STATEMENT OF WORK (SOW)	Doc. No. PS-391-000-86 R0	LUSI SUB-SYSTEM XPP

STATEMENT OF WORK:
LCLS-LUSI X-ray Pump Probe Diffractometer System Anthropomorphic Six-Axis Robot Motion Characterization Test

Prepared by:
J B Langton
XPP System Manager

Signature Date

Approved:
David Fritz
XPP Instrument Scientist

Signature Date

Approved:
Tom Fornek
LUSI System Manager

Signature Date

Revision	Date	Description of Changes	Approved
R0		Initial release	

Summary: This statement of work describes the testing to be conducted pursuant to validating the suitability of an anthropomorphic six-axis robot for the XPP detector mover system.

Work to be Performed: Motion measurements of installed, functional anthropomorphic robot to confirm key parameters as specified in LUSI XPP detector mover engineering specification document SP-391-000-62.

Project Manager: J B Langton

Test Lead Organization:

Square One System Design
PO box 10520
Jackson, Wyoming 83002
Phone: 307-739-0946
Info@sqt-1.com
Http://www.sqr-1.com

Deliverables:

a) Complete description of all test methodologies.
b) Objective evaluation of motion parameters
   i. All raw measurement data for all tests, samples, runs.
   ii. Reduced data / measurement evaluations providing verifications of specification compliance (or noncompliance).
c) Subjective evaluations of robot motion and hardware suitability for intended installation, usage and requirements.

Test Location:

Stäubli Corporation
210 Parkway West
Duncan, SC 29334
USA
phone: 864 433-1980

Subject Hardware:

Staubli RX160 6-axis Robot

Subject Participation:

Staubli Corporation:
Shall provide access to installed base RX160 robot, additional required support hardware (control computers, etc), and support personal (operators, maintenance, etc.) to complete tests as described herein.

Square One Design:
Minimum one engineer on site during test. Deliverables as specified in this SOW. Shall provide specialized hardware as required to complete tests as described herein.

SLAC:
Minimum of one engineer or physicist on site during test. Minimum of one survey engineer on site during test. Shall provide laser tracker hardware for position-motion measurements.

Test Objectives:

1) Determination of robot's ability to meeting positional repeatability and stability requirements as specified in SP-391-000-62.
    a. Are published technical specifications from manufacturers directly applicable to our application, without reservation or modification ?
    b. Specific determination of key parameter, repeatability, for Staubli RX160 as absolute, in the context of SLAC-LUSI-XPP required motions.
    c. Determine if Staubli RX160 hardware has any particular motion constraints / traits (hysteresis, payload weight, etc.) that would effect its suitability for use as required in XPP.
2) Determination of robot's ability to execute programmed motions of XPP detector as specified in SP-391-000-62.
    a. Confirm Staubli RX160 ability to move detector along circular / spherical paths at commanded radii per specification requirements.
    b. Confirm ability to position motion center to required specification.
3) Improved understanding of Staubli control system / user interface.
    a. Evaluate suitability of Staubli control system with respect to SLAC-LUSI-XPP requirements.
    b. Gain "Hands on" knowledge for the controls interface development task to achieve full XPP functionality.

Test Stipulations:

a) The robot employed in all tests must have a nominal working envelope sufficient to satisfy the range extents and stayclear requirements as defined in SP-391-000-62 sections 7 and 8.

b) The robot employed in all tests must have sufficient degree of freedom capability to satisfy coordinate system alignment and nominal pointing requirements as defined in SP-391-000-62 section 6.
c) Tests shall be conducted with payload 25 kg (~55 Lb), maximum, to satisfy SP-391-000-62 section 9 requirements. Testing can be conducted with lesser masses to establish specification - payload dependence.
d) A minimum of 10% of test data sets shall be conducted with robot end affecter velocity at or below 0.2 meter / sec max velocity requirement. Ref: SP-391-000-62 section 9.

Square One Design Supplied Hardware:

1) One Keyence high resolution laser gage.
2) One digital inclinometer.
3) One detector mock-up. Mock-up shall:
   a. Mount to robotic end effecter.
   b. Have approximate dimensions (200 mm square by 150 mm thick) specified in SP-391-000-62.
   c. Provide capability of adjusting total mass by addition or subtraction of ballast.
   d. Provide for the mounting of any required hardware for Keyence laser gage.
   e. Provide for the mounting of digital inclinometer in minimum two orthogonal orientations.
   f. Provide for the mounting of three Hubbs machine and manufacturing 1.5 inch diameter sphere mount, negative, 0.25 inch diameter nominal shank. Mounts shall be positioned in a triangular pattern as appropriate on the front face of the mock-up

SLAC Supplied Hardware:

1) One Laser Tracker System.
2) Three spherical mounts, 1.5 inch diameter x 0.25 inch nom shank.
3) Three spherical retro-reflectors.

Minimum Required Test Protocol:

Position Repeatability Testing:

1) RX160 robot is fixtured with detector mock-up.
2) Detector mock-up is ballasted to maximum mass as specified in SP-391-000-62 (25 Kg).
3) Detector mock-up is instrumented for acquisition of Keyence laser gage, inclinometer and laser tracker data.
4) An initial position is established for all sensors (“position 1”).
5) The robot in commanded to a offset position at the extreme limit of the required work envelope as specified in SP-391-000-62, section 7 9,approximate 1.4 meter distant (“position 2”).
6) The robot is commanded to alternate between position 1 and position 2 a minimum of 50 times.
   a. The path between positions is to be varied.

   b. The paths between positions shall gravity load individual robot articulations in numerous directions to establish any hysteresis effects.
7) Upon completion of minimum 50 motion cycles, as time permits, data shall be acquired for:
   a. Reduced payload mass (remove mock-up ballast).
   b. Reduced work envelope (position 1 -2 offset less than 1.4 meter).
   c. Varied motion velocity.

Positional Stability:

1) RX160 robot is fixtured with detector mock-up.
2) Detector mock-up is ballasted to maximum mass as specified in SP-391-000-62 (25 Kg).
3) Detector mock-up is instrumented for acquisition of Keyence laser gage and laser tracker data.
4) Robot shall be commanded to hold position for a minimum 30 minutes during which position data is accumulated.
5) The laser gage shall be reoriented to acquire data in a direction orthogonal to the original and data accumulated for an additional 30 minutes minimum.
6) The laser gage shall be repositioned to acquire data in a direction orthogonal to the original two and data accumulated for and additional 30 minutes minimum.

Rotation Precision / Repeatability:

1) RX160 robot is fixtured with detector mock-up.
2) Detector mock-up is ballasted to maximum mass as specified in SP-391-000-62 (25 Kg).
3) Detector mock-up is instrumented for acquisition of inclinometer laser tracker data.
   a. The inclinometer is oriented to acquire angle data with respect to a horizontal plane.
4) The robot is commanded to move along a straight line of circular path in a horizontal plane.
5) Inclinometer and laser tracker data is acquired at representative points along the commanded path

Path and Motion Center:

1) RX160 robot is fixtured with detector mock-up.
2) Detector mock-up is ballasted to maximum mass as specified in SP-391-000-62 (25 Kg).
3) Detector mock-up is instrumented for acquisition of laser tracker data.
4) The laser tracker is positioned in an appropriate location within the robot's work envelope.
5) The robot is commanded to 4 or 5 locations on a spherical surface nominally centered on the laser tracker.
   a. Radius of motion per SP-391-000-62 section 7 (10 to 100 cm).
6) The tracker data is used to calculate the location of the center of the commanded spherical motion.
7) The offset is feed to the robot system to reposition the center of motion at the tracker location.

8) The robot is commanded to 4 or 5 locations on a spherical surface nominally centered on the laser tracker.
9) Offsets of data sets one and two are compared and a new offset determined as required to minimize center location offset.
    a. Offset goal per SP-391-000-62, section 6 (<300 micron).

Test protocols as described above may be combined as applicable as agreed by on site SLAC and Square one personnel.