WBS	WBS Name	WBS Definition	WBS Level
1	SoLID Project	SoLID base equipment, including a solenoidal magnet, , EM calorimeter (including showere, preshower and SPD), light gas cherenkov, heavy gas cherenkov, DAQ system (including	1
1.1	Engineering, Design & Procedures	Project engineering, design and procedures	2
1.1.1	**EM Calorimeter (EM)**	This section includes EM calorimeter (Shower and Preshower), and Scintillator Pad Detectors	3
1.1.1.1	Shower, Preshower and SPD modules	Detailed design of shower, preshower, and SPD modules, with a focus on feasibility of mounting onto the module frame and integrating into SoLID, rouning of WLS and clear	4
1.1.1.2	Preshower and SPD module frame	Design of Preshower and SPD module frames, including holding the preshower lead sheets	4
1.1.1.3	Shower module frames	Design of Shower (shashlyk) module frames	4
1.1.1.4	PMT base design	Design of all PMT and MAPMT bases with pre-amps, prototyping and testing	4
1.1.2	**Light Gas Cherenkov (LGC)**		3
1.1.2.1	Adjustable Mirror System	The primary mirror set will rotate about an inner joint when changing experimental configurations to configure the optics for different target-z locations. This system needs to	4
1.1.2.2	Tank and plumbing	The overall tank design requires a closed gas-tight pressure vessel. The design of the pump-and-dump gas system and how it integrates with the larger vessel will be coverd in this	4
1.1.2.3	Support and mounting	The tank will need to support it's own weight as well as the weight of the individual components. The support structures will need to affix to the mount points on the backside	4
1.1.3	**Heavy Gas Cherenkov (HGC)**	The design of HGC	3
1.1.3.1	Tank and front thin window	The thin window needs to be designed with the lesser of 90% yield or 50 Ultimate strength (Note: 50% Ult will govern for aluminum). The thin window needs to be tested to 2X operational (design) pressure to qualify design and material batch. The tank needs to be designed to a safety factor of 3 using engineering analysis. The tank	4
1.1.3.2	Magnetic Shielding and reflection cone	The design of magnetic shielding and reflection cone needs to reach the goal of shielding with	4
1.1.3.3	Gas System	The gas system design will follow the existing JLab experience with heavy gas systems to fill,	4
1.1.3.4	Sum Readout	The sum readout includes both a set of electronic board to read out photonsensor (MAPMT) signal and the mechanic support to make the readout assembly to be mounted in the magnetic shielding and reflection cone. The design of summing board will depend on	4
1.1.4	**GEM**		3
1.1.4.1	GEM Modules	a cathode foil.	4
1.1.4.1.1	GEM Module component design	the specification of SoLID tracking. The CAD design of GEM foils holding frames and overall assembly design of GEM modules	5
1.1.4.2	**GEM Readout**	The desgin of the electronics for reading out the GEM detectors meeting the high rate operation requirements and radiation hardness needs specified in the SoLID CDR.	4
1.1.4.2.1	VMM electronics design	readout boards to match the requirements of SoLID.	5
1.1.4.5	**GEM mechanical support**	The desgin of the mechanical supports system for the SoLID GEM tracker consisting support w	4
1.1.4.5.1	GEM mechanical support wheels design	The engineering design of the mechanical support wheels to hold the GEM modules, and associated components such as electronics, cables and gas lines, inside the SoLID magnet.	5
1.1.4.6	Transport and travel	technical staff. The transport and travel costs include trips to CERN to work on the GEM components design.	4
1.1.4.7	Management	Overall management and supervision of the GEM module and electronics engineering design.	4
1.1.5	**DAQ/Electronics/Controls design**		3
1.1.5.1	**DAQ/Electronics design**		4
1.1.5.1.1	FADC specification	Document for specifications of Flash ADCs for SoLID	5
1.1.5.1.2	Crate and support module design	Specifications for electronics including crates, trigger module and CODA specific modules	5
1.1.5.1.3	GEM Readout specification	Specifications for GEM readout electronics and algorithm for data reduction on SSP and VTP	5
1.1.5.1.4	FADC VXS readout design	Specifications and design of fast readout of FADC using the VXS backplane	5
1.1.5.1.5	Calorimeter trigger design	Design of ECAL clustering trigger with FADC	5
1.1.5.1.6	Cherenkov readout design	Design of Cerenkov readout with FADC	5
1.1.5.1.7	PVDIS trigger design	Design of PVDIS trigger : coincidence between ECAL and LGC	5
1.1.5.1.8	SIDIS trigger design	Design of SIDIS trigger : coincidence between electron and hadron trigger	5
1.1.5.2	**Detector Power and Cabling**		4
1.1.5.2.1	HV and LV Power supply specification	Specification of LV and HV supplies	5
1.1.5.2.2	HV and LV cable/patch design	Design for patch panel and cabling for HV and LV	5
1.1.5.2.3	Signal cable/patch design	Design for patch panel and cabling signals	5
1.1.5.3	**Slow Controls**		4
1.1.5.3.1	Slow Controls specification	Specifications of slow controls	5
1.1.5.4	**Electronics Shielding**		4
1.1.5.4.1	Shielding design	Design of shielding bunker to hold DAQ and slow controls electronics in hall	5
1.1.6	**Magnet**	Design requirements for retrofitting the CLEO II solenoid magnet for the SoLID experiments	3
1.1.6.1	**Magnet Steel**	Design of new magnet steel pieces and modification of existing pieces for SoLID configuration	g
1.1.6.1.1	Yoke	Design and engineer modifications to existing yoke pieces.	5
1.1.6.1.2	Upstream Endcap	Design and engineer modifications to existing upstream coil collar and new adjustable	5
1.1.6.1.3	Downstream Endcap	Design and engineer new cylindrical shell and back plates to include drawing packages ready	5
1.1.6.1.4	Nose Extension	for procurement.	5
1.1.6.1.5	Downstream Coil Collar	Design new downstream coil collar	5
1.1.6.2	**Support and Alignment**	Design of magnet and endcap supports and motion system for endcap	4
1.1.6.2.1	Magnet Support and Vertical Alignment System	Design new magnet support & vertical alignment system	5
1.1.6.2.2	Endcap Support and Motion System	Design endcap support and motion system	5
1.1.6.3	**Control**	Integration of magnet controls with Hall A and accelerator control systems.	4
1.1.6.4	**Power Supply**	Specify power supply for SoLID solenoid	4
1.1.6.5	**Cryogenic**	Integration of magnet cryo system with existing hall cryo infrastructure.	4
1.1.6.6	**Magnet Testing**	Full magnet systems checkout after final assembly.	4
1.1.7	**Infrastructure and Support Structure**		3
1.1.7.1	**Detector Support**	Design of detector support systems in the magnet and endcap to include installation of	4
1.1.7.1.1	Magnet Detector Support	Design internal detector support system for magnet	5
1.1.7.1.2	Endcap Detector Support	Design internal detector support system for endcap	5
1.1.7.1.3	Detector Support Integration	Integration of individual detectors into support system	5
1.1.7.1.4	Detector Installation Fixtures	Design detector installation fixtures	5

1.1.7.2	**Baffles**	Baffle system for PVDIS including baffle layers and internal support frame	4
1.1.7.2.1	Baffle Layers	Design of baffle layers and finish machining requirements.	5
1.1.7.2.2	Baffle Support System	Design and engineering of the baffle mounting system that will integrate into detector	5
1.1.7.3	**Access**	Design of all personnel access for SoLID	5
1.1.7.3.1	Magnet Personnel Access	Design personnel access platform for cyro/controls on top of magnet	5
1.1.7.3.2	Endcap Personnel Access	Design personnel access system for endcap detectors	5
1.1.7.4	**Power**	Power utilities design.	4
1.1.7.5	**Beamline**	Design and engineering of new or modified beamline components for all SoLID experimental	4
1.1.7.6	**Hall A Modifications**	Planning for Hall A modifications to facilitate SoLID installation	4
1.1.7.6.1	Ramp	Planning for cryostat transit into the hall to include design of low ground clearance cryostat transport frame or modifications to the existing frame. Also includes planning for largest	5
1.1.7.6.2	Hall	Planning labor for modifications and preparations of Hall A for the installation and operation	5
1.1.7.7	**Layout**	Design and engineering labor to provide experimental configuration data.	4
1.1.7.8	**Assembly/Installation**	Labor for installation and assembly planning.	4
1.2	Construction	Project Construction, including initial testing and commissioning	2
1.2.1	**EM Calorimeter (EM)**	EM Calorimeter and Scintillator Pad Detectors (SPDs) modules construction, testing, and	3
1.2.1.1	**Shower**	1800 Shower modules based on Shashlyk design	4
1.2.1.1.1	scintillators shower	Procure scintillator sheets needed for constructing Shower modules, 200 sheets per module	5
1.2.1.1.2	lead sheets	Procure lead sheets needed for constructing Shower modules, 200 sheets per module	5
1.2.1.1.2	reflective layer	Procure reflective layers needed for constructing Shower modules, 400 units per module	5
1.2.1.1.4	aluminum end plates	Aluminum front and back end plates for Shower modules, one pair per module	5
1.2.1.1.5	stainless steel rods	Procure rods needed to assemble the shower modules, six rods per module	5
1.2.1.1.6	assembling stands	Ten assembling stands needed to assemble and compress the Shower modules	5
1.2.1.1.7	fiber handling	Cut and polish WLS fibers, insertion into the Shower module, and coat one fiber end with	5
1.2.1.1.8	silver painting (fiber end reflection coating)	Procure reflective painting needed to coat the fiber ends	5
1.2.1.1.9	shower and preshower module assembling	To assemble parts into Preshower and Shower modules	5
1.2.1.1.10	Shower and preshower module initial testing	Cosmic ray test of all Shower and preshower modules once assembled, but before transporting to JLab. All modules need a fast (horizontal) test, a fraction of modules will go	5
1.2.1.2	**Pre-Shower**	1800 Preshower modules	4
1.2.1.2.1	scintillators preshower	Procure preshower scintillators	5
1.2.1.2.2	preshower lead sheet	Procure 2 radiation length thick lead sheets to place in front of the preshower	5
1.2.1.3	**Scintillator Pedal Detector (SPD)**	Materials will be procured from vendor(s), for module assembling and testing please see	4
1.2.1.3.1	LASPD and light guide	Procure 60 Large-Angle SPD modules and the coupling light guide	5
1.2.1.3.2	FASPD	Procure 240 Forward-Angle SPD modules (in groups of 4, 60 groups)	5
1.2.1.4	**Fibers**	All fibers and associated items needed for Preshower, Shower, and SPD modules.	4
1.2.1.4.1	Wave-length-shifting (WLS) Fiber	Procure 1mm diameter WLS fibers for Shower, Preshower, and FASPD modules	5
1.2.1.4.2	Clear Fiber	Procure 1mm diameter clear fibers for connecting all WLS fiber signals to PMTs	5
1.2.1.4.3	WLS to clear fiber connectors	Procure fiber connectors to connect WLS to clear fibers	
1.2.1.4.4	Fiber to PMT connectors	in-house made connectors to hold clear fibers to PMT or MAPMT	
1.2.1.4.5	LEDs for monitoring	LED monitoring system for ECal and SPDs	5
1.2.1.5	**PMTs**	All PMT needs for ECal and SPDs	4
1.2.1.5.1	Shower PMTs	Procure PMTs with mu-metal shielding. With in-house made pre-amps/base.	5
1.2.1.5.2	Pre-shower MAPMTs	Procure multi-anode PMTs for Preshower readout. With in-house made pre-amps/base	5
1.2.1.5.3	FASPD MAPMTs	Procure multi-anode PMTs for FA SPD readout. With in-house made pre-amps/base	5
1.2.1.5.4	LASPD fine-mesh PMTs	Procure fine-mesh PMTs assembly for LA SPD readout	5
1.2.1.5.5	PMT base	Production of in-house designed bases for Shower, Preshower and FASPD PMTs	5
1.2.1.6	**Assembling/Testing**	Testing EMCal Shower and Preshower modules; Assembling and Testing SPD modules	4
1.2.1.6.1	Testing Shower and preshower upon receiving at JLab	Upon receiving shower and preshower modules from the vendor, test each module at JLab	5
1.2.1.6.2	Assembling and testing SPD modules	Upon receiving LASPD and FASPD parts from the vendor, assemble fibers into FASPD. Wrap	5
1.2.1.7	**Support Structure**	EMCal and SPD module frames to mount all modules and to integrate with the SoLID support	4
1.2.1.7.1	FAEC module frame	Structure for mounting all Forward Angle Shower modules into supermodules and/or a	5
1.2.1.7.2	LAEC module frame	Structure for mounting all Large Angle Shower modules into supermodules and/or a	5
1.2.1.7.3	FASPD module frame	Structure for mounting all Forward Angle SPD modules onto a mounting frame, to be	5
1.2.1.7.4	LASPD module frame	Structure for mounting all Large Angle Preshower modules onto a mounting frame, to be	5
1.2.1.7.5	FA Preshower module frame	Structure for mounting all Forward Angle Preshower modules into supermodules and/or a	5
1.2.1.7.6	LA Preshower module frame	Structure for mounting all Large Angle Preshower modules into supermodules and/or a	5
1.2.1.7.7	assembling EC and SPD modules to module frames	To mount all detector modules onto respective module frames	5
1.2.1.8	**Transport**	Shipping of all Preshower and Shower modules from the vendor(s) to JLab	4
1.2.2	Light Gas Cherenkov (LGC)	The general design of the LGC optimizes efficiencies for detecting electrons for the SIDIS,	3
1.2.2.1	Tank and Support	The LGC tank is designed to operate at "just-over" atmospheric pressure, and house all components of the detector. The tank will be mounted to the back of the Solenoidal magnet. A separate port for each photosensor array on the outer radius of the tank will allow access to the PMTs and housed electronics. Six support frame "spokes" will provide internal support and provide mounting support for the mirrors. These supports are designed to minimally	4
1.2.2.1.1	Gas System	The LGC gas system will be a simple "pump-and-dump" style assembly. The design includes the initial Nitrogen gas, plumbing, gaskets, electronic valves and controllers, and readback.	5
1.2.2.1.2	Windows/Frame/Support	The tank frame and support pieces will be machined from aluminum. The windows will be PVF (Tedlar) of 0.05 mm and 0.1 mm thickness for the front and back windows respectively.	5
1.2.2.1.3	Integration/Assembly	The tank will house the mirrors and photosesnsor arrays. Integration of the precision frame assembly, precision mirror, and photosensor array installation is necessary. Additional	5
1.2.2.2	Mirrors	A total of 30 sectors (5 per tank "section") will house 2 spherical mirrors each, bringing the total mirror count to 60. A >80% mirror reflectivity down to 200 nm is a requirement of the	4
1.2.2.2.1	Mirror Blanks	The mirrors spherical mirror segmnets will be crafted to minimize areal density while	5
1.2.2.2.2	Mirror Coating	The mirror coating will be accomplished by purchasing pre-coated flexible reflective film and	5
1.2.2.2.3	Mirror Assembly	Mirrors will need to have the reflective film applied with adhesive to the mirror blanks under	5
1.2.2.3	Photosensor Detector Array	One photosensor array exists for each mirror section of the detector (30 total). Each PMT array will consist of 9 PMTs arranged in a square, housed in an assembly that includes a	4

1.2.2.3.1	Photosensors	Each photosensor array will need to cover a circular detection area with a radius of 7.5cm, defined by the optics of the detector and the focosing area of the reflective cone. A sensitive	5
1.2.2.3.2	Photosensor Coating	The photosensors will be coated with the wave-length shifting chemical p-Terphyl to increase	5
1.2.2.3.3	Summing Electronics	Many photosensors provide a multichannel pixel readout, but the trigger level electronics require one summed signal per photosensor. The summing electronics are designed at Jlab	5
1.2.2.3.4	Mu-Metal Shielding	PMT photosensors will require magnetic shielding to maintaining good efficiency. Each shield is a simple cylinder constructed of mu-metal that is designed to slide over a square photosensor array of required detection size. Non-PMT photosensors may require less or no	5
1.2.2.3.5	Reflective Cones	For reflections near the edges of mirrors, reflective cones are required to maintaining photon collection efficiency. These cones are machined from aluminum and coated with reflective	5
1.2.2.3.6	Array Assembly	The reflective film must be applied to the cones. The reflective cone, photosensors, magnetic shielding and summing electronics must be assembled into a single unit which is the secured	5
1.2.2.4	Transport, Travel, and Testing	Additional support for transport, travel, and testing is listed here.	4
1.2.2.4.1	Transport	The tank will be assembled locally and specially shipped to Jefferson lab in an effort to	5
1.2.2.4.2	Travel	Travel for prototyping, on-site testing, and various collaborative efforts with staff scientists	5
1.2.2.4.3	Testing	Testing of procured and assembled components and materials to verify that construction is within design tolerances will be crucial at every stage of the total construction. Each and	5
1.2.3	**Heavy Gas Cherenkov (HGC)**	The construction, testing and instllation of HGC	3
1.2.3.1	Tank and front thin window	The tank with front thin windows encompasses all components of the detector and will be mounted from the outer radius to the rail system in the endcap. The tank has 30 identical sectors and each sector includes a mirror, magnetic shielding and light collection cone, and photosensor array. Every 3 sectors form a super sector with one front thin window and one back window. Each supersector will be constructed separately. 5 super sectors will be	4
1.2.3.2	**Mirrors**	mirrors to focus Cerenkov light onto photosensors	4
1.2.3.2.1	Mirror Blanks	mirror blanks will use the same ones LGC uses.	5
1.2.3.2.2	Mirror Coating	mirror coating will use the same coating LGC uses.	5
1.2.3.2.3	Mirror Assembly	mirror assembly will be similar to how LGC mirrors assembly except HGC has only one mirror	5
1.2.3.3	**Magnetic Shielding and reflection cone**	a combined structure to collect light and shield magnetic field around photosensor array	4
1.2.3.3.1	Magnetic Shielding	shielding cone made with layers of low carbon iron and mu-metal	5
1.2.3.3.2	Reflection cone	reflection layer such as coated reflective film and is attached to shielding layer	5
1.2.3.4	**Photon sensors and Coating**	photosensors with WLS coating	4
1.2.3.4.1	Photon sensors	photosensors (64 channel multi-anode PMTs with 2" square shape), the same ones LGC uses	5
1.2.3.4.2	Photon sensor coating	the photosensors will be coated with the wave-length shifting chemical such as p-Terphenyl to increase the detection efficiency of photoelectrons in the UV range. It will use the same	5
1.2.3.5	**Gas and Gas System**	heavy gas and its gas system	4
1.2.3.5.1	Gas System	gas system for filling, recovery and purification	5
1.2.3.5.2	Gas for Testing, Commissioning and Initial Operation	Cherenkov gas medium to meet the requirement for pion detection. If C4F8 is used, for an entire volume of 20m3 at 1.7atm, 2000kg is needed for testing, commissioning and initial	5
1.2.3.6	Sum Readout	The summing electronics to integrate analog signal from pixels of MAPMT into a total sum signal. It would share similar design that LGC uses, except it is not needed for trigger. The mechenic support for photosensors assembly and short cables are included in the cost also.	4
1.2.3.7	Testing and Installation	test individual components like mirrors, magnetic shielding and reflection cones, MAPMTs and readout as soon as they are made available. Once the tank is finished and shiped to JLab, install and align all optical components to verify that construction is within design	4
1.2.4	GEM	The fabriation, testing and instllation of the Gas Electron Multiplier (GEM) tracker for SoLID	3
1.2.4.1	GEM Modules	An individual GEM detector unit consisting of 3 GEM foils, a readout layer and a cathode foil.	4
1.2.4.1.1	GEM foils	A GEM (Gas Electron Multiplier) foil has small holes (on a scale of 100 µm), etched in a	5
1.2.4.1.2	GEM readout planes	A GEM readout foil is a 2-dimensional readout strip structure with a readout strip pitch of 400 microns or 600 microns. The readout foil is located after the 3 GEM foils in the GEM	5
1.2.4.1.2	GEM cathode foils	The GEM cathode foil is located before the 3 GEM foils in the module. It is a Kapton foil with	5
1.2.4.1.4	GEM module frames	The GEM module frames hold the different foils in a GEM module; they also have built in spacer grids to keep the foils from touching each other under electrostatic forces. The foils	5
1.2.4.1.5	GEM module supplies	The supplies for GEM module construction include specialized epoxy glue, specialized	5
1.2.4.1.6	GEM module tooling	The especially designed tooling needed for GEM modules construction include GEM foil stretchers with tension monitoring, GEM foil testing setup, GEM module assembly jigs etc.	5
1.2.4.1.7	GEM module assembly	The GEM module assembly includes testing and validation of all components, ultra-sonic cleaning and varnish coating of frames, stretching and gluing of foils on to frames, gluing together stretched frames on the assembly jig to form the module, gas sealing of the module,	5
1.2.4.2	GEM Readout	GEM readout system is used for reading out the signals from the individual GEM channels, amplifying and digitizing the signals and then transmit this information to the DAQ system for each event. The SoLID GEM tracker requires 200 k readout channels. The plan presented	4
1.2.4.2.1	VMM electronics channels	VMM is a new readout chip from BNL. The use of VMM based readout for SoLID will require	5
1.2.4.2.2	VMM electronics cables	The readout cables or optical fibers are used to connect the front end readout card located on the GEM modules to the DAQ system located outside the SoLID magnet.	5
1.2.4.3	GEM high voltage	Ultra low noise, fast trip high voltage power supplies for the GEM modules. Each of the 150 GEM moudles is powered by a single high voltage channel through a voltage divider.	4
1.2.4.3.1	HV power supplies	The current CERN-Uva GEM design requires high voltage power supplies delivering at least 1 mA at 4500 V per channel. The power supply modules will be located in a high voltage main-	5
1.2.4.3.2	HV power cabling	High voltage cables and connectors to connect the GEM detectors to the high voltage	5
1.2.4.4	GEM gas system	The gas system supplies the Argon and CO2 gas mixture needed for the operation of the GEM modules. The plan presented here assumes the existence of a gas system with the required	4
1.2.4.4.1	GEM Gas plumbing	Gas tubing, manifolds, connectors and flow meters to connect the existing gas system to the	5
1.2.4.5	GEM mechanical support	The mechanical support structure to hold the GEM modules in place in the SoLID	4
1.2.4.5.1	GEM mechanical support wheels	The mechanical support system will include 5 (6) GEM support wheels for the PVDIS (SIDIS)	5
1.2.4.6	Transport and travel	Includes GEM module transportation from Uva to Jefferson lab, travel to CERN for GEM foil design, travel and stay at Jefferson lab for the installation and testing of GEMs.	4
1.2.4.7	Installation and Testing	Includes the testing of the individual GEM modules, installation of GEM modules in the support structure, installation of the readout system, and testing of the assembled GEM	4

1.2.4.8	Management	Overall management and supervision of the GEM module design, manufacture and	4
1.2.5	**DAQ/Electronics/Controls**		3
1.2.5.1	**DAQ Electronics**		4
1.2.5.1.1	FADC	Flash ADC Trigger and readout electronics	5
1.2.5.1.2	Crates and DAQ support modules	VME Crates and VME DAQ support modules - VTP, SSP, CPUs, ...	5
1.2.5.1.3	FADC VXS readout	Fast readout of the FADC using the unused VXS line from backplane. Needed for PVDIS to	5
1.2.5.1.4	GEM Readout	VTP and SSP firmware for GEM background suppession and GEM readout computer	5
1.2.5.1.5	Calorimeter trigger	Reuse HPS trigger scheme as base for 6+1 calorimeter trigger, include transfer of adjacent	5
1.2.5.1.6	Cherenkov readout and trigger	Readout of FADC for Cherenkov, transfer of blocks at interface, trigger on digital sum of 9	5
1.2.5.1.7	PVDIS trigger	Coincidence between ECAL and Light Gas Cherenkov	5
1.2.5.1.8	SIDIS trigger	Coincidence between ECAL and Light Gas Cherenkov and pion trigger (SPD + ECAL (+MRPC if	5
1.2.5.2	Detector Power and cabling	Power supplies for detector and front end. Cabling for high voltage, low voltage and signals.	3
1.2.5.2.1	High and Low voltage power supplies	High voltage for photomultiplier bases. Low voltage for active component Crenkov summing and ECAL active bases. LV power supplies needed for Cerenkov summing circuit and ECAL amplified bases. Power was evaluated to be 10 mA at 10V of base current plus 1 mA per MHz of rate in Cerenkov. 60 summing circuits are needed giving about 9 W of power. For ECal is	4
1.2.5.2.2	High and Low voltage cabling and patch panels	Procurement of new cabling and patch panels for 682 HV channels and modification of existing cabling and patch panels for 2000 channels. Cabling for low voltage supplies.	5
1.2.5.2.3	Signal Cables and Patch Panels	Signal cables for detectors	5
1.2.5.3	**Slow Controls**		4
1.2.5.3.1	Slow controls IOCs and host	EPICS Input Output Controllers and host computer for GUI display.	5
1.2.5.3.2	Slow controls programming	Slow controls software and graphical interface. For control and monitoring of HV, LV, gas systems, and detector environment. Includes general purpose input output controlers and a	5
1.2.5.4	**Setup and Testing**	Cables connecting Cherenkov, ECAL, SPD PMTs to readout cards, including patch panels.	4
1.2.5.4.1	HV cables and patches	Installation and testing of HV cables and patches	
1.2.5.4.2	Ecal	Cabling to DAQ and testing with pulser and cosmics	5
1.2.5.4.3	SPD	Cabling to DAQ and testing with pulser and cosmics	5
1.2.5.4.4	Light Gas Cerenkov	Cabling to DAQ and testing with pulser and cosmics	5
1.2.5.4.5	Heavy Gas Cerenkov	Cabling to DAQ and testing with pulser and cosmics	5
1.2.5.4.6	Full sytem testing	Cabling to DAQ and testing with pulser and cosmics	5
1.2.5.5	Shielding hut		4
1.2.5.5.1	Shielding hut	Procurement and assembly of bunker to hold DAQ and controls electronics in the Hall	
1.2.6	**Magnet**	**alignment, magnet utilities and magnet testing**	**3**
1.2.6.1	**Magnet Steel**	Procure new steel or modifications to existing steel	4
1.2.6.1.1	Yoke	Modify the 24 existing yoke pieces. Procure machining services and provide engineering	5
1.2.6.1.2	Upstream Endcap	Procure modifications to existing upstream coil collar and new adjustable endcup	5
1.2.6.1.3	Downstream Endcap	Procure new material and fabricate cylindrical shell including support mounting	5
1.2.6.1.4	Nose Extension	Procure new two piece cast nose extension including finish machining. Provide engineering	5
1.2.6.1.5	Downstream Coil Collar	Procure new downstream coil collar complete with machined details.	5
1.2.6.2	**Support and Alignment**	Procure support and alignment system for magnet and endcap	4
1.2.6.2.1	Magnet Support and Vertical Alignment System	Procure new magnet support & vertical alignment system	5
1.2.6.2.2	Endcap Support and Motion System	Procure endcap support structure and endcap motion system.	5
1.2.6.3	**Control**	Integration of magnet controls with Hall A and accelerator control systems.	4
1.2.6.4	**Power Supply**	Procure and installation of power supply	4
1.2.6.5	**Cryogenic**	Integration of magnet cryo system with existing hall cryo infrastructure.	4
1.2.6.6	**Magnet Testing**	Full magnet systems checkout after final assembly.	4
1.2.7	**Infrastructure and Support Structure**	**Procurement of support structures, personnel access, infrastructure modifications and**	**3**
1.2.7.1	**Detector Support**	Procurement of detector support system	4
1.2.7.1.1	Magnet Detector Support	Procure internal detector support system for magnet	5
1.2.7.1.2	Endcap Detector Support	Procure internal detector support system for endcap	5
1.2.7.1.3	Detector Support Integration	Integration of individual detectors into support system	5
1.2.7.1.4	Detector Installation Fixtures	Procure detector installation fixtures	5
1.2.7.2	**Baffles**	Procurement of baffle system	4
1.2.7.2.1	Baffle Layers	Procure material and finish machining of baffle layers.	5
1.2.7.2.2	Baffle Support System	Procure baffle mounting system that will integrate into detector mounting system inside of	5
1.2.7.3	**Access**	Procurement of personnel access	5
1.2.7.3.1	Magnet Personnel Access	Procure access platform for cyro/controls on top of magnet	5
1.2.7.3.2	Endcap Personnel Access	Procure access system for endcap detectors	5
1.2.7.4	**Power**	Procurement and installation of power utility components required for SoLID.	4
1.2.7.5	**Beamline**	Procurement and installation of new or modified beamline components for all SoLID	4
1.2.7.6	**Hall A Modifications**	Modifications of hall infrastructure for SoLID installation	4
1.2.7.6.1	Ramp	Procurement of low ground clearance cryostat transport frame or modifications to the	5
1.2.7.6.2	Hall	Perform modifications and preparations of Hall A for the installation and operation of the	5
1.2.7.7	**Layout**	Labor for installation support related to experimental layout.	4
1.2.7.8	**Assembly/Installation**	Manpower for the assembly of experimental components and installation within Hall A	4
1.2.8	Software		3
1.2.8.1	Simulations	Develop simulation software infrastructure and implementation to the level required for	4
1.2.8.1.1	Physics generators	Implement physics event generators relevant for the planned experimental program	5
1.2.8.1.2	Geometry definitions	Choose a suitable geometry storage format. Describe geometry of target, spectrometer, detectors and detector components in sufficient detail for design study simulations and	5
1.2.8.1.2	Digitization	Implement algorithms for simulating the detector responses, including readout electronics.	5
1.2.8.1.4	DAQ/trigger emulation	Develop simulation of the data acquisition and trigger system including handling of pile-up	5
1.2.8.1.5	Framework integration	Integrate simulation algorithms into overall end-to-end software framework	5
1.2.8.1.6	Testing/QA	Assess performance of chosen simulation algorithms (generators, particle transport,	5
1.2.8.1.7	Coordination	Coordinate simulation efforts via periodic group/subgroup meetings, issue tracking, forum	5
1.2.8.2	Online Analysis Infrastructure	Develop software infrastructure and reconstruction algorithms suitable for online analysis	4
1.2.8.2.1	Software Framework adaptation	Implement required additions to software framework, in particular a suitable (Jlab-compatible) build/packaging system, geometry, conditions and mapping databases, and	5

1.2.8.2.2	Data model	Develop a preliminary data model (data structures) compatible with desired granularity of reconstruction algorithms and matched to anticipated experimental configurations.	5
1.2.8.2.3	Raw data decoder	Develop an input module for the sofwtare framework capable of decoding/mapping the	5
1.2.8.2.4	Track reconstruction	Implement algorithms for track reconstruction for the anticipated experimental	5
1.2.8.2.5	Detector analysis	Develop basic detector analysis algorithms, such as calorimeter clustering and Cherenkov amplitude summation, suitable for performance evaluation. This may include particle	5
1.2.8.2.6	Event display	Implement an event visualization system capable of showing raw and aggregated detector	5
1.2.8.2.7	Testing/QA	Evaluate the performance of the online analysis software using simulated and test beam data,	5
1.2.8.2.8	Coordination	Coordinate development efforts via meetings, issue tracking, discussion groups and source	5
1.2.9	Oversight/Project Management	Oversight and project management for the project and for all subsystems	3
1.2.9.1	Project Management	Oversight and project management for the project	4
1.2.9.1.1	Project Management-Scientist	Scientific oversight and project management for the project	5
1.2.9.1.2	Project Management-Engineer	Engineering oversight and project management for the project	5
1.2.9.1.3	Safety	Oversight on safety aspects for the project	5
1.2.9.1.4	Project Office Support	Support from the JLab project office	5
1.2.9.2	PMO Support	Oversight and project management for all subsystems	4
1.2.9.2.1	PMO-Magnet	Project management and oversight for magnet subsystem	5
1.2.9.2.2	PMO-DAQ/Electronics	Project management and oversight for DAQ/Electronics subsystem	5
1.2.9.2.3	PMO-Infrastructure/Support Structure	Project management and oversight for infrastructure, support structure, baffles, assembling	5
1.2.9.2.4	PMO-Calorimeters	Project management and oversight for calorimeters	5
1.2.9.2.5	PMO-Tracking	Project management and oversight for tracking detectors	5
1.2.9.2.6	PMO-Cherenkovs	Project management and oversight for Cherenkov detectors	5