Functional Software Requirements

User Interface

- Must have a GUI interface to support automated or manual movement of the positioner.
- GUI must support real-time updates on PUP position feedback.
- GUI must operate on a Windows compatible desktop or laptop computer.

Data Storage

- A snapshot of probe head XYZ position and an image frame grab must be stored in conjunction with spectral data. The user shall control when the snapshot occurs, rather than have the data continuously logged.
- The time stamp of the snapshot should synchronize with the Holograms spectral data file and/or include the spectral data file name.

Communications Transport

- Must be used over standard Ethernet protocol to utilize existing Ethernet science ports on the Ventana and Tiburon ROV's used for LRS control.

Start-up and Shutdown

- Must initiate a homing sequence during startup. The home position may not necessarily be the mechanical home position if it puts the instrument in an unsafe configuration.
- In the event of a power loss, the software must move the positioner back to its last known focus position.

Precision

- Position accuracy shall be commanded and displayed within +/-0.1 mm of desired position.

Automation

- Must include the ability to automate complex motions through the GUI, for example moving in raster mode over a target or moving across a straight line in two planes.

Control Modes

- Must have different control modes to accommodate use scenarios. Control modes will include the following: position, variable speed, and focus mode.
- *Position mode* will provide the capability to move at a constant velocity to an absolute or relative position.
- *Variable speed mode* will provide the capability to move at a constant velocity in a given direction and operate at user defined ranges, e.g. 100, 50, or 10 % of full speed.
- *Focus mode* will provide controlled movement of the probe head to optimize the Raman signal. This might include positioning the laser beam as normal as possible to the surface and adjusting the laser focus by incrementally moving the focus motor forward and reverse in user defined increments.
- *Macro mode. <<Author's note>>If the motor controllers support a macro language, it would be nice for debugging to have the capability to download a new macro and start, stop, or resume a macro from the GUI. A library of macro functions for testing may be stored on the laptop/control computer. This would be for engineering use initially, but may be useful for science use as well.*

Functional Software Requirements - cont'd

Motor Protection and Collision Avoidance

- Software must take actions where possible to not exceed designed force limits. For example, this may include:
  - Positioner or axes range software limits that restrict commanded movement beyond the PUP safe operating range.
  - Sampling of limit switches, force (torque, current) sense, motor status or other non-contact/optical proximity sensors indicating a potential object collision.
- Must provide the ability to adjust current/torque limits. This would be useful, for example, when placing the insertion probe into thick sediment where some additional current/torque might be sensed.

Interfaces

- Network. (Fiber optic data/power connection to ROV.)
- Motor controller (RS485/RS232/Ethernet?) and limit switches or force (torque, current) sense
- Keyboard and mouse
- HoloGRAMS & GRAMS32© (Control software for LRS instrument and spectral data processing software respectively).

Other Possible Interfaces…

- Camera & lights *<<author's note>> According to the functional requirements, if we are 5 m minimum standoff distance to the ROV and will likely need our own camera and lighting system to realistically see the target we are sampling. I suggest a small web-enabled camera because they are small to package and network ready. We could mount it piggyback on the probe head, or wherever appropriate.*
- On/off control of two crossing pen lasers to define focus point?
- Accelerometers *<<author's note>> As suggested by Martin Lee's 8/22 memo page 4 of 12.* `"1)We may want to use 1 or 2, three axes accelerometers mounted to measure the platform's motion as we move the load. These sensors will also tell us about any system vibration due to ocean currents and other sources."`

High Risk Elements of PUP Software

- During heavy network traffic, e.g. during spectral acquisition or while in focus mode, network communication to HoloGRAMS could reduce the update rate in GUI and possibly response to user input (keystrokes, mouse clicks, etc.).

- Others?

Use Scenarios

User control overview

User control of the positioner will be on several levels. The simplest level will be manual control through the mouse or keyboard. For more complicated control, the user will use automated control functions through the menu options (e.g. *Profile* or *Focus* menus). The level of control will depend on what the user wants to do. A user may want to switch between using manual control with the mouse, and profile mode, for example, using manual control to grossly position the probe head, then switch to profile mode to execute a motion profile.

Keyboard and mouse control

To use the keyboard or mouse for manual positioning, the user will set the speed for operation in the PUP user interface then initiate the movement by pushing and holding an arrow key or mouse button. In a typical use case, the user will use 100% speed to move the probe head to within range of the object of interest. The user will then switch to a lower speed and use a mouse click or keyboard for macro movements.

Focusing probe head

1. In HoloGRAMS user starts focus mode
2. In PUP user interface, user selects *Focus menu setup*, inputs gross increment for focus movement (e.g. 1 mm), direction for laser focus motor to traverse, and the option to stop or delay between focus increments.
3. In PUP user interface, user starts focus cycle.
4. Software sends command to move focus motor in user defined increment.
5. User then monitors Raman signal peaks. When the peaks appear at maximum, the user stops the PUP focus mode.
6. User selects *Focus mode setup* again, then adjust laser focus to smaller increment, e.g. 0.1 mm then starts focus mode again.
7. This cycle is repeated until Raman signal is maximized.

Software Use Scenarios - cont'd

Profiling the sediment, liquid, or vertically or horizontally across a solid target.

1. In PUP user interface, user switches to *Profile menu setup.*
2. User defines a profile plane e.g. horizontal, vertical, user defined angle in two planes, range in cm, increment in 0.1 mm.
3. If we are using a pan/tilt motion for the head, the user could have the option of locking the pan/tilt, or having the software normalize the pan/tilt to the working plane at each point.
4. User starts the profile.
5. Software sends command to move to first point. When positioner arrives at point, software prompts for user to acquire spectra in HoloGRAMS.
6. In HoloGRAMS user starts acquisition. Following acquisition, in PUP user interface, user resumes profile.
7. This cycle is repeated for each point in the profile.

Rastering, or "mowing the lawn" over a target

This is much like running a profile, except two additional parameters are required: offset between profiles, e.g. 1 cm, and number of rows.