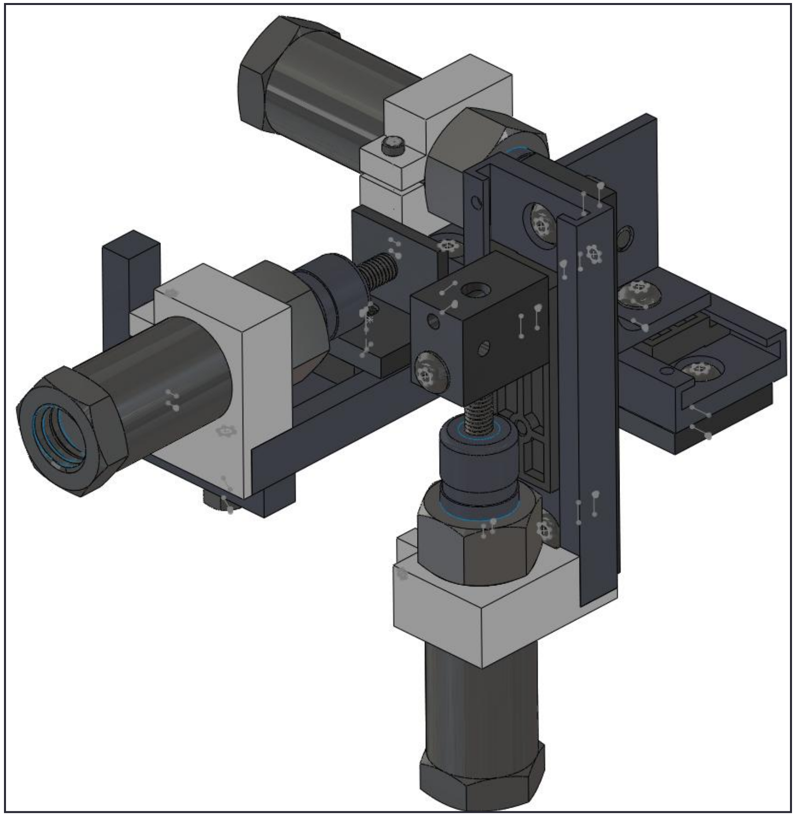
P12371: DEVELOPING A NANOMANIPULATOR TO BROADEN GLOBAL PARTICIPATION IN NANOSCIENCE



Team

- Customer:
  - Professor Michael Schrlau
- Team Members:
  - Jaclyn Bastardi - ME
  - Robert Hughes - ME
  - Bradley Ling - ME
  - Sabine Loebner - CE
  - Brad Olan - ME
- Guide:
  - William Nowak

Agenda

Agenda Item	Allotted Time
Project Description, Needs, and Specs	5 min (9:45-9:50)
Concept Summary and System Architecture	5 min (9:50-9:55)
Design Summary	5 min (9:55-10:00)
Testing Results	5 min (10:00-10:05)
Success and Failure	5 min (10:05-10:10)
Suggestions for Future Work and Lessons Learned	5 min (10:10-10:15)

What is a Nanomanipulator?

- Ultra-high precision positioning instrument
- Maneuver objects at the micro- and nano-scale
- Primary Customer Use:
  - Cell behavior for medical diagnostic

Project Description

- Broaden Participation and collaboration in nanoscience by creating a computer controlled nanomanipulator that is less expensive and more precise than manipulators currently on the market.

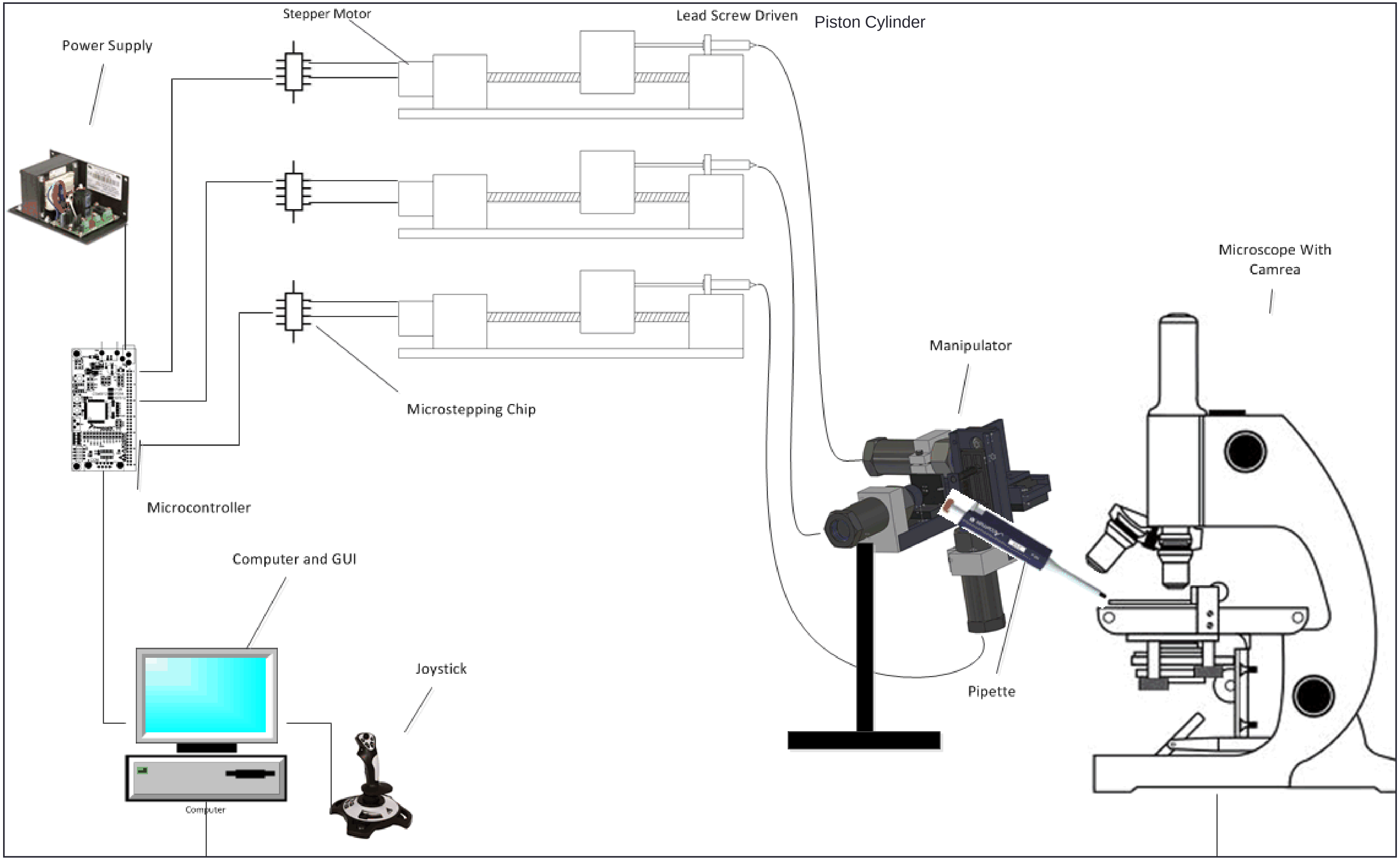
Customer Needs

Customer need #	Description
CN1	Manipulator will have fluid based 3-axis motion
CN2	System controllable via a computer
CN3	System mounted independently of microscope stage
CN4	System able to mount standard pipette holder
CN5	Manipulator mimics performance of other commercial available of commercially available hydraulic manipulators
CN6	System actuators are of the same design and dimension
CN7	System is designed to be low cost
CN8	Electrical control is performed through a computer stationed at the optical microscope
CN9	The control software is standard issue at RIT or well supported free ware (Avoid costly software)
CN10	Live camera feed from microscope provides visual feedback
CN11	Manipulator will have adjustable speed settings
CN12	System has a intuitive interface located at microscope computer
CN13	Control software and algorithms are contained on a computer stationed at the optical microscope
CN14	System is controllable with and without a joystick

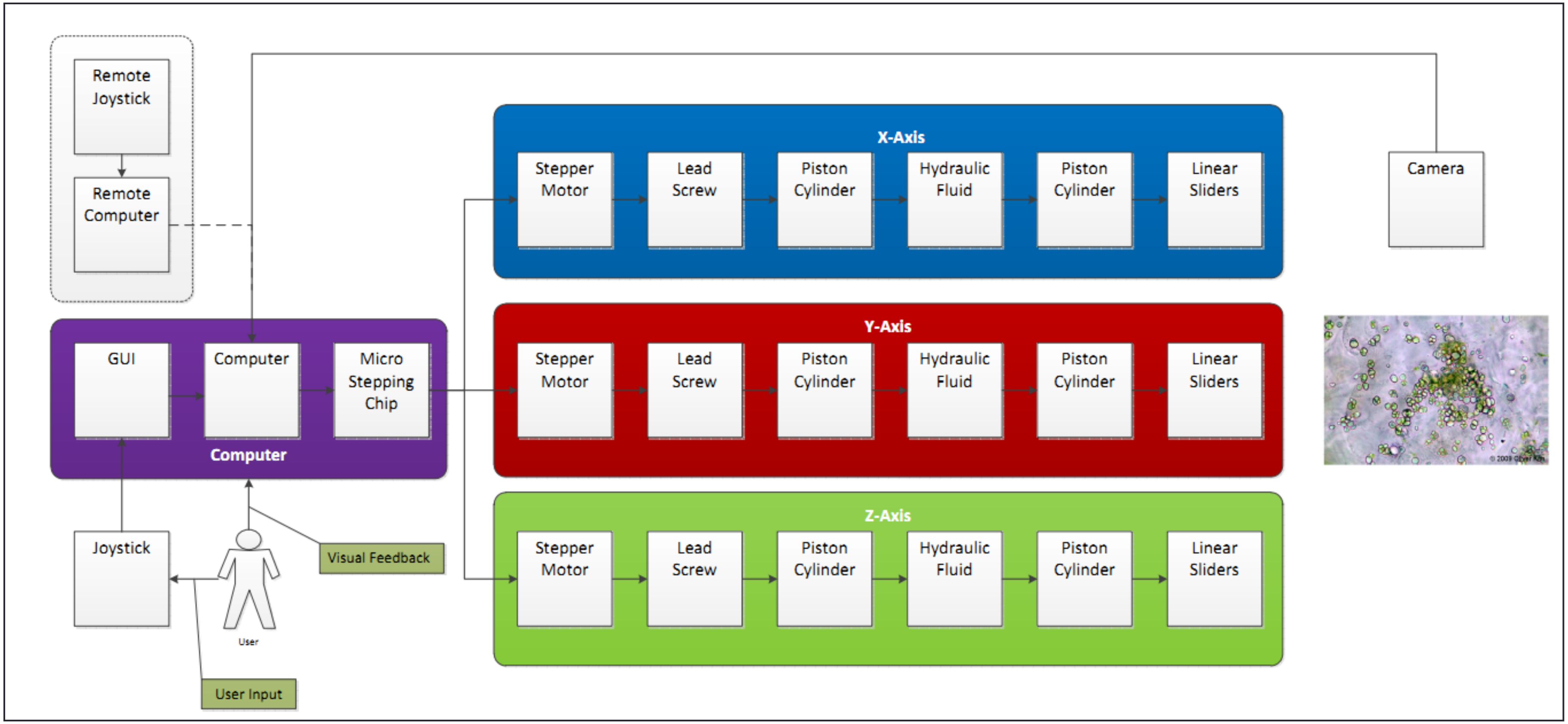
Specifications

	Source	Function	Specification	Unit of Measure	Marginal Value	Ideal Value	
S1	CN1-6	Manipulator	Size (h x w x l)	cm		8 x 8 x8	10 x 10 x 10
S2	CN1-6	Manipulator	Manipulator weight	Grams		550	750
S3	All	System	Development cost	$	2500	1000	2152
S4	All	Manipulator	Manufacturing Cost	$	1000	< 500	1720
S5	CN1,5,11	Manipulator	Limits of travel	cm	0.25	1	0.9
S6	CN5,11	Manipulator	Speed of Travel	m/sec	TBD	TBD	
S7	CN1-8	Manipulator	Resolution	nm	500	< 100	~53nm
S8	CN8	Interface	Sampling Rate	Hz		60	60
S9	CN8-14	Interface	Ease of use	Binary		yes	Yes
S10	CN9	Interface	Supported control Software	Binary		yes	Yes
S11	CN10	Interface	Visual Feed Sampling Rate	Hz		60	Variable
S12	CN14	Interface	Joystick controlled	Binary		yes	Yes
S13	CN4-5	Manipulator	Standard Pipette holder	Binary		yes	Yes
S14	CN1	Manipulator	3-axis motion	Binary		yes	Yes

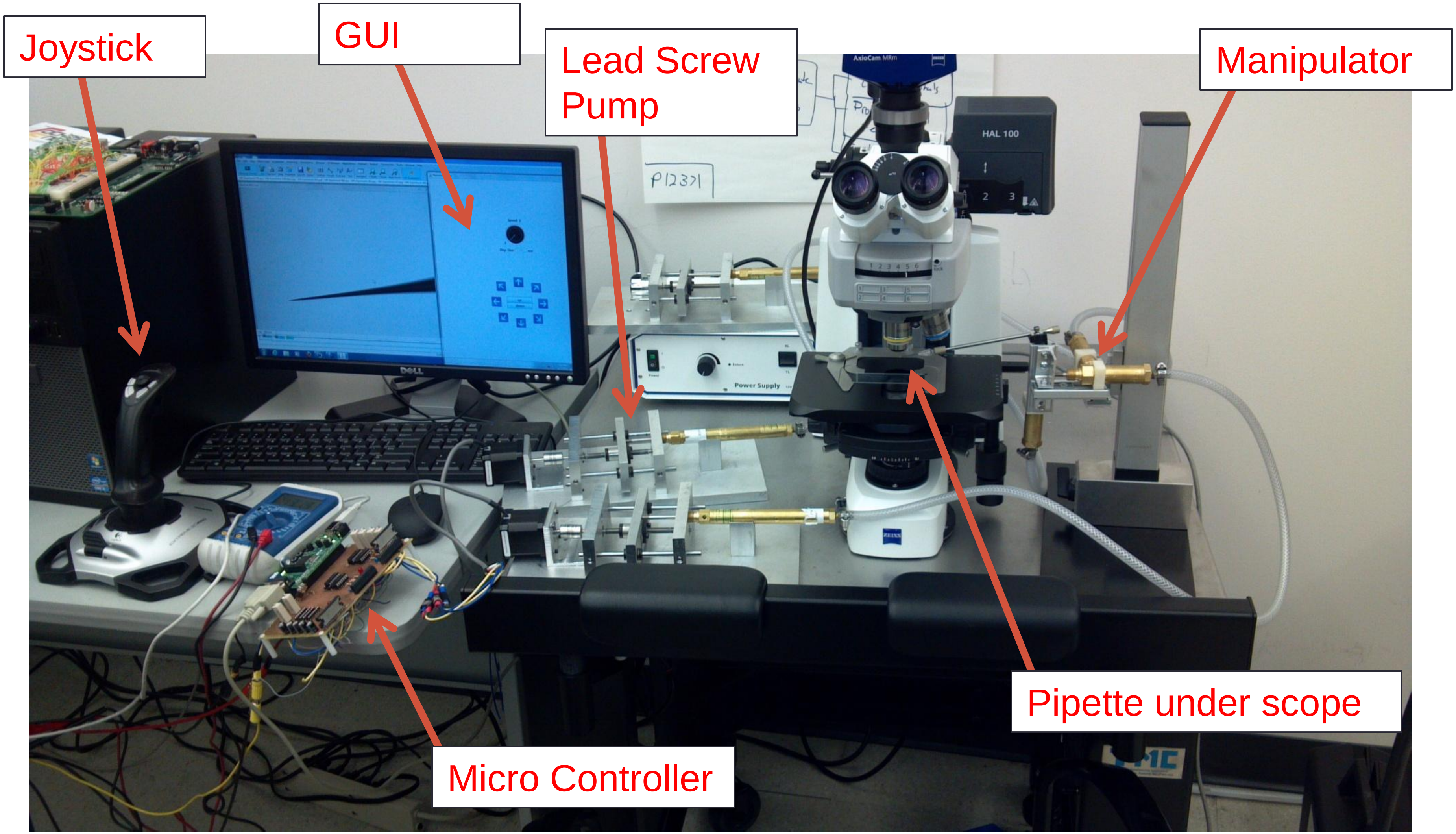
Concept Summary



System Architecture



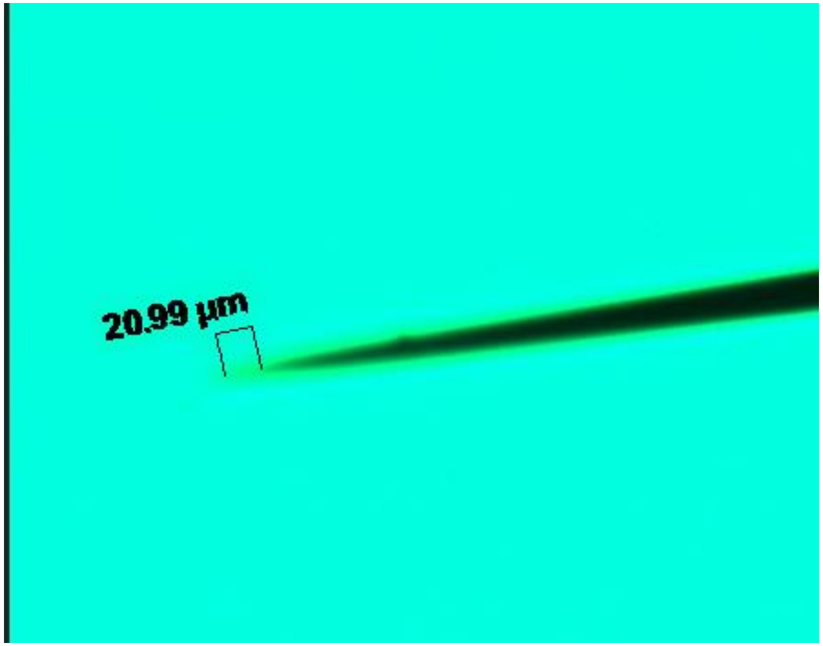
Design Summary



System Testing Results

Resolution Test Data

Steps	Delta x (µm)	Resolution (nm)
263	20.99	79.8
85	3.25	38.2
266	17.53	65.9
324	36.08	111.4
750	10.34	13.8
825	22.78	27.6
908	28.89	31.8
	Average Value:	**53**
	Standard Deviation:	34



RESOLUTION MET BY 47 NM

Success

- 3 axis motion (Achieved).
- Manipulator size constraints (10 x 10 x 10 cm only slightly larger than 8 x 8 x 8 cm and acceptable for customer).
- Manipulator Weight (760 grams > 550 grams but acceptable).
- Development Cost ($2152 < $2500).
- Limits of travel (9 cm > .25 cm).
- Resolution (~53 nm < 100 nm)
- Sampling rate (Achieved 60 Hz)
- Supported Control Software (Custom C and Java)
- Standard Pipette Holder (Mountable in various positions).

Failure

- Joystick Controlled (1 out of 3 motors controlled by joystick).
- Computer Controlled (1 out of 3 axes controlled).
- Visual Feedback not in UI.
- Will achieve control of remaining 2 axes in the coming week.

Suggestions for Future Work

- Establish control from a remote computer, preferably through the internet.
- Reduce size of entire system. Though the Manipulator subsystem fits well under the microscope, the other subsystems (lead screw/wiring) are rather large and it would be desired to have the system more portable.
- Reduce backlash in system.
- Higher step size causes vibration.
- Improve usability of the system.

Lessons Learned

- Use Technology that is well documented and has been proven by others first.
- Hydraulic properties play more of an impact on system backlash than anticipated.
- Ensure design is more robust and can handle machining errors.

Special Thanks

- Professor Schrlau
- William Nowak
- Michael Bady - Eppendorf NA
- Rob Kraynik and the RIT machine shop
- Office of sponsored research
- Rick Tolleson