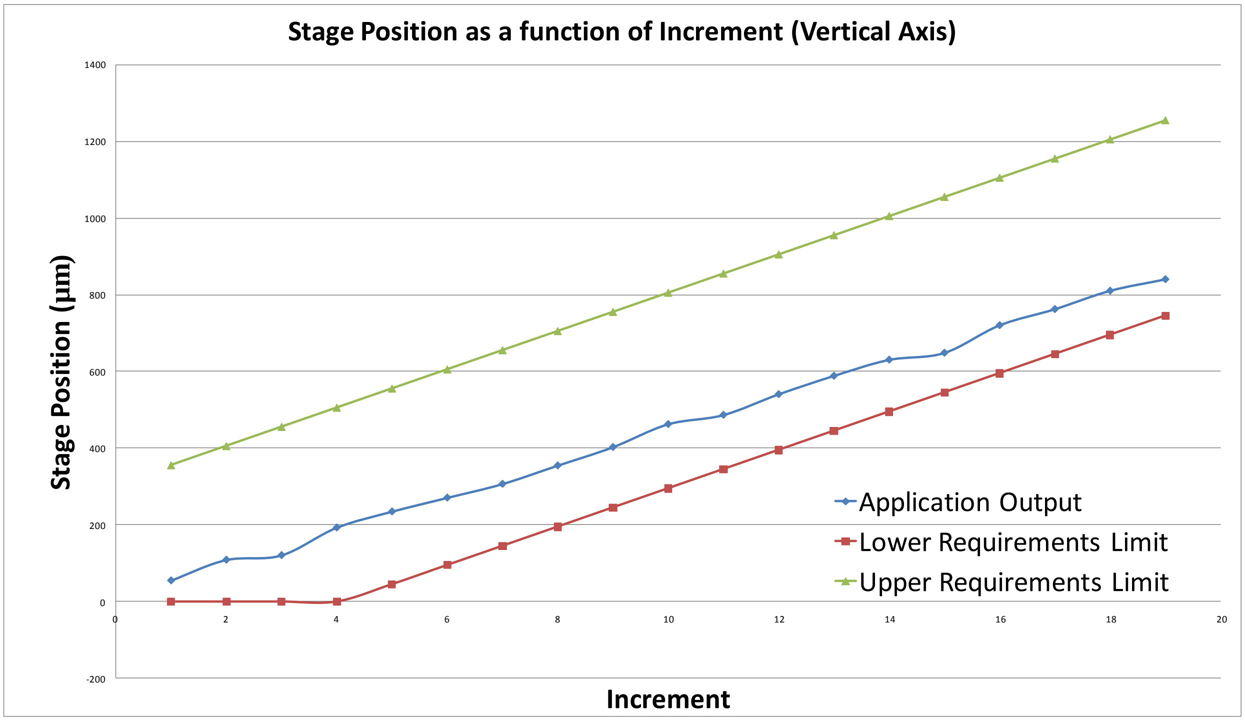

Figure 7: Stage position testing results for vertical axis

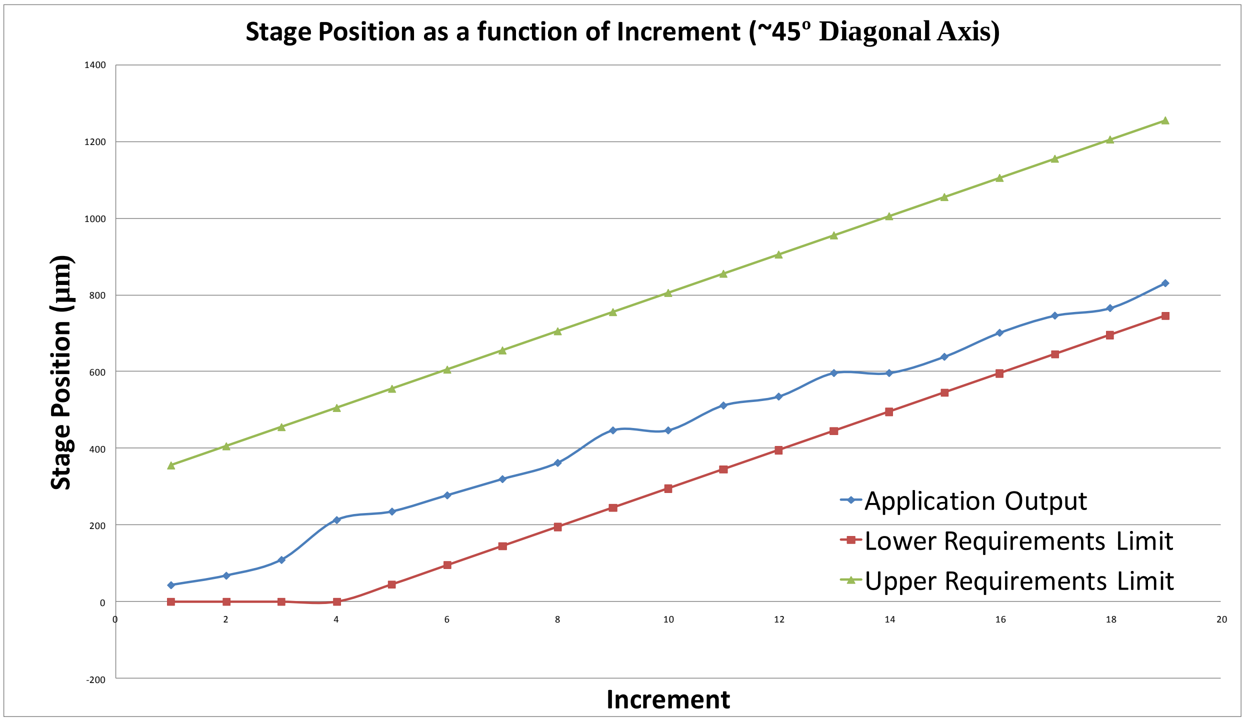

Figure 8: Stage position testing results for diagonal axis

The distance measurement function of the MOS was calibrated and tested in a similar manner. The distance of the stage micrometer that was used for testing was limited by the field of view of the microscope objective. The system passé don all accounts as seen in Figures 9-11 below.

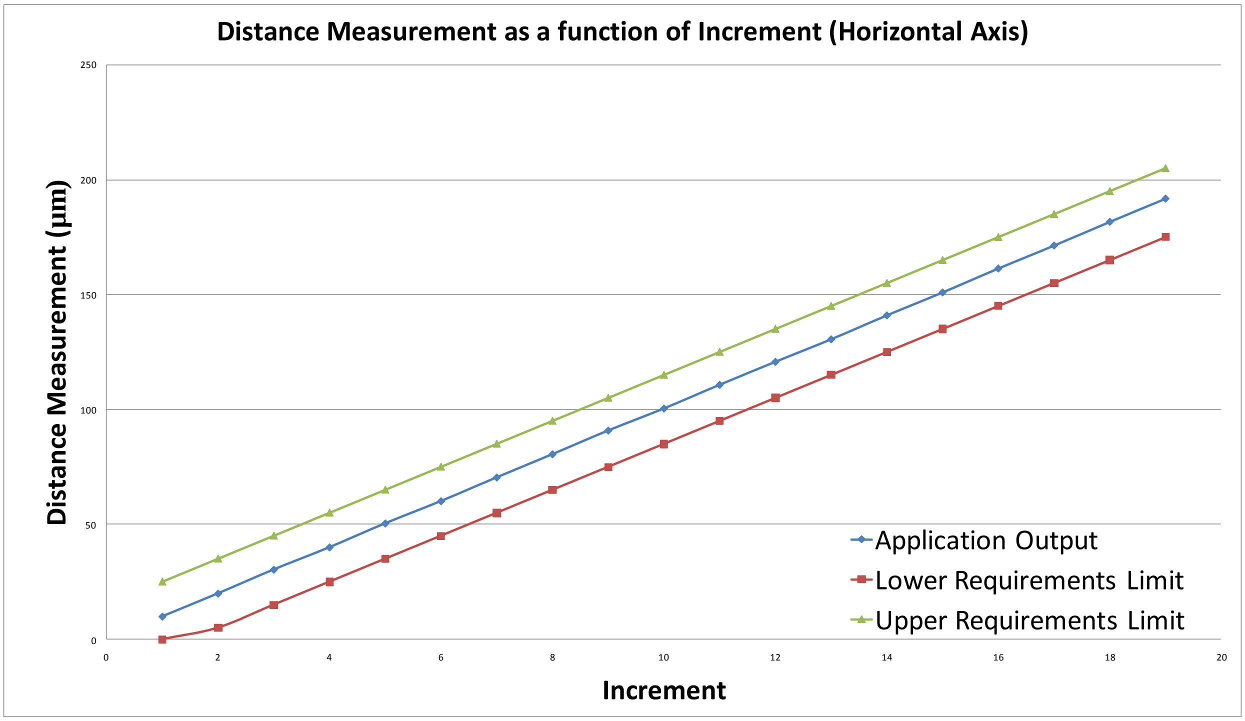

Figure 9: Distance measurement testing results for horizontal axis

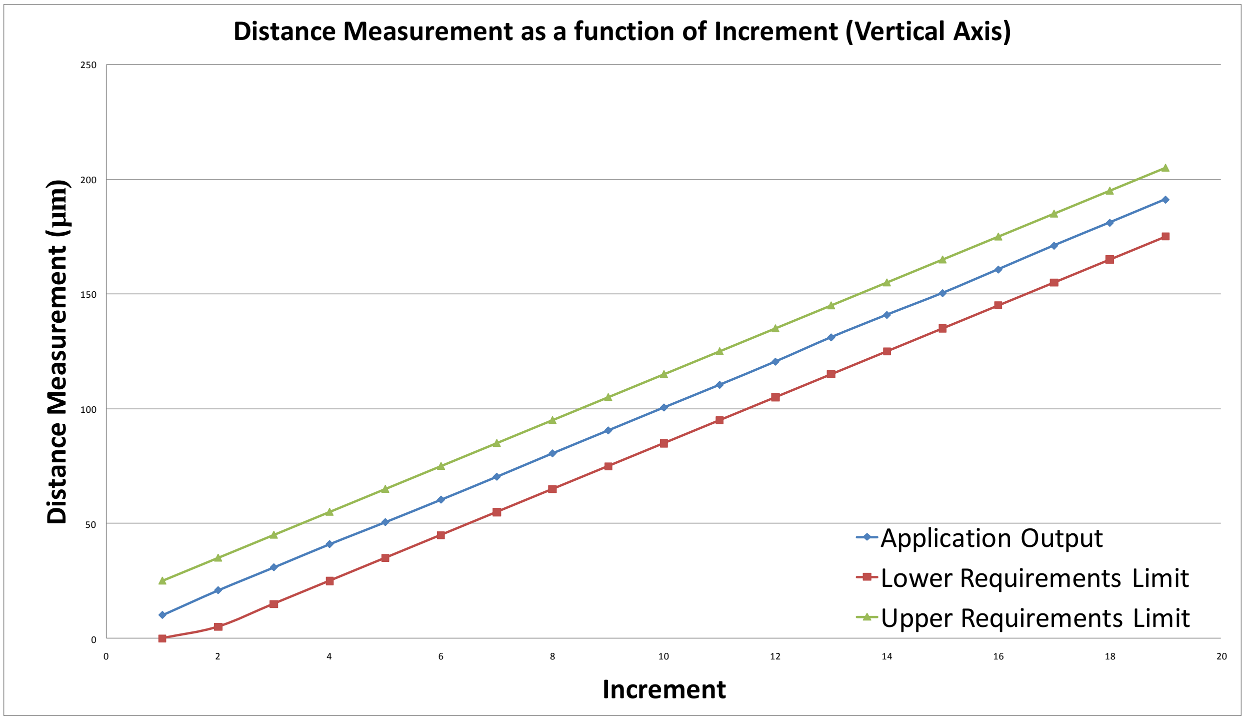

Figure 10: Distance measurement testing results for vertical axis

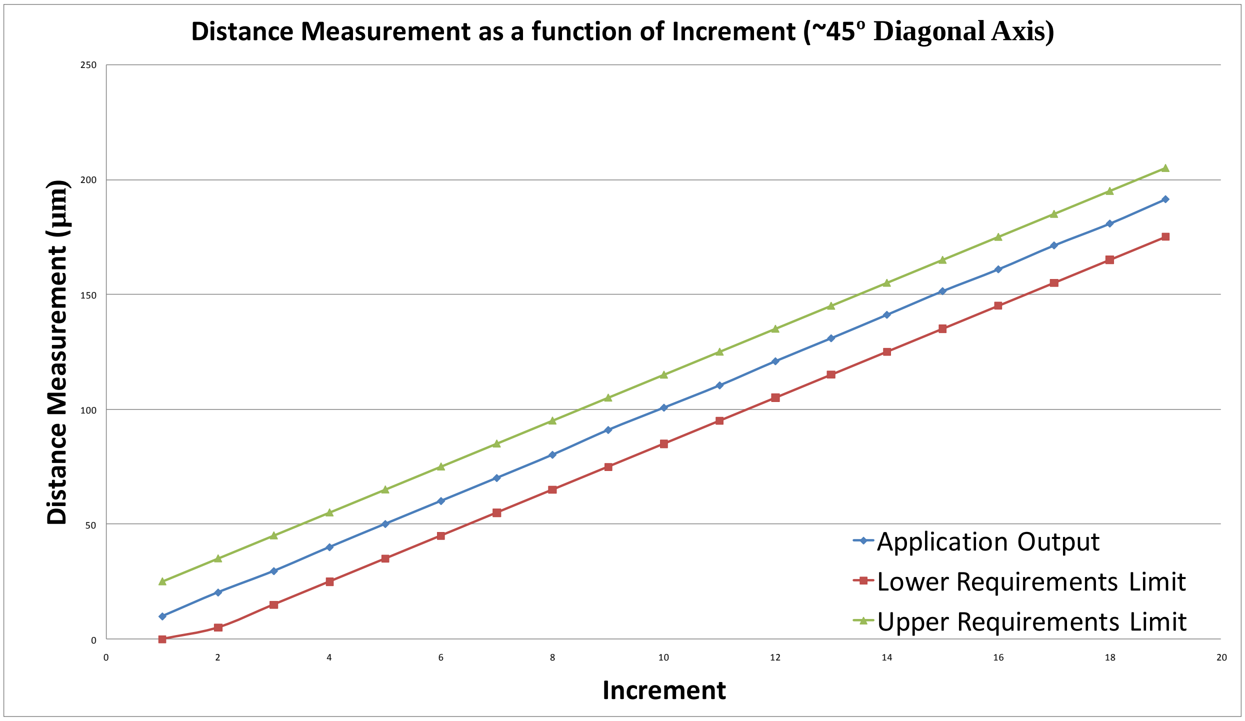

Figure 11: Distance measurement testing results for diagonal axis

The system was also tested to make sure that the video feed and image saving functions were working properly. All of the requirements set forth for the MOS were met if not surpassed.

7. PROTOTYPE

The assembled MOS prototype can be seen below in Figure 12.

Figure 12: Assembled prototype

8. RECOMMENDATIONS

The MOS system proved to be very successful as it verified a concept that Siskiyou may choose to use in future endeavors. The accuracy of the stage position function of the MOS could be improved through the use of a high resolution optical mouse. Also, if the MOS is to be made commercial, Siskiyou should design a custom circuit board to minimize the size of the printed circuit board. Many of the commercial mice tested had printed circuit boards that were quite large to house extra features. If the system were to be put into production it is estimated that the system would cost less than $50 per unit.