WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	05				X-RAY TRANSPORT & DIAGNOSTICS SYSTEMS	XTOD includes mechanical and vacuum systems for the x-ray beam path, attenuators, x-ray optics and x-ray diagnostics required for manipulation and characterization of the x-ray beam downstream of the undulator. “Manipulation” includes collimation, attenuation, focusing, splitting/delaying, turning, and monochromatizing. “Characterization” includes measurement of x-ray beam properties as necessary for commissioning and operation of the LCLS.
1	05	01			System Management & Integration	This element provides overall management for XTOD.
1	05	01	01		Management	This element provides overall management for XTOD safety, conceptualization, R&D, design, construction, testing, installation, integration, and commissioning.
1	05	01	01	01	XTOD Management - Technical	This covers a full time manager.
1	05	01	01	02	LLNL Project Support	This covers a half time administrator, and funding for programmatic travel to attend weekly staff meetings, recruit project staff prepare monthly reports, prepare reviews, and other required project documentation.
1	05	01	01	03	Commissioning Coordinator	This element provides support to develop a schedule for installation, testing, and commissioning activities for X-Ray Transport. Also, the work must be coordinated with X-Ray Endstations as well as other LCLS subprojects.
1	05	03			Mechanical & Vacuum Subsystem	Design pumps, pipes and stands for interconnecting the experimental tanks in the FEE, Near Hall, Tunnel and Far Hall.
1	05	03	01		Mechanical / Vacuum Systems Engineering	This covers the management for the Mechanical and Vacuum work.
1	05	03	02		Mech/Vac Front End	This covers the mechanical and vacuum specification, design, and procurement for the FEE.
1	05	03	03		Mech/Vac Near Hall	This covers the mechanical and vacuum specification, design, and procurement for the Near Hall.
1	05	03	03	01	Mech/Vac Near Hall	This covers the mechanical and vacuum specification, design, and procurement for the Near Hall.
1	05	03	04		Mech/Vac Tunnel	This covers the mechanical and vacuum specification, design, and procurement for the Tunnel.
1	05	03	05		Mech/Vac Far Hall	This covers the mechanical and vacuum specification, design, and procurement for the Far Hall.
1	05	04			Optical Subsystem	All elements used to manipulate the X-Ray beam.
1	05	04	02		Facility Optics	This WBS element will provide specification, design, procurement, install and testing for the fixed masks, the slits and collimators, the flipper mirror, the gas attenuator, and the solid attenuator.
1	05	04	02	01	Fast Valve	This WBS element supports the design, procurement, fabrication, assembly, testing, and shipping, of the Fast Valve, its sensor and its controller. The Fast Valve is located in the electron beam dump area and the sensor is located in the FEE.
1	05	04	02	02	Fixed Mask	The 3 Fixed Masks insure that all radiation allowed downstream is confined to within a very small angular region. The masks are cm thick blocks of hi-z material with a TBD (~4 mm) clear aperture in the center.
1	05	04	02	03	Slit/Collimators	Slit consists of a two movable jaws defining an adjustable horizontal aperture, and two movable jaws defining an adjustable vertical aperture. The purpose of the slit is to allow the users to remove the halo of spontaneous radiation surrounding the FEL. The jaws are thick blocks of heavy metal, capped with B4C. This prevents the jaws from being damaged when inadvertently struck by the FEL.
1	05	04	02	05	Gas/Solid Attenuator	This element is both the solid and gas attenuators. The gas attenuator is a 10 m long section of pipe filled with gas whose purpose is to attenuate the FEL beam especially at low photon energies. The gases under consideration are N2 and Ar at pressures up to 60 Torr. The gas attenuator must be windowless because of damage and absorption issues with the FEL beam. This means that gas will leak into the beam pipe and must be differentially pumped.
1	05	04	02	05	Gas/Solid Attenuator (Cont.)	The solid attenuators reside in one of the gas attenuator cells. The attenuators are mounted on a series of windows inside the tank allowing various combinations of attenuators to be selected. The attenuators will be made of low-Z Be in thicknesses raging from 100 microns to 5 cm. Their use is limited to photon energies above 2 KeV.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	05	04	02	06	TTF Damage Experiment	This WBS element covers the planning, procurement, running, analysis, and documentation of a series of measurements at the TTF VUVFEL facility. The purpose of these measurements is to measure damage thresholds of materials used at the LCLS under the conditions of high brightness and short times.
1	05	04	02	07	FEL Offset Mirrors	This WBS element covers the specification, design and procurement of FEL Offset Mirrors located in the Front End Enclosure. This purpose of this device is to filter the spontaneous energy.
1	05	05			Diagnostics Subsystem	Provide diagnostics to characterize and measure beam performance for the users and the facility.
1	05	05	02		Modeling & Simulation	Develop Monte Carlo and Wave based numerical models of the LCLS FEL and spontaneous radiation for use indesign and specification of the diagnostics.
1	05	05	02	01	Wave Model	This element covers the development and execution of programs modeling the wave properties of the diagnostics and optical elements.
1	05	05	02	02	Monte Carlo Model	This element covers the development and execution of Monte Carlo simulations of the x-ray interactions within the diagnostics and optical elements.
1	05	05	02	03	Beam Simulation	This WBS covers the development of computer codes to simulate the expected levels of FEL and spontanious beams. Both monte-carlo and wave models will be developed and applied to each instrument.
1	05	05	03		Facility Diagnostics	This WBS element will provide specification, design, procurement, prototype, install and testing for the Direct Imager, Indirect Imager, Pulsed Ion Chamber, Gas Mixing System, FEE Diagnostic Tanks, Ion Pump Diagnostic Tanks.
1	05	05	03	01	Direct Imager	The Direct Imager is an insertable, high-resolution scintillator viewed by a CCD camera for measuring spatial distributions and for alignment and focusing of optical elements. The imager utilizes a thin crystal of LSO or YAG to convert x-rays into visible photons and will be damaged by the full FEL.
1	05	05	03	02	Indirect Imager	The Indirect Imager overcomes the FEL damage problems of the Direct Imager by utilizing selectable multi-layer mirrors to act as a beam splitter to partially reflect a portion of the beam onto the scintillator imaging camera which remains out of the beam. The reflected intensity can be adjusted by changing the angle of incidence. The imager creates a spectral slice of the beam over a limited bandwidth and will be use to perform monochromatic measurements of the attenuator performance.
1	05	05	03	06	Gas Detector	These are smaller tanks, which are ion pumped to hold diagnostics in the FEE. Specification, design and procurement for the Ion Chamber and the tank located in the Front End Enclosure.
1	05	05	03	07	NEH Imager	This WBS element supports the design, procurement, fabrication, assembly, testing, and shipping of the NEH Imager System, which is located in the NEH to provide measurements and characterization of the beam in the NEH.
1	05	05	03	08	FEH Imager	This WBS element supports the design, procurement, fabrication, assembly, testing, and shipping of the FEH Imager System, which is located in the FEH to provide measurements and characterization of the beam in the FEH for the CD4 milestone.
1	05	05	04		Commissioning Diagnostics	This WBS element will provide specification, design, procurement, prototype, install and testing for the Commissioning Diagnostic Tank, Total Energy Measurement, Spectral Measurement, Spatial Coherence, Spatial Shape & Centroid Measurement, and the Divergence Measurement.
1	05	05	04	01	Commission Diagnostic Tanks	This tank is a 2 m x 1 m stainless steel tank and vacuum system housing the commissioning diagnostics and associated rails and stages for positioning them. One tank for the NEH and one tank for the FEH
1	05	05	04	02	Total Energy Measurement	This calorimeter is a small volume x-ray absorber (probably Be), which absorbs all of the x-ray energy resulting in a rapid temperature rise that may be used to infer the intensity of the FEL pulse. The heat capacity and mass of the absorber determine the temperature rise.
1	05	05	04	04	Low Energy Spectral Measurement System	The commissioning diagnostic tank is converted into a spectrometer by adding a crystal at 8 keV or a grating at 0.8 keV. In either case the optic disperses the radiation onto an x-ray sensitive region of a fast readout position-sensitive detector.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
1	05	05	04	05	Popup Cameras	This WBS element supports the design, procurement, fabrication, assembly, testing, and shipping of the Popup Alignment System. The Popup Alignment System is a series of stations consisting of cameras viewing scintillators that normally are not in the beam path but when required can be inserted into the beam path, one at a time. The Popup camera systems are not radiometrically calibrated but instead are located at various positions before, after, and between the mirrors of the FEL offset systems to provide information on the position of the main and reflected beams. This information will be used during commissioning to align the FEL offset systems.
1	05	05	04	06	K Measurement System	This WBS element supports the design, procurement, fabrication, assembly, testing, and shipping of the K Measurement System excluding the channel cut crystal optical elements which are supported through WBS element 1.6.?.? Crystals and Gratings. which is located in the FEE. The K Measurement System is housed in the spectrometer tank located in the FEE and contains optical elements that can be inserted into the LCLS beam to disperse the radiation for the purposes of determining its spectral content when the dispersed radiation is imaged by the camera systems downstream.
1	05	06			X-Ray Transport System Installation & Alignment	This covers the mechanical and vacuum installation for the Front End Enclosure, Near Hall, Tunnel and Far Hall areas in the X-Ray Transport system.
1	05	06	01		Front End Enclosure Install	This covers the mechanical and vacuum installation for the FEE.
1	05	06	02		Near Hall Install	This covers the mechanical and vacuum installation for the NEH.
1	05	06	03		Tunnel Install	This covers the mechanical and vacuum installation for the Tunnel.
1	05	06	04		Far Hall Install	This covers the mechanical and vacuum installation for the FEH.
1	05	06	05		Electron Dump Enclosure Install	This covers the mechanical and vacuum installation for the EDE.
2	05				X-RAY TRANSPORT & DIAGNOSTICS SYSTEMS (OPC)	OPC Summary for the S-Ray Transport, Optics and Diagnostics System. It includes effort and costs associated with R&D, Spares, and Commissioning.
2	05	01			System Management & Integration	This summary element covers the management and integration for the X-Ray Transport system.
2	05	01	01		Management	This WBS element covers the management of R&D issues associated with component design and layout at the conceptual level. It also covers the commissioning team that brings up the Diagnostics systems.
2	05	02			Controls	This covers commissioning the control system for the X-Ray Transport system.
2	05	02	01		Controls - EPICS	This covers the commissioning of the EPICS controls.
2	05	02	02		Controls - System	This covers the commissioning of the remaining controls.
2	05	03			Mechanical & Vacuum Subsystem	This summary element covers commissioning the mechanical and vacuum for the X-Ray Transport system.
2	05	03	02		Mech/Vac Front End	This WBS element covers the commissioning of the mechanical and vacuum systems in the Front End Enclosure.
2	05	03	03		Mech/Vac Near Hall	This WBS element covers the commissioning of the mechanical and vacuum systems in the near Hall.
2	05	03	04		Mech/Vac Tunnel	This WBS element covers the commissioning of the mechanical and vacuum systems in the x-ray transport tunnel.
2	05	03	05		Mech/Vac Far Hall	This WBS element covers the commissioning of the mechanical and vacuum systems in the Far Hall.
2	05	04			Optical Subsystem	This summary element covers the optics commissioning for the X-Ray Transport system.
2	05	04	01		Optical Systems Engineering	This WBS element covers R&D into FEL induced damage of the optical and Diagnostics systems.
2	05	04	02		Facility Optics	This WBS element covers the commissioning of the slits, solid attenuator, fixed masks, flipper mirror, and the gas attenuator.
2	05	04	03		End Station Optics	This provides the optics for the Endstation system.
2	05	04	04		Crystals & Gratings	This WBS element covers the commissioning of the pulse split delay system, and the monochromator.
2	05	05			Diagnostics Subsystem	This summary element covers the diagnostics commissioning for the X-Ray Transport system.
2	05	05	02		Modeling & Simulation	This WBS element covers R&D aimed at the development of practical simulations of the LCLS beam for use in developing Diagnostics and optics.

WBS NUMBER					TITLE	DESCRIPTION
1	2	3	4	5		
2	05	05	03		Facility Diagnostics	This WBS element covers R&D aimed at the development of practical simulations of the LCLS beam for use in developing Diagnostics and optics. It also has spare parts for diagnostic equipment likely to be damaged by the FEL.
2	05	05	04		Commissioning Diagnostics	This WBS element covers R&D aimed at the development of the commissioning Diagnostics.