APPENDIX 07

X-Ray ICT1500 Specification

X-Ray (ICT1500) Specification

1) The contractor shall provide a table with picture and a guide that describes all components that will be replaced or modified. The proposal shall be evaluated providing a detail diagram showing the different parts, and details of new parts being installed including cut sheet. In their contractor's proposals

2) The extension plan includes replacement and upgrades of obsolete key components necessary for the continued use and sustainability for the CTI 1500 key capital equipment.

3) Because the existing design of specialized/critical components (shutter, beam collimators, tungsten sensor housings, linear accelerator), structural/shielding assemblies and low-wearing parts that have served the 709th group decades. These proven parts are considered stable/safe and would be cost prohibitive and extremely difficult to reproduce for no value added

4) No changes are necessary for the source, foundations, structures, radiation shielding, enclosures, lead-screws, bearing assemblies, counterweights or major components not listed below. The range of performance of the source, motion, speed and accuracy of the mechanical system will remain as-is.

5) There are just a few qualified contractors that could interface with this ICT 1500 system and provide upgrades to extend the life

   A. Adaptive Energy (adaptiveenergy.com)
   B. Industrial Imaging Solutions (solutionsimaging.com)

6) The contractor shall maintain the Linear Diode Array (LDA) concept and arrangement while replacing the electronics and sensors. The circuit boards and modules shall 'Plug and Play' into the existing machine without significant modification. Modifications are limited to the Detector Housings (to accept alternate form factor photodiode and electronics bay to support new (printed circuit boards) PCB's.

7) Replace PCB's and PCB support back bone Update Detector housing New Housing Photodiodes and Scintillators

8) Scintillator Assembly The scintillator assembly is currently comprised of three bonded components made up of the photodiode, light pipe and the Cadmium Tungstate (CdW04) scintillating crystal the assembly is the photodiode. The photodiode, like the PCBs, are obsolete and no longer produced. Therefore, specified diode need to be chosen that gives installation a higher preforming and more robust part opportunity

9) The contractor shall separate the light pipe and scintillator assembly from the diode. The material, shape and size of the scintillator will remain the same. The new light pipe (BK7 material) shall be designed to couple the gathered light to the new form factor diode. The diode will remain replaceable via a PCB socketed connection. The scintillator and light pipe assembly shall be coated with a highly reflective material to maximize photon collection.

10) Reference Detector The system makes use of a reference detector The contractor shall continue using this practice. The reference detector is placed before the part near the output of the linear accelerator. The main job of the reference detector is to monitor the output beam time and frequency of the source.

11) The contractor shall include a method to use the same proposed scintillator assembly with revised detector housing. Mounting and shielding are as-is. Communication to the host computer will be part of the main detectors serial chain.

12) PCB's There are 90 channels in the imagining portion of the system. The 90 channels have 45 PCBs performing the A/D (analog to digital) conversion. Each board gets input from two scintillator assemblies.

13) The existing system also has separate control, communication and power supply PCBs to manage the A/D boards. The contractor shall consolidate all of these exterior functions into a single detector PCB. The detector boards would be interchangeable from position to position within the LDA and via high speed and deterministic control communicate with their peers to handle all functions of image acquisition.

14) The contractor shall install new PCBs include 24bit A/Ds, Xilinx FPGA processor, individual gain corrections, linear accelerator synchronization, data storage, power isolation, fiber optic communication and faraday shielding.

15) MOTORS AND CONTROLS The existing motion control system incorporates technology considered very high-end during its construction. The precision and repeatability are still impressive. The accuracy is heavily influenced by the outstanding mechanical design. It shall be the contractor's task to provide a modern and sustainable motor and control package that benefits from the inherent precision of the machine which remains unaltered.

16) Motion Controls

17) Currently the motion controls are a complex array of motors, drives cards, sensors, processors, power supplies, interconnecting cables, etc. which take up several large equipment cabinets to support. The points of failure on such a system are too great for the maintenance person. The contractor shall provide an Engineer or System Manufacturer to replace the hardware controls with a single multifunction multi-axis controller by Galil or equivalent. The contractor shall install the Galil RISC based ASIC controller or equivalent that can run up to eight axis and be configured for servo or stepper motors. The contractor shall install a controller that has inputs for limit and home switches, encoder or resolver

inputs, serial/USB/ethernet communication, pulse on position, BiSS for external encoders, 16 general purpose inputs and outputs for safety switches or other facility/machine devices. Depending on the larger servo motors (>750W) exact system specification. The contractor shall provide external amps source. The amps shall be an inline extension of the Galil controller and provide the additional motor current/power.

18) Motors The contractor shall install proven motors developed for a range of installations. The contractor shall use commonly known motors such as Seimens, Kollmorgen, Maxon, Anaheim Automation and Parker. The contractor shall install Kollmorgen line or equivalent Servos and Stepper in this system. Motors must specify a wide range of encoding and brake options. Motors and cables shall be shielded and oil resistant

19) External Encoders In addition to the motors feedback encoders/resolvers, the motion control also receives position data from 4 very high precision absolute encoders mounted to the output stage of the gantry and turntable axis. These encoders (3 linear, 1 rotary) shall be replaced with modern equivalents. The contractor shall provide Renishaw or equivalent radiation shielding of the external encoder's electronic modules.

20) SOFTWARE The contractor shall have inhouse software development and support capabilities. The contractor shall install a Control and Inspection Software product runs all the aspects of generation and processing image data. A single User Interface an operator may control the motion systems, detectors (LDA and DR), sources (LINAC and CP) and integrate combination of these elements into an automated scan plan. The contractor shall include acquisition tools; but, tools for the post processing of images as well as file management/data base of all variables including user annotations, measurements, position, setup, corrections, pixel maps, etc. Software shall be open ended and have proprietary control. The software shall be expanded to communicate with the new LDA, Reference Detector and the handling of the external encoders. Galil Motion, Kollmogen Motion , Kuka Robots and lesser peripherals. The software runs a collection of C++, Java, Python, SQL and .NET. The image prost processing controls are open source and run with ImageJ

21) WORKSTATION The contractor shall provide control workstations with application and needs fist.. If post processing is to be performed by an off-line station, the standard AE Dell PC is adequate.
Basic Description: 1) Processor - Intel Xeon 4GHz, 4Core, 8.25MB Cache, DDR4-2666 Video Card - Nvidia Quadro P1000, 4GB, 4mDP
NIC - 1x Fiber, 2x Gig Ethernet
Ram - 64GB DDR4-2666MHz RDIMM
Storage - PCIe 1TB SSD Optical - DVD+/- RW
Power - 950W

Hill Specs.

Scan Modes
Translate-Rotate

Helical < 600 mm
Helical > 600 mm
Radiograph < 600 mm
Radiograph < 600 mm
Calibration periodically throughout scan
Reference detector data
Data correction based on calibration and reference detector
Easy way to re-shoot bad data (specific shot, traverse, slice, etc.).
Remote monitoring / control of scan and parameters (from networked computer
Manual Motion Control Box Need to be able to manually control the gantries from a manual control box in the bay.

Positioning

Need to be able to position all axes to user designated positions for setup, alignment,

Controller

4 Stepper motors driving collimators
3 open loop1 with 3 discreet position indications
5 DC Servos driving large gantries
5 Optical encoders - B, X, Zs, Zd + 4 servo resolvers
Rotary (B) - accuracy of 0.001 deg or better Linear Axes (X, Zs, and Zd) - 1 µm or better Servo Resolvers (B, X, Zs, and Zd) - 4000 counts / rev. or better
Must provide trigger pulse based on encoder position
This is to trigger the x-ray pulse and data collection cycle
It must be accurate and repeatable - ideally within 50 um or 0.025 deg depending on scan mode.
We need to provide a continuous pulse stream to the x-ray source even when motion is stopped

Replace 5 large DC servos with new motors / amplifiers compatible with controller and with any necessary adapters to mate with existing hardware

Replace 5 stepper motors with new motors / amplifiers compatible with controller and with any necessary adapters to mate with existing hardware

Encoders

Replace 4 existing linear encoders with new absolute encoders - accuracy of 1 µm or better
Replace rotary encoder with compatible absolute encoder - accuracy of 0.001 deg or better

Detector 90 Channel

Photodiodes

Scintillators

Preamps

Data Acquisition

24 bit A/D conversion with sample-and-hold if required

Output stream to software/computer over fiber