WBS NUMBER					TITLE	DESCRIPTION
1	01	03	05		Global Controls NRE	This is all non-recurring development for the first instance of each subsystem solution.
1	01	03	05	01	EPICS Controls Modules	All CPUs and VME crates for commissioning.
1	01	03	05	02	LLRF Controls	Development of the first low-level RF system.
1	01	03	05	03	E-Beam Diagnostics & Controls	Development of the first E-Beam diagnostics system.
1	01	03	05	04	Laser Controls Design	Development of the laser control system.
1	01	03	05	05	Laser Heater Controls Design	Development of the laser heater system.
1	01	03	05	06	Timing Controls	Development of the LCLS timing system.
1	01	03	05	07	Vacuum Controls Infrastructure	Development of the first vacuum controls.
1	01	03	05	09	Power Supply Control	Development of the first power supply system.
1	01	03	05	10	MPS/PPS/BCS Controls	Development of the first machine protection, personnel protection and beam containment systems.
1	01	03	05	12	Global Controls NRE	Management support
1	01	03	05	13	SLC Aware IOC - PED	Design and implementation of the software to emulate the SLC micro communication inside the EPICS IOC to allow the existing high level applications on SLC to be used for early commissioning and operation.
1	02	02			Injector Controls Subsystem	The injector controls system is to be an EPICS – Experimental Physics and Industrial Control System. The Injector control system must interface with the existing linear accelerator (LINAC) timing system. Local system control, at Sector 20, will be used for development through the commissioning phase of the project. Operational control will reside in the LCLS Main Control Center (MCC).
1	02	02	01		Personnel Protection Subsystem (PPS)	This section covers the cost of designing and writing software to integrate the new EPICS Control system with the existing accelerator PPS control system.
1	02	02	02		Beam Containment Subsystem (BCS)	This section covers the cost of designing and writing software to integrate the new EPICS Control system with the existing accelerator BCS control system.
1	02	02	03		Machine Protection Subsystem (MPS)	This section covers the cost of designing and writing software to integrate the new EPICS Control system with the existing accelerator MPS control system.
1	02	02	04		Injector Power Conversion	Provide all instances of the magnet power supply system for the Injector.
1	02	02	04	01	Beamline Pwr Supplies - (Dipole Type)	Provide all instances of the magnet power supply system for the Injector.
1	02	02	04	02	Power Supply Controls	Provide all instances of the magnet power supply system for the Injector.
1	02	02	04	03	Beamline Pwr Supplies - (Trim Type)	Provide all instances of the magnet power supply system for the Injector.
1	02	02	04	04	Beamline Pwr Supply - Misc Hdwr	Provide all instances of the magnet power supply system for the Injector.
1	02	02	05		LLRF Controls	Provide all instances of the LLRF system for the Injector.
1	02	02	05	01	Readback & Controls - RF Gun LLRF & Temperature	Provide all instances of the LLRF supply system for the Injector.
1	02	02	05	02	Readback & Controls - L0 LLRF	Provide all instances of the LLRF supply system for the Injector.
1	02	02	05	03	Readback & Controls - Transverse Cavity LLRF	Provide all instances of the LLRF supply system for the Injector.
1	02	02	05	04	S-Band Cavity Controls	Provide all instances of the LLRF supply system for the Injector.
1	02	02	06		E-Beam Diagnostics Controls	Provide all instances of the E-Beam Diagnostics for the Injector.
1	02	02	06	02	Controls - BPM	The BPM (Beam Position Monitor) controls for the injector consist of the cables from the BPM hardware to the local VME crate, along with the controller, license and software to communicate with the BPM.
1	02	02	06	03	Controls - Toroids	Toroid (current monitor) controls include the cables from the hardware to the control modules in the VME crates, the VME control modules and the software to communicate with the toroids. The crate, controller and license are included in section 1.2.2.8.

WBS NUMBER					TITLE	DESCRIPTION
1	**02**	**02**	**06**	**05**	Controls - Profile Monitors	There are two types of profile monitors: YAGs (where energy is low) and Optical Thermal Radiators (OTR) (where energy is higher). Controls include the camera and accompanying PC (ratio of cameras: PC may > 1), the Cables between each and the Ethernet cable to get data to MCC, along with software for interpreting the image data.
1	**02**	**02**	**06**	**06**	Controls - E/O Diagnostics	The electro-optic phase diagnostic consists of an analog signal of pulse length measurements which will be input into an ADC VME module in the diagnostics crate or via a digitizer. Software in the IOC will calculate the centroid of the array of pulse lengths, and from that, due to the linear relationship between the chirped pulses' length and time, determine the relative time between the electron and the laser beam. The result will be converted to an analog signal via a DAC VME module which will be used to vary the drive laser signal such that the relative time goes to zero. This same result will also be used to vary the gun phase such that the relative time goes to zero.
1	**02**	**02**	**06**	**14**	Controls - Faraday Cups	There are four Faraday Cups in the LCLS injector. Each contains its own OTR or YAG profile monitor. Where the energy is low, a YAG is used; where the energy is high, an OTR is used. Where the Faraday Cup is used to momentarily intercept the electron beam, a pneumatic actuator is used to insert the FC/PM assembly.
1	**02**	**02**	**06**	**15**	Controls - Tune-Up Dump	Tune up dump controls include the cables from the hardware to the control modules in the VME crates, the VME control modules and the software to communicate with the toroids. The crate, controller and license are included in section 1.2.2.8.
1	**02**	**02**	**08**		Timing Controls	One master timing controller is needed for the injector. This controller interfaces to the LINAC's Main Drive Line (MDL) and passes on the timing signals to a maximum of 8 outputs. The fiducial output (FIDO) module divides the 476 MHz signal by 4 to become a 119 MHz signal (8.4 nsec ticks). The FIDO sends its signal to the PDU II module in the VME crate of the receiving system. It uses Heliax cable between the FIDO and the PDU II.
1	**02**	**02**	**09**		Vacuum Controls	The vacuum design for the waveguide is based on the vacuum design at LINAC sector 2. Controllers, power supplies, gauges, valves, and cables are identified in this system. The pumps are small ion pumps, equally spaced along the waveguide. The pump power supplies are controlled via set points sent via VME IDIM signals. Two kinds of gauge controllers will be used. The Pirani and the Cold Cathode gauges are controlled by a HPS 937 gauge controller; the hot filament gauges are controlled by a GP307 Ion gauge controller. During the design phase, the number of each type of gauge used will be determined. There are 4 valves. All 4 valves can be controlled by a single programmable multi valve controller, PMVC6, module. Faston relays are also used to control the valves.
1	**02**	**02**	**10**		Software & Controls Infrastructure	Application development environment, control crates, control CPUs for the Injector controls.
1	**02**	**02**	**10**	**03**	Data Communications	Controls workstations will have access to MCC from the control room and from the RF hut. The network will be configured to get images to MCC without compromising control commands. Laptops will have wireless access to the visitor network. Access points will be at both the ground and subground levels.
1	**02**	**02**	**10**	**04**	Computers & Crates	The VME crates with Power PC IOC controller and VxWorks.
1	**02**	**02**	**12**		Laser Controls	Controls for the Injector Laser provided by the vendor.
1	**02**	**02**	**12**	**02**	Controls - Gun Laser	This element includes costs for the design and documentation of local control and the interface of the Gun Laser to the main control system.

WBS NUMBER					TITLE	DESCRIPTION
1	**02**	**02**	**13**		Laser Heater Controls	The laser heater controls system consists of control modules, cables and software to do on/off control of two laser shutters one in beam conditioning optics, one at launch table. Steer the IR beam by controlling two motorized mirror stages on the launch table. Modifying the OTR control, if necessary, for the laser heater. Transmit the IR joulemeter signal from IR diagnostics to MCC. There are 4 analog signals which need to get to PEP via an ADC. There might be 0.5 months software work here, too. Transmit the IR timing diode signal to an oscilloscope near diagnostics port. Transmit the Spiricon camera image on the diagnostic table to MCC and receive controls from MCC. Transmit the electron beam energy spread data from OTR and to MCC. A PC might be needed here for the spectrometer. Reduce the data for the laser and the e-beam (the previous two items). Control the Undulator by stepping the motor and reading the position from LVDT sensors and the limit switches.
1	**03**	**02**			Linac Controls & Power Conversion Subsystem	System Summary
1	**03**	**02**	**01**		Personnel Protection System (PPS)	This system creates a physical barrier that subtends the LCLS for the purpose of personnel protection from radiation, electrical, and other present or imagined hazards. An LCLS area may use or combine with other SLAC control areas. The PPS system will include monitoring of radiation shielding integrity, barriers, area status annunciators, and multiple interlocked control gates for access to a safe machine space.
1	**03**	**02**	**02**		Beam Containment System (BCS)	The BCS includes components like stoppers and dumps that along with shielding provide a safe way to contain radiation that is generated under all LCLS operating conditions. This system also includes active instruments (beam shut off ion chambers - BSOIC's) that will disable operations if elevated levels of radiation (Neutron & Gamma) are detected outside of the PPS control area.
1	**03**	**02**	**03**		Machine Protection System (MPS)	This is a system of sensors (i.e. water flow switches, thermocouples) supplied as Digital and/or Analog signals which are interlocked, that will in turn shut off the beam if conditions exist/persist that will cause damage to machine hardware or other protection systems.
1	**03**	**02**	**04**		Linac Power Conversion Subsystem	The power supplies for the LCLS Linac will, for the most part, be a standard design and are used throughout the SLAC accelerator. This Linac WBS Power Supply subsystem has been divided into three types, Dipole, Quadruple and Trim and are described below. The WBS unit will not provide for Fabrication or Installation activities. In addition, the design of the magnet power supply systems assumes that all magnets will have their magnet electrical connections covered such that the powered systems comply with SLAC, National Electric Code and OSHA regulations. There is no provision for interlocking the magnet power supplies for magnet safety.
1	**03**	**02**	**04**	**01**	Beamline Power Supplies - (Dipole Type)	The Dipole Power Supplies provide power to dipole magnets. These units cover the LINAC, BSY and the LTU. There are 7 units, which are: BXH11-14, BXH 21-26, BXH 31-34, BY1, KICKER (BYBKIK), BYW, and the Dump Bend.
1	**03**	**02**	**04**	**02**	Beamline Power Supplies - (Quad Type)	The Quadruple Section power supplies power quadruple magnets which provide power to the focusing elements in the transport system. This section have the largest number of units and there will be 31 units which are: SEC-23 (2KW), SEC-24(2KW), SEC-25 (2KW), SEC-26 (2KW), SEC-27 (2KW), SEC-28 (2KW), SEC-29 (2KW), Q24701, QM21, Q24901, QM22, QVM1, QVM2, QVM3, QVM4, QVB1, QDL1, QE31, QEM1, QEM2, QEM3, QEM4, Qtm1, Qtm2, QUM1, QUM2, QUM3, QUM4, QDMP, QUE1 and QUE2.

WBS NUMBER					TITLE	DESCRIPTION
1	03	02	04	03	Beamline Power Supplies - (Trim Type)	The last type is the Trim Type and these power supplies power magnets that operate at low currents and make minor orbit corrections to the beam. There will be 10 new units, which are: MCOR_1, MCOR_2, MCOR_3, MCOR_4, MCOR_LTU1, MCOR_LTU2, MCOR_LTU3, MCOR_LTU4, MCOR_LTU5, MCOR_LTU6.
1	03	02	04	04	Beamline Power Supplies - Misc Hdwr	This section covers the costs associated with the packaging (integration of systems equipment) and testing of electrical equipment racks for the Power Conversion and Control Systems. Rack infrastructure i.e. AC power distribution, plugstrips, utility outlets, cooling fans and mounting brackets are integrated prior to the integration of previously procured rack and crate mounted equipment from the various sections. Cableplant installation design of Trays and Long-Haul cables (Using CAPTAR database) to be installed into the various areas, resulting in an award of contract, takes place here.
1	03	02	05		Controls - LLRF	LLRF is a system for the amplitude and phase control of the electron beam. It includes a new master oscillator and the distribution of the 2856 MHz RF and the machine timing signals. It also includes the RF control system around individual klystrons for stabilizing (low noise, low drift) and monitoring of their operation. A preponderance of design and procurement resides within the RF Section budget leaving controls with a engineering supporting role. This equipment also provides the means of avoiding Main Drive Line phase jumps when operating PEPII.
1	03	02	06		Controls - E-Beam Diagnostic	Diagnostic devices measure salient beam parameters such as beam size, position, phase, bunch length, beam current etc. for the purposes of setting and tuning the various machine parameters such as the strength of magnets and the amplitude and phase of klystrons. The diagnostic signals provide a monitoring function and in some case a direct feedback for closed-loop control of the accelerator hardware.
1	03	02	06	01	Controls - Wire Scanners	Wire scanners are beam profile monitors used to provide accurate measurements of beam size and position in all three planes (vertical, horizontal and 45 degrees) for beam measurement systems and beam tuning procedures. Components include wires capable of being moved precisely through the path of a beam, and a detector which can accurately measure the amount of charge striking a wire. When in use, a wire is scanned across the path of a beam using stepper motors, and a plot of wire position versus beam intensity is generated that represents the beam profile.
1	03	02	06	02	Controls - BPMs	Beam Position Monitor. A device including four electrodes located inside the beam pipe, and the associated electronics necessary to locate the position of the centroid of the beam. The electrodes are usually located about 90 degrees apart inside the vacuum chamber, far enough away from the beam's path not to interfere with it, but close enough to feel the electric charge of the beam's passing. A device called an RF cavity BPM uses resonant cavities in place of electrodes to detect the electric charge of the beam.
1	03	02	06	03	Controls - Toroids	The Toroid is an average beam current (charge) monitor (CM) which uses transformer action to measure the intensity of a beam pulse. A lead shielded pre-amplifier is usually placed near and connected to the wire wound ferrites. The amplified signal is then cabled to an electronic module external to the shielded housing. Comparisons can be made between Toroid installations as a way of determining beam losses between two points.
1	03	02	06	04	Controls - Stoppers	A Personnel Protection System device used to stop the beam, usually by allowing a heavy metal slug to pivot into the beam's path. The de-energized default is in the beam path as a fail-safe. This is removed from the path by means of air solenoids. This device, as all PPS devices rely on redundant parallel limit switches to supply status prior to allowing entry into beamline areas.

WBS NUMBER					TITLE	DESCRIPTION
1	03	02	06	05	Controls - Profile Monitors	A screen inserted is inserted into a beam transport line to view the beam cross section via a remote camera focused through a glass viewing port. The screen can be made from a variety of materials suited to the beam energy at that location. The visible emission picture is captured on a digital video camera, triggered to look a specific beam pulse. Profile monitor screens can be inserted and removed remotely by the machine operators. Position status is determined by limit switches. Cameras can be remotely triggered, iris controlled, zoom activated, lamp intensity varied via electronic modules connected to a two channel Profile Monitor chassis.
1	03	02	06	06	Controls - E/O Diagnostics	The electro optic, EO, bunch length monitor is a laser-based measurement for measuring the absolute bunch with subpicosecond resolution. An instrumented class 3 laser is table-mounted and can be remotely operated and parameters changed via electronic stepper motor modules and interface with positional information read-back via an analog input module. Control and monitoring are transmitted by cable to modules located in a non-hazardous area.
1	03	02	06	07	Controls - Bunch Length Monitors	The bunch length monitor, BLM, is used to measure the length of the bunch after each longitudinal compression stage in the accelerator. The measurement is done on a pulse-by-pulse basis so that the information can be transmitted to a feedback loop for control and stabilization of the bunch length. The BLM device senses the coherent radiation from the bunch, where the spectral power is proportional to the peak current in the bunch and so is able to detect relative changes in bunch length. For calibration purposes this measurement is compared to measurements made with the RF transverse deflecting cavities.
1	03	02	06	08	Controls - Beam Loss Monitors	Beam loss monitors, BLM's, are placed on the beamline immediately adjacent to the beam pipe wherever there is a potential for beam loss or beam scraping to occur, such as locations where the beamline bends, or there is a fixed aperture protection collimator, or a moveable collimator to scrape the beam. The signal from the loss monitor is compared to a preset threshold by the Machine Protection System, MPS, which will respond by limiting the rate of the beam pulses according to the severity of the beam loss. The BLM can measure local losses at a point on the beamline using a Protection Ion Chamber, PIC, or can measure global losses along the length of the beamline by using a distributed Panofsky Long Ion Chamber, PLIC, device. Different beam loss sensing detectors can be used according to the type of radiation expected and the sensitivity required.
1	03	02	06	09	Controls - Single Beam Dump	The single bunch beam dumper, SBBD, consists of a fast-acting pulsed magnet that is able to selectively deflect a bunch toward a beam stopper on a pulse-by-pulse basis. The purpose of this is to control the rate at which beam is sent to the downstream undulator beam line which contains sensitive equipment. If a fault condition occurs such as a beam loss in the undulator then the SBBD is able to prevent the next beam pulse from being sent down the beam line and potentially causing damage. The fault conditions are passed to the SBBD from the Machine Protection System, MPS. The SBBD is able to stop the full-rate 120 Hz beam from the linac upstream and selectively allow single shots, 1 Hz, 10 Hz or an arbitrary rate to be sent downstream, thereby facilitating tune up of the beam without risking damage to the beam line.
1	03	02	06	10	Controls - E Beam Dump	The main electron beam dump is used to safely stop the spent electrons after the undulator. The design of the dump addresses issues of cooling the maximum possible heat load from the electron beam with regard to thermal stress and corrosion problems to ensure that the radiation in the dump is fully contained. The control system monitors temperatures and coolant systems for long-term reliability.

WBS NUMBER					TITLE	DESCRIPTION
1	**03**	**02**	**06**	**11**	Controls - Protection Collimator	These fixed mask devices are a principal initial means of scraping errant beams thereby preventing damage to beamline components and/or beampipe if not outright venting of the vacuum envelope. Water flow and temperatures are monitored using distributed digital and analog input modular devices via signal interfaces.
1	**03**	**02**	**06**	**12**	Controls - Movable Collimator	This system provides control and monitoring of two-axis beam intercepting blades which can be used as a diagnostic in the LTU front end and further downstream for beam clean-up. Stepper-motors are used for movement which is read back with transducers (LVDT's) for positional information.
1	**03**	**02**	**06**	**13**	Controls - X-Band Accel Structure	System Summary
1	**03**	**02**	**08**		Controls Timing	This system includes the synchronization of pulsed accelerator devices with generating the beam and the acquisition of beam measurements for use in feedback and timing.
1	**03**	**02**	**09**		Controls - Vacuum	This system includes the monitoring and control of gages, pumps, and valves. This system includes interlocks for the protection of the machine during maintenance and against a catastrophic change in pressure.
1	**03**	**02**	**09**	**01**	Interlocks	This system collects and displays the operating state of vacuum system in discrete areas of the accelerator. It uses this information to control beam operation as well as the state of isolation valves and vacuum pump power supplies.
1	**03**	**02**	**09**	**02**	Vacuum Instrumentation & Controls	These are High Voltage power supplies, controlled current, to pump down and maintain design operating pressure in the accelerator.
1	**03**	**02**	**10**		Software & Controls Infrastructure	The controls infrastructure provides the interconnection between various parts of the control system. It performs supervisory function for the control network. It includes the software tolls and applications for the real time programming of the control modules as well as the tools for supporting the database structure.
1	**03**	**02**	**10**	**04**	Data Communications	Gigabit networking has been costed to connect 5 locations to MCC. The locations are: Bldg 406, sector 24, sector 30, support bldg at near end and the end of the LTU. One gigabit switch has been allocated per location except at the end station, where two have been allocated because of the high quantity of cameras at this location. Wireless network access points (to the visitor network) are also included.
1	**03**	**02**	**10**	**05**	Computers	This is actually "Computers and crates". VME crates with Power PC controllers and VxWorks run-time licenses have been costed for all systems. The cables and the modules that go in the crates are distributed across the systems (in the rest of the controls WBS) that use/need them. No workstations have been costed for the Linac controls. We need to add 2 per location still (Linux PCs at $1.2K each).
1	**04**	**02**			Controls	Overall undulator controls task covers all controls issues involved with the LCLS undulator. This includes the costs involved with the entire controls section of the LCLS undulator. It also consists of the specification, design, procurement, assembly and testing of all controls components of the LCLS undulator.
1	**04**	**02**	**01**		Controls Management & Integration	Cost tracking for management issues within the undulator controls section, including controls management and integration with SLAC. Specifically the subsystems which must communicate with the SLAC control system.
1	**04**	**02**	**01**	**03**	Software Interface with SLAC	This is the Cost Center for the software design effort required for high-level control applications which will interface with the SLAC control system. Includes commercial software required for design and implementation of these applications. The high level software is that which the operators and scientists in charge of the LCLS use to interact with the undulators. By necessity, this software must function in a dual control system environment (LCLS and SLAC).

WBS NUMBER					TITLE	DESCRIPTION
1	**04**	**02**	**01**	**04**	General Rack and Cable Layout Plan	This is the Cost Center for the design effort required to generate a plan for the equipment location, layout and distribution within the undulator hall. All components connected via cable to equipment located in racks must be accounted for, and estimates on cable lengths and locations will be made.
1	**04**	**02**	**02**		Motion	This element tracks any controls effort and materials for motion within the LCLS undulator hall. This consists of all controls effort and materials required to control motion based component within the LCLS undulator.
1	**04**	**02**	**02**	**01**	Fine Motion	This element covers effort and materials for the multiple motion platforms that require accurate (with feedback) positioning.
1	**04**	**02**	**02**	**02**	Motion Test Stand	In order to test certain controls aspect of the undulator motion, a test stand will be assembled to evaluate a variety of motion parameters. This cost center will cover the design and procurement of these components.
1	**04**	**02**	**02**	**06**	Scanning WIre Motion	The motion of the scanning wire element is contained within this element. This covers the controls effort and costs involved in the motion of the scanning wire transducer.
1	**04**	**02**	**02**	**07**	Macroscopic Motion	This section is the total center for macroscopic motion controls effort and equipment. Macroscopic motion is defined as any motion requirement that does not need positional feedback for operation. Currently it includes the diagnostic "elevator" and OTR camera controls.
1	**04**	**02**	**03**		Signal Analysis	This element includes all signal analysis done for data acquisition and beam analysis within the LCLS undulator. All signal acquisition hardware and software for signal analysis is included in this element. Effort for data analysis and control is also included.
1	**04**	**02**	**03**	**01**	RFBPM	This element consists of the hardware and software required to interface the RFBPM units to the control system. All hardware and software required for interfacing the RFBPM units to the control system is included within this element. This includes the timing interface, signal acquisition and control software.
1	**04**	**02**	**03**	**02**	Charge Monitor (CM)	This element consists of effort involved in interfacing the charge monitors into the undulator control system. All effort involved in the interfacing of the charge monitor into the undulator control system will be tracked in this element.
1	**04**	**02**	**03**	**03**	Scanning Wire	This covers the integration of the scanning wire transducer into the undulator control system. All effort involved in interfacing the scanning wire transducer into the undulator control system will be tracked in this element.
1	**04**	**02**	**04**		Video	All video requirements for the undulator control system. Any effort or materials required for video signal acquisition, routing and analysis are tracked within this element.
1	**04**	**02**	**04**	**01**	OTR Monitor	All video requirements needed for the OTR Monitor. Any video requirements for use of the OTR diagnostic within the LCLS undulator will be tracked in this element. The OTR diagnostic uses image capture (via video cameras) and data analysis to characterize the beam (size, position, shape) in real time.
1	**04**	**02**	**04**	**03**	Observation Station Video	This element consists of all controls responsibilities for the observation stations. All control effort for the observation video stations will be tracked in this element. Also, the video multiplexing system will be tracked here.
1	**04**	**02**	**05**		Data Acquisition & Control	This element covers the various I/O that is not covered in previous elements but is a part of the control system. In general the costs underneath this section are effort only. If hardware is required, it is typically for reading of discrete signals. This consists of the specification and integration of general signals into the control system.

WBS NUMBER					TITLE	DESCRIPTION
1	**04**	**02**	**05**	**01**	Strongback Temperature Monitoring	Consists of the software required to communicate to the strongback temperature probes. The costs cover the effort involved in interfacing the strongback temperature monitoring equipment to the undulator control system. This consists mainly of effort involved in creating software to talk to the temperature equipment.
1	**04**	**02**	**06**		Vacuum	This is the overall element covering any controls tasks involved in interfacing the vacuum equipment. This is a parent to the other (specific) vacuum controls tasks. It consists of software effort to interface commercial vacuum components.
1	**04**	**02**	**06**	**01**	Ion Pump Controller	Integration of the ion pump controllers into the undulator control system (UCS). The costs cover the software design and effort for integrating the ion pump controllers to be used within the undulator hall. Readback and control of the ion pump controllers via dedicated communications cables.
1	**04**	**02**	**06**	**02**	RGA	Integration of the residual gas analyzer controllers into the undulator control system. The costs cover the software design and effort for integrating the residual gas analyzers to be used within the undulator hall.
1	**04**	**02**	**07**		Machine Protection	All MPS components and effort will fall under this category. The MPS system is responsible for protecting the undulator hall from equipment damage. It must interface to the SLAC injector to cause a beam abort in event of a failure.
1	**04**	**02**	**07**	**01**	Undulator Global MPS	This element covers the design of necessary components and the interface effort for commercial products into the machine protection system. This includes any custom hardware required and the interface effort for equipment.
1	**04**	**02**	**07**	**02**	Cherenkov Detector	All effort and materials devoted to the MPS portion of the Cerenkov detector will be tracked within this element. The Cerenkov detector generates a signal which must be processed to interface to the machine protection system.
1	**04**	**02**	**07**	**03**	Gamma Ray Detector	All effort and materials devoted to the MPS portion of the gamma-ray detector will be tracked within this element. The gamma-ray detector generates a signal which must be processed to interface to the machine protection system.
1	**04**	**02**	**08**		Power Supply Controls	This element covers design of the power supply controls software, documentation, construction of the computer interface, and integration.
1	**05**	**02**			Controls	Controls captures upper-level work required to interface and integrate the LCLS system-wide control systems to the XTOD primitive controls and to provide remote access to the instrumentation in the Front End Enclosure (FEE), the Near Experimental Hall (NEH), the Tunnel, and the Far is one Hall (FEH).
1	**05**	**02**	**02**		Slow Controls	This element covers the development and delivery of an overlying control system for remote access to the slower instrumentation. The slower instrumentation includes valve positions, motor positions, and gas flows and pressures. The planned system will have two servers in the NEH, and one in the FEH and 3 VME crates for interface electronics.
1	**05**	**02**	**03**		Fast Controls	This element covers the development and delivery of an overlying control system for remote access to the faster instrumentation. This is mostly data acquisition and storage of imagery data from the sensors. Resources for this element cover the programming tasks required to select data streams from specific cameras and store them on user accessible disks.
1	**05**	**02**	**04**		Femto Controls	This element covers labor Engineering and parts for interfacing the very fast timing signals from the FEL to the streak camera and pulse length sensors in the commissioning Diagnostics Tank.
1	**06**	**02**			Controls Subsystem	Create protocols, networks, and systems needed for controlling experimental equipment and handling experimental data, and design and create safety interlock systems.

WBS NUMBER					TITLE	DESCRIPTION
1	06	02	01		Cabling	Design, procure, and test the cabling required for the control systems.
1	06	02	01	01	Front End Enclosure Cable	Design, procure, and test the cabling for the Front End Enclosure cabling.
1	06	02	01	02	Near Hall Cable	Design, procure, and test the cabling for the Near Hall cabling.
1	06	02	01	03	Tunnel Cable	Design, procure, and test the cabling for the Tunnel cabling.
1	06	02	01	04	Far Hall Cable	Design, procure, and test the cabling for the Far Hall cabling.
1	06	02	02		Network	Design, procure, and test the hardware and software required for computer network support for LCLS experiments.
1	06	02	03		PC Support	Design, procure, and test the hardware and software needed for experimental station computer systems and associated computer systems used by experimenters at LCLS.
1	06	02	04		Beamline Controls	Design, procure, and test the hardware and software needed to control equipment installed at the experimental stations, including precision motion equipment, sample manipulation and monitoring equipment, and detectors.
1	06	02	05		X-Ray PPS	Design, procure, and test the hardware and software needed for the personnel protection system that will ensure radiological safety for the experimental stations and x-ray beam transport areas (front end enclosure, Near Experimental Hall, x-ray transport Tunnel, and Far Experimental Hall).
1	06	02	05	01	FEE X-Ray PPS	Design, procure, and test the X-Ray PPS for the Front End Enclosure.
1	06	02	05	02	Near Hall X-Ray PPS	Design, procure, and test the X-Ray PPS for the Near Hall.
1	06	02	05	03	Tunnel X-Ray PPS	Design, procure, and test the X-Ray PPS for the Tunnel.
1	06	02	05	04	Far Hall X-Ray PPS	Design, procure, and test the X-Ray PPS for the Far Hall.
1	06	02	06		X-Ray MPS	Design, procure, and test the hardware and software needed for the machine protection system that will minimize the possibility of significant damage to the LCLS source due to accidents in the experimental stations and x-ray beam transport areas (front end enclosure, Near Experimental Hall, x-ray transport Tunnel, and Far Experimental Hall).
1	06	02	06	01	FEE X-Ray MPS	Design, procure, and test the X-Ray MPS for the Front End Enclosure.
1	06	02	06	02	Near Hall X-Ray MPS	Design, procure, and test the X-Ray MPS for the Near Hall.
1	06	02	06	03	Tunnel X-Ray MPS	Design, procure, and test the X-Ray MPS for the Tunnel.
1	06	02	06	04	Far Hall X-Ray MPS	Design, procure, and test the X-Ray MPS for the Far Hall.
1	06	02	07		Laser PPS	Design, procure, and test the hardware and software needed for the personnel protection system that will ensure laser safety in the Near Experimental Hall and Far Experimental Hall.
1	06	02	07	01	Near Hall Laser PPS	Design, procure, and test the Laser PPS for the Near Hall.
1	06	02	07	02	Far Hall Laser PPS	Design, procure, and test the Laser PPS for the Far Hall.
1	06	02	08		User Safeguards	Design, procure, and test the hardware and software needed for the personnel protection system that will guard against experiment-specific hazards in the experimental stations in the Near Experimental Hall and Far Experimental Hall (i.e., special chemical hazards, oxygen deficiency hazards, etc).
1	06	02	08	01	Near Hall User Safeguards	Design, procure, and test the User Safeguards for the Near Hall.
1	06	02	08	02	Far Hall User Safeguards	Design, procure, and test the User Safeguards for the Far Hall.
2	01	01	10		Global Controls Physics Liaison	This WBS provides support for the LCLS Global Controls Physicist through the R&D and commissioning phases of the LCLS. The LCLS Global Controls Physicist is responsible for directing the overall physics controls effort for the LCLS and for providing control system requirements that satisfy the global requirements of the LCLS project.
2	01	01	11		Global Controls (OPC)	This is all non-recurring development for the first instance of each subsystem solution.
2	01	01	11	01	EPCIS Control Modules	All CPUs and VME crates for commissioning.
2	01	01	11	11	Global Controls Commissioning	Support machine commissioning of the control system including: test support, revisions from operational experience, and problem resolution.
2	01	01	11	12	Global Controls Management (OPC)	Management support

WBS NUMBER					TITLE	DESCRIPTION
2	**01**	**01**	**11**	**13**	SLC Aware IOC	Design and implementation of the software to emulate the SLC micro communication inside the EPICS IOC to allow the existing high level applications on SLC to be used for early commissioning and operation.
2	**02**	**02**			Injector Controls Subsystem	System Summary
2	**02**	**02**	**01**		Personnel Protection System (PPS)	This element coves commissioning costs for this system.
2	**02**	**02**	**04**		Power Conv (Beamline pw supp) Spares	This element coves commissioning costs for this system.
2	**04**	**02**			Controls	All controls related spares and OPC. Any spares purchased for controls are tracked underneath this element.
2	**04**	**02**	**01**		Controls Management and Integration	Management and integration tasks associated with spares and OPC. Any management effort associated with control spares and OPC will be tracked within this element.
2	**04**	**02**	**07**		Machine Protection	Controls spares to support the machine protection system of the LCLS undulator. Any spares required for the machine protection system of the undulator will be tracked in this element. This consists of 10% spares for all components.
2	**05**	**02**			Controls	This covers commissioning the control system for the X-Ray Transport system.
2	**05**	**02**	**02**		Slow Controls	This covers the commissioning of the slow controls.
2	**05**	**02**	**03**		Fast Controls	This covers the commissioning of the fast controls.
2	**05**	**02**	**04**		Femto Controls	This covers the commissioning of the Femto controls.
2	**06**	**02**			Controls Subsystem	This element covers the effort associated with commissioning of the Controls.
2	**06**	**02**	**01**		Cabling	This element covers the effort associated with commissioning Cabling in the X-Ray End Station functional area.
2	**06**	**02**	**02**		Network	This element covers the effort associated with commissioning the Network.
2	**06**	**02**	**03**		PC Support	This element covers the effort associated with commissioning PC Support.
2	**06**	**02**	**04**		Beamline Controls	This element covers the effort associated with commissioning Beamline Controls.
2	**06**	**02**	**05**		X-Ray PPS	This element covers the effort associated with commissioning X-Ray PPS in the X-Ray End Station functional area.
2	**06**	**02**	**06**		X-Ray MPS	This element covers the effort associated with commissioning X-Ray MPS in the X-Ray End Station functional area.
2	**06**	**02**	**07**		Laser PPS	This element covers the effort associated with commissioning Laser PPS in the X-Ray End Station functional area.
2	**06**	**02**	**08**		User Safeguards	This element covers the effort associated with commissioning User Safeguards in the X-Ray End Station functional area.