NOνA Schedule – Activity Notes

R & D

CD-2/3a Director's Review
June 4-6, 2007

Nova Project
WBS 1.x - R & D
Activity Notes

CD-2/3a Director's Review
June 4-6, 2007

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1	**Research and Development**				
1.0	**ANU Planning, Engineering & Design**				
1.0.1	**Recycler Upgrades**	**This summary task for the work to convert the Recycler Ring from an anti-proton storage ring to a proton pre-injector, includes planning for removing anti-proton specific devices in the Recycler, design of new injection and extraction lines, design of new injection, extraction, and abort kickers, design of a new 53 MHz RF system, and engineering to upgrade the instrumentation.**			
1.0.1.1	**Recycler Ring Modifications**	**This summary task covers planning and removal of existing devices no longer required in the Recycler Ring, planning, engineering, design, and alignment of RR Extraction, MI Injection, RR-30 SS beamlines, design of a new 53 Mhz RF system, and engineering modifications to existing cooling systems.**			
1.0.1.1.1	**Decommission Pbars Devices in Recycler**				
1.0.1.1.1.1	**Removal of Stochastic cooling tanks**	**This summary task covers the removal of 12 stochastic cooling tanks and their electrical cables, also reconstituting the vacuum systems. Also removal of the Electron cooling insert, consisting of 10 cooling solenoids, 3 major bend magnets, and correctors and instrumentation for the electron transfer line. The electron transfer line devices will be boxed for possible future use.**			
1.0.1.1.1.1.1	Recycler - Remove Electronics Equipment			1530	1530
1.0.1.1.1.1.2	Recycler - Remove Tanks Q103-Q104 & Q211-Q212			1530	1530
1.0.1.1.1.1.3	Recycler - Reconstitute Vacuum System			1530	1530
1.0.1.1.1.2	Remove Ecool Magnets & Devices		M&S for boxing items	1530	1530
1.0.1.1.1.3	**R22 Line Removal**	**This summary task covers the removal of the Lambertson and other magnets and instrumentation from the R22 line; the vacuum must be reconstituted in the RR and MI at the sites of the Lambertson removal.**			
1.0.1.1.1.3.1	Recycler - Remove Lambertsons at Q214/MI221			1845	1845
1.0.1.1.1.3.2	Recycler - Reconstitute Vacuum System Q214 & MI221			1845	1845
1.0.1.1.1.3.3	R22 Remove Instrumentation/Trim Magnets		Includes BPMs, toroids, multiwires. Vertical, horizontal and quad trims.	1845	1845
1.0.1.1.1.4	**R32 Line Removal**	**This summary task covers the removal of the Lambertson and other magnets and instrumentation from the R32 line; the vacuum must be reconstituted in the RR and MI at the sites of the Lambertson removal.**			
1.0.1.1.1.4.1	Recycler - Remove Lambertsons at Q328/MI321			1845	1845

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1.0.1.1.1.4.2	Recycler - Reconstitute Vacuum System Q328 & MI Q321			1845	1845
1.0.1.1.1.4.3	R32 Remove Instrumentation/Trim & Mirror Magnets		Includes BPMs, toroids, multiwires. Vertical, horizontal and quad trims.	1845	1845
1.0.1.1.2	**Beam Lines (Transfer, Abort & RR 30 Straight)**				
1.0.1.1.2.1	**Beam Lines (Transfer, Abort & RR 30 Straight) - R&D**				
1.0.1.1.2.1.1	**Initial Design/Parameter Assessment**	**This summary task covers the lattice design work for the injection line, extraction line, rebuild of the RR30 straight section, and the abort line (including the vacuum interface for the abort line). 3D renderings of the lines are included in the tasks.**			
1.0.1.1.2.1.1.1	**Design Lattice**				
1.0.1.1.2.1.1.1.1	Design IL Lattice				
1.0.1.1.2.1.1.1.2	Design EL Lattice			1-Apr	1-Apr
1.0.1.1.2.1.1.1.3	Design RR-30 SS Lattice			1-Apr	1-Apr
1.0.1.1.2.1.1.1.4	Design Abort Lattice			1-Apr	1-Apr
1.0.1.1.2.1.1.2	Investigate Need of Removal of Vacuum Window			1-Apr	1-Apr
1.0.1.1.2.1.1.3	**Magnetic Shielding Assessment**				
1.0.1.1.2.1.1.3.1	RR Determine Need for Magnetic Shielding of IL Beam Pipe		Assume no additional shielding needed.	1-Apr	1-Apr
1.0.1.1.2.1.1.3.2	Determine Need for Magnetic Shielding of EL Beam Pipe		Assume no additional shielding needed.	1-Apr	1-Apr
1.0.1.1.2.1.1.4	**Preliminary Installation Planning**				
1.0.1.1.2.1.1.4.1	Preliminary IL Installation Planning			1707	1707
1.0.1.1.2.1.1.4.2	Preliminary EL Installation Planning			1707	1707
1.0.1.1.2.1.1.4.3	Preliminary RR-30 SS Installation Planning			1707	1707
1.0.1.1.2.1.2	**Magnet Stands**	**This summary task covers the design of magnet stands for all installations in the RR and MI, including drafting layouts and part drawings.**			
1.0.1.1.2.1.2.1	Design IL Magnet Stands			1725	1725
1.0.1.1.2.1.2.2	Design EL Magnet Stands			1725	1725
1.0.1.1.2.1.2.3	Design RR-30 SS Magnet Stands			1725	1725
1.0.1.1.2.1.2.4	Design BA Kicker Stands			1725	1725
1.0.1.1.2.1.2.5	Design Instrumentation Stands			1725	1725

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1.0.1.1.2.1.3	**Vertical Dipole Magnets**	**This summary task covers the design work for the large vertical dipole magnets used in the injection and extraction lines. These magnets, known as ADCWs, serve as the main switch magnet for the injection line and the main vertical bend in the extraction line. They are a reworked version of an existing magnet (ADC), opening up the gap to 2". The power supply design task is for the main switch magnet. Included is drafting support to produce construction drawings..**			
1.0.1.1.2.1.3.1	Design Vertical Dipole Magnet Power Supplies		Copying existing designs, need time to cross check.	1526	1526
1.0.1.1.2.1.3.2	Spec & Initial Design for Bending Magnets				
1.0.1.1.2.1.3.4	Engineering Design of Bending Magnets			1842	1842
1.0.1.1.2.1.4	**Permanent Quadrupoles**	**This summary task covers the training and design work for permanent magnet quadrupoles. Also included is the effort necessary to remove 38 permanent magnet quads from the existing RR30 electron cooling insert and ship to TD for refurbishing. The new transfer lines require different integrated field, this task will evaluate, design, and test ferrite arrangements to meet the requirements. Included is drafting support to produce construction drawings.**			
1.0.1.1.2.1.4.2	RR Evaluate Ferrite Capabilities			1812	1812
1.0.1.1.2.1.4.3	RR Assemble Test Magnets		Recommission all equipment, bring all suitable quads that are above ground into a ready state.	1812	1812
1.0.1.1.2.1.4.4	Engineering Design		Get quantity of instock spares from Dave Harding.	1812	1812
1.0.1.1.2.1.5	**PDD Magnets**	**This summary task covers the internal design and tooling review for the construction of new permanent magnet dipoles (PDD).**			
1.0.1.1.2.1.5.1	Review PDD Design & Tooling			1793	1793
1.0.1.1.2.1.6	**IL PDDW Magnets**	**This summary task covers the engineering design review for the construction of new reduced field permanent magnet dipoles (PDDW).**			
1.0.1.1.2.1.6.1	IL PDDW Magnets Engineering Design Review			1795	1795
1.0.1.1.2.1.7	**Trim Magnets**	**This summary task covers the reassignment of existing trim correctors to locations in the new transfer lines.**			
1.0.1.1.2.1.7.1	Corrector Reassignment			1873	1873
1.0.1.1.2.1.8	**Mirror Magnets**	**This summary task covers the design work for new permanent mirror magnets for the injection line. Included is drafting support to produce construction drawings.**			
1.0.1.1.2.1.8.1	Design Mirror Magnets			1794	1794
1.0.1.1.2.1.9	**MGS Mirror Magnets**	**This summary task covers the engineering design review for the construction of new permanent gradient mirror magnets (MGS).**			
1.0.1.1.2.1.9.1	MGS Mirror Magnets Engineering Design Review			1800	1800

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1.0.1.1.2.1.10	**Lambertson, 8GEV**	**This summary task covers the design of a wide gap Lambertson magnet (MLAW) for the injection line. Included is drafting support to produce construction drawings.**			
1.0.1.1.2.1.10.1	Engineering Design Wide Gap MLA			1813	1813
1.0.1.1.2.2	**Beam Lines (Transfer, Abort & RR 30 Straight) - OP**				
1.0.1.1.2.2.1	**Vertical Dipole Magnets**	**This summary task covers the effort needed to locate existing ADC magnets.**			
1.0.1.1.2.2.1.1	Locate 3 Bending Magnets			1-Apr	1-Apr
1.0.1.1.2.2.2	**Permanent Quadrupoles - OP**	**This summary task covers the removal of 38 existing permanent magnet quadrupoles from Q310 to Q308, and the shipping of these to TD for refurbishing**			
1.0.1.1.2.2.2.1	Recycler - Remove all 38 Quads from Q301-Q308 & Ship to TD for			1845	1845
1.0.1.1.2.2.3	**Stakeout Beamlines**	**This summary task covers the work of an alignment crew, marking out the locations of new installation magnets and other devices on the tunnel floor. This is a valuable aid in planning the installation of both the magnets and other devices and utilities such as water hose connections, vacuum tubing and pumps, and electrical cable tray.**			
1.0.1.1.2.2.3.1	IL Stakeout Beamline			1527	1527
1.0.1.1.2.2.3.2	EL Stakeout Beamline			1527	1527
1.0.1.1.2.2.3.3	RR30 Stakeout Beamline			1527	1527
1.0.1.1.2.2.3.4	BA Mods Stakeout Beamline			1527	1527
1.0.1.1.2.2.3.5	IL Installation Stakeout			1527	1527
1.0.1.1.2.2.3.6	EL Installation Stakeout			1527	1527
1.0.1.1.2.2.3.7	RR-30 SS Installation Stakeout			1527	1527
1.0.1.1.2.2.3.8	BA Mods Installation Stakeout			1527	1527
1.0.1.1.2.2.5	**Alignment**	**This summary task covers the work of an alignment crew, adjusting the positions of new installation magnets and other devices with the stand adjustments. This is the final step in the installation of the magnets and other devices before the vacuum is made up and electrical cable hooked up.**			
1.0.1.1.2.2.5.1	Final IL Alignment			1527	1527
1.0.1.1.2.2.5.2	Final EL Alignment			1527	1527
1.0.1.1.2.2.5.3	RR30 Final Alignment			1527	1527
1.0.1.1.2.2.5.4	BA Mods Final Alignment			1527	1527
1.0.1.1.2.2.6	**Common Tooling for Permanent Magnet Assembly**	**This summary task covers the common tooling for the permanent magnet construction and refurbishment. Included are tasks to check availability and applicability of existing tooling. Procurement and assembly are included elsewhere.**			
1.0.1.1.2.2.6.1	Ensure Availability of Tooling			1809	1809
1.0.1.1.2.2.6.2	Verify Design Compatibility			1809	1809

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1.0.1.1.3	**53 Mhz RF System**				
1.0.1.1.3.1	**53 Mhz RF System**	**This summary task covers the design work for the 53 MHz RF cavities. Included is drafting support to produce fabrication and installation drawings.**			
1.0.1.1.3.1.1	Prel Design 53 Mhz RF System				
1.0.1.1.3.1.2	Final Design 53 Mhz RF System			1899	1899
1.0.1.1.3.2	**53 Mhz RF System - OP**	**This summary task covers the testing of the 53 MHz RF cavities before installation.**			
1.0.1.1.3.2.1	Purchase S&C Disconnect			1907	1907
1.0.1.1.3.2.2	Assembly of MI60 Anode Supply Room			1907	1907
1.0.1.1.3.2.3	Test 53 Mhz RF System		1/2 costs spares. See UID 1647 for spares.	1900	1900
1.0.1.1.4	**Recycler Cooling System**				
1.0.1.1.4.1	Analyze RR Cooling System Capacities	This task covers the verification and analysis of the total cooling needs for all RR modifications, and deciding the appropriateness of all planned modifications.		1513	1513
1.0.1.1.4.2	**Design Injection Line Water System Mods**	**This summary task covers the design work for the injection line water systems. Included are any modifications due to interferences, the connection of MI 14 service building water, and cooling loads in the MI 14 service building. Included is drafting support to produce fabrication and installation drawings.**			
1.0.1.1.4.2.1	Design Connections for Magnet Change/Move			1517	1517
1.0.1.1.4.2.2	Design Pipe/Bus Move			1517	1517
1.0.1.1.4.2.3	Design Water Line Installation to MI-14			1517	1517
1.0.1.1.4.2.4	Design Connections for Flourinert & Power Supplies for MI-14			1517	1517
1.0.1.1.4.3	**Design Extraction Line Water System Mods**	**This summary task covers the design of all cooling system mods in the Extraction Line area, including piping and bus moves, magnet connection, any new connections for MI-30 power supplies and flourinert skids.**			
1.0.1.1.4.3.1	Design Connections for Magnet Change/Move			1516	1516
1.0.1.1.4.3.2	Design Water Line Installation to MI-30			1516	1516
1.0.1.1.4.3.3	Design Connections for Flourinert & Power Supplies for MI-30			1516	1516
1.0.1.1.4.4	**Design Abort Line Water System Mods**	**This summary task covers the design of all cooling system mods in the Abort Line area, including piping and bus moves, magnet connection, and new lines to MI-39 for the power supplies and flourinert skids.**			
1.0.1.1.4.4.1	Design Connections for Magnet Change/Move			1518	1518
1.0.1.1.4.4.2	Design Water Line Installation to MI-39			1518	1518

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1.0.1.1.4.4.3	Design Connections for Flourinert & Power Supplies for MI-39			1518	1518
1.0.1.1.4.5	**Design RF Cavity Water System Mods**	**This summary task covers the design of all cooling system mods for the RF Cavities, for both the 95°F and 55°F LCW systems.**			
1.0.1.1.4.5.1	Design Connections for Magnet Change/Move			1519	1519
1.0.1.1.4.5.2	Design Mods for RF Cavities Q600 Area			1519	1519
1.0.1.1.4.5.3	Design Mods for Power Supplies MI-60 Gallery			1519	1519
1.0.1.1.4.6	**Design MI-8 Pump Room Water System Installation**	**This summary task covers the evaluation of the need for an additional pump room installation at MI-8, and the subsequent design of the LCW system and pump room equipment, as well as required mods to the Pond Water sytem at PV-9.**			
1.0.1.1.4.6.1	Determine Basic Pump Room Needs			1537	1537
1.0.1.1.4.6.2	Determine Heat Exchanger Size			1537	1537
1.0.1.1.4.6.3	Determine Pond Pump Size			1537	1537
1.0.1.1.4.6.4	Design Pump Room Layout			1537	1537
1.0.1.1.4.6.5	Design Electrical Service Modifications			1537	1537
1.0.1.1.4.6.6	Design Instrumentation & Controls Systems			1537	1537
1.0.1.1.5	**Recycler Ring Modifications Reviews**	**This summary task covers design reviews and milestones for the Recycler Ring Modifications section of the ANU WBS. Included are reviews of the 53 MHz RF system, the transfer lines and the water cooling systems.**			
1.0.1.1.5.1	53 Mhz RF System Design Review			1913	1913
1.0.1.1.5.2	Recycler Transfer Lines Review				
1.0.1.1.5.3	Recycler Cooling Systems Initial Design Review			1514	1514
1.0.1.1.5.4	Recycler Cooling System Engineering Design Review			1514	1514
1.0.1.1.6	**Recycler Ring Modifications Milestones**				
1.0.1.1.6.1	RR All 3 ADC Magnets Found	Identified location of 3 ADC magnets			
1.0.1.1.6.2	RR Lattice Designs Complete	Beamline design lattices completed, includes the 3d drawings to check for interferences.			
1.0.1.1.6.3	RR 53 Mhz RF Design Review Complete	53 MHz RF design review complete and recommendations addressed.			
1.0.1.1.6.4	RR Vacuum Window to be Removed Finalized	The beam abort line contains a vacuum window. The decision is whether to eliminate the window and have the beam abort line vacuum integrated with the circulating beam vacuum, or to leave it as a separate vacuum system with its own vacuum pumping and instrumentation. This Milestone is complete when the L3 and L4 managers finalize the decision.			

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1.0.1.1.6.5	RR Beamline Modifications Design Review Complete	Beamline modifications design review complete and recommendations addressed.			
1.0.1.1.6.6	RR Mirror Magnet Design Finalized	PDD Mirror magnet for the injection line design is complete and signed off by AD.			
1.0.1.2	**Recycler Kicker Systems**	**This summary task covers engineering, design, and prototyping for the five new kicker systems: RR Injection, Injection Gap Clearing, RR Extraction to MI, MI Injection, and RR Abort.**			
1.0.1.2.1	**RR Injection & Gap Clearing Prototype Magnet**		**Includes ceramic chamber for all RR inj & gap magnets.**		
1.0.1.2.1.1	**Design RR Injection Line Prototype Kicker**	**This summary task covers the design of the prototype for the RR injection and Gap Clearing kicker magnets, including three different designs for the ferrites. It includes revisions to the design based on testing of prototype magnets with the three ferrrite designs. Also included are design tasks for the ceramic beam tubes, pulse forming lines and fluorinert cooling system. Drawings of all systems and parts will be produced.**			
1.0.1.2.1.1.1	Design Prototype RR Injection & Cleanup Kicker Magnets - Preliminary		FTE highly dependant on skill set similar to ME305818A.	1462	1462
1.0.1.2.1.1.2	Design Prototype RR Injection & Cleanup Kicker Magnets			1462	1462
1.0.1.2.1.1.3	Ceramic Beamtube Brazing Test			1462	1462
1.0.1.2.1.1.4	Des RR Inject & Gap Clearing Prototype Mag prototype fluorinert temp control syst			1784	1784
1.0.1.2.1.1.5	RR Injection & Gap Clearing Design Prototype Magnet PFL Cable Spool Assy		Similar to ME359554 but for larger cable.	1785	1785
1.0.1.2.1.1.6	Revise RR Inject & Gap Clearing Prototype Magnet Design & Fab Revised Parts (After 3rd Test)		Make some new parts for final potting.	1780	1780
1.0.1.2.1.1.7	Revise RR Inject & Gap Clearing Magnet Design for Production & Choose Ferrite (After 4th Test)			1780	1780
1.0.1.2.1.1.8	Design Load & Adaptor			1784	1784
1.0.1.2.1.2	**Procurement RR Injection Line Prototype Kicker**	**This summary task covers the procurement of all parts for the prototype kicker magnets. We will buy parts for and build three prototypes so we can test all three ferrite designs at once. The ceramic tubes must be measured as received to determine if the final design of the ferrites must be modified to accomodate the actual dimensions of the beam tubes as received. Tooling for potting the magnets is purchased under this summary task. One load assembly with adapter and one fluorinert cooling skid are needed for testing in the Transfer Gallery cage and parts are purchased under this summary task. The time delay for delivery of parts after placement of orders varies depending on the type of parts, and unpacking and inspection of parts is included in the receiving tasks.**			

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1.0.1.2.1.2.1	Oversight for Procurement of Ceramic Beamtubes Off Project			1462	1462
1.0.1.2.1.2.2	RR Injection Kicker Magnet Measure Tubes as Received		Design of ferrites could possibly change depending on measurements of tubes.	1462	1462
1.0.1.2.1.2.3	Prep Req & Award PO for Proto Ferrites (2 Designs)		3 vendors, 3 material specs.	1780	1780
1.0.1.2.1.2.4	Receive Prototype Ferrites (2 Designs)			1780	1780
1.0.1.2.1.2.5	Procure Tooling for Magnet Potting & Measurement			1462	1462
1.0.1.2.1.2.6	Procure parts & Fluorinert for prototype magnets		3 @ $37,000 each	1780	1780
1.0.1.2.1.2.7	Prep Req & Award PO for Parts & Fluorinert for 1 Prototype Fluorinert		$50K parts, $50K installation T&M pipefitters.	1784	1784
1.0.1.2.1.2.8	Receive Parts & Fluorinert for 1 Prototype Cooling Skid			1784	1784
1.0.1.2.1.2.9	Purchase Prototype Load & Adaptor			1784	1784
1.0.1.2.1.3	**Assembly & Testing RR Injection Line Prototype Kicker**	**This summary task covers the assembly and both low voltage and high voltage testing of three prototype kicker magnets, and potting and final testing of the chosen prototype. Also included are assembly of the test load and fluorinert cooling skid needed to test the magnets.**			
1.0.1.2.1.3.1	RR Injection Measure Response of Existing Cables			1-Apr	1-Apr
1.0.1.2.1.3.2	Assemble 1st Design prototype magnet & Existing Ceramic		Use existing spare ceramic chamber for testing.	1780	1780
1.0.1.2.1.3.3	Assemble 1 Prototype Load Temperature Control Fluorinert Skid			1784	1784
1.0.1.2.1.3.4	Assemble Prototype Load & Adaptor			1784	1784
1.0.1.2.1.3.5	Low voltage testing 1a of Prototype Magnet			1781	1781
1.0.1.2.1.3.6	High voltage testing of Prototype Magnets		Testing in transfer gallery	1781	1781
1.0.1.2.1.3.7	Assemble 1st Design Prototype Magnet with 2nd ferrite			1780	1780
1.0.1.2.1.3.8	Repeat low voltage & high voltage test of Proto Mag		Testing in transfer gallery	1781	1781
1.0.1.2.1.3.9	Assemble 2nd Design Prototype magnet			1780	1780
1.0.1.2.1.3.10	Repeat low voltage & high voltage test of Proto Mag		Testing in transfer gallery	1781	1781
1.0.1.2.1.3.11	Pot prototype magnet		Potted with Sylgard RTV silicone elastomer. Use a mandrel or temporary ceramic tube not flanged, magnet ends blanked off and sealed with RTV for potting.	1780	1780
1.0.1.2.1.3.12	Repeat low voltage 4a & high voltage 4b testing of Prototype Magnet		Testing in transfer gallery	1781	1781
1.0.1.2.2	**RR Injection & Gap Clearing Prototype Pulser**		**Includes cable for all RR inj & gap pulsers.**		

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1.0.1.2.2.1	**Design of RR Injection & Gap Clearing Prototype Pulser & Final Pulser Enclosure**	**This summary task covers the design of the prototype pulser for the RR Injection and Gap Clearing magnets, the final design of the pulser enclosure, revisions to the pulser design, two designs for the two types of Pulse Forming Network, and design of two types of Resonant Chargers. Drawings of all systems and parts will be produced.**			
1.0.1.2.2.1.1	RR Injection & Gap Clearing Design Prototype Thyratron Pulser Enclosures (2 variations)		Similar to ME142605	1782	1782
1.0.1.2.2.1.2	RR Injection & Gap Clearing Design Pulse Forming Network (2 types)			1481	1481
1.0.1.2.2.1.3	RR Injection & Gap Clearing Revise Design of Pulsers			1782	1782
1.0.1.2.2.1.4	RR Injection & Gap Clearing Design Resonant Charger (2) Types			1482	1482
1.0.1.2.2.2	**Procurement RR Injection & Gap Clearing Prototype Pulser**	**This summary task covers the procurement of all parts for two RR Injection and Gap Clearing prototype pulsers, including thyratrons, procurement of 10 PFL frames, procurement of all cable for the RR Injection and Gap Clearing kicker systems, procurement of all parts for two Pulse Forming Networks, and procurement of parts for two Resonant Chargers. The time delay for delivery of parts after placement of orders varies depending on the type of parts, and unpacking and inspection of parts is included in the receiving tasks.**			
1.0.1.2.2.2.1	RR Injection & Gap Clearing Prep Req & Award PO for Parts & Fluorinert for 2 Prototype pulsers			1782	1782
1.0.1.2.2.2.2	RR Injection & Gap Clearing Receive Parts & Fluorinert for 2 Prototype pulsers			1782	1782
1.0.1.2.2.2.3	RR Injection & Gap Clearing Prep Req & Award PO for Thyratrons for 2 HV Prototype pulsers			1782	1782
1.0.1.2.2.2.4	RR Injection & Gap Clearing Receive Thyratrons for 2 HV Prototype pulsers			1782	1782
1.0.1.2.2.2.5	RR Injection & Gap Clearing Pre-production Pulser Prep Req & Award PO for 10 PFL Frames		See UID 3149 for 6 spares	1785	1785
1.0.1.2.2.2.6	RR Injection & Gap Clearing Pre-production Pulser Receive 10 PFL		See UID 3149 for 6 spares	1785	1785
1.0.1.2.2.2.7	RR Inj & Gap Clearing Pre-prod Pulser Procure 6 Spare PFL Frames			4785	1785
1.0.1.2.2.2.8	RR Injection & Gap Clearing Pre-production Pulser Prep Req & Award PO for All Cable		10 PFLs X 600 ft ea @ $16/ft	1785	1785
1.0.1.2.2.2.9	RR Injection & Gap Clearing Pre-production Pulser Receive All Cable		16 PFLs X 750 ft ea @ $16/ft 10 + 6 spares	1785	1785
1.0.1.2.2.2.10	RR Injection & Gap Clearing Pre-production Pulser Procure Spare Cable (6 spools)		600 ft ea spool @ $16/ft = $9,600/spool.	1785	1785

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.1.2.2.2.11	RR Injection & Gap Clearing Pulse Forming Network Procure Parts for (2) PFNs			1481	1481
1.0.1.2.2.2.12	RR Injection & Gap Clearing Resonant Charger Procure Parts for 2 Assys			1482	1482
1.0.1.2.2.3	**Assembly/Testing/Install RR Injection & Gap Clearing Prototype Pulser**	**This summary task covers all assembly and testing of the RR Injection and Gap Clearing prototype pulsers, assembly and testing of 2 PFNs, assembly and testing of 2 Resonant Chargers, testing of cables, winding cable on 10 PFL frames and installation of PFLs in the MI-14 and MI-39 service buildings, and installing the PFNs and Resonant Chargers in the buildings.**			
1.0.1.2.2.3.1	RR Injection & Gap Clearing Assemble Prototype pulsers (2)			1782	1782
1.0.1.2.2.3.2	RR Injection & Gap Clearing Testing of Prototype Pulsers (2)			1783	1783
1.0.1.2.2.3.3	RR Injection Clear Transfer Gallery Cage for Prototype Testing			1783	1783
1.0.1.2.2.3.4	RR Injection & Gap Clearing Pulse Forming Network Assemble & Test (2) PFNs			1481	1481
1.0.1.2.2.3.5	RR Injection & Gap Clearing HV & Impedance Testing of Cable			1785	1785
1.0.1.2.2.3.6	RR Inj & Gap Clearing Wind Cables on 10 PFL frames		See UID 3150 for spare info.	1785	1785
1.0.1.2.2.3.7	RR Inj Gap Clearing Wind Cables on 6 Spare PFL Frames			1785	1785
1.0.1.2.2.3.8	RR Injection & Gap Clearing Install 5 PFL Frames in MI-14 Bldg		See UID 2840 for spares.	1785	1785
1.0.1.2.2.3.9	RR Injection & Gap Clearing Resonant Charger Assemble & Test 2 Assys			1482	1482
1.0.1.2.2.3.10	RR Injection & Gap Clearing Install 5 PFL Frames in MI-39 Bldg		See UID 2841 for spares.	1785	1785
1.0.1.2.2.3.11	RR Injection & Gap Clearing Install 3 Spare PFL Frames in MI-14 Bldg		See UID 1640 for production units.	1785	1785
1.0.1.2.2.3.12	RR Injection & Gap Clearing Install 3 Spare PFL Frames in MI-39 Bldg		See UID 1641 for production units.	1785	1785
1.0.1.2.2.3.13	RR Injection & Gap Clearing Install PFNs in Bldgs MI-14 & MI-39			1481	1481
1.0.1.2.2.3.14	RR Injection & Gap Clearing Install Resonant Chargers in MI-14 & MI-39			1482	1482
1.0.1.2.3	**RR Injection & Gap Clearing Prototype Bumper Power Supply**	**This summary task covers the design, procurement, assembly and testing of the prototype flattop bumper pulser for the RR Injection and Gap Clearing Bumper magnets, also the installation of a test kicker magnet in the tunnel at Q103, testing the system with this magnet, and revising the bumper pulser design based on these tests. Drawings of all systems and parts will be produced. The time delay for delivery of parts after placement of orders varies depending on the type of parts, and unpacking and inspection of parts is included in the receiving tasks.**			
1.0.1.2.3.1	Design & Build Prototype Flattop Bumper Power Supply			1782	1782

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.1.2.3.2	Testing of Flattop Bumper PS with Prototype Magnet			1786	1786
1.0.1.2.3.3	Design Vacuum Layout for RR Injection Bumper Beam Test			1480	1480
1.0.1.2.3.4	Procure Vacuum Parts & Stands for RR Injection Bumper Magnet			1480	1480
1.0.1.2.3.5	Procure Bumper Magnet from Spares			1480	1480
1.0.1.2.3.6	Pull Cables & Install Magnet in MI @Q103			1480	1480
1.0.1.2.3.7	Testing of Flattop Bumper w/Beam			1480	1480
1.0.1.2.3.8	Update Design of Bumper Pulser PS			1480	1480
1.0.1.2.4	**RR Extraction Line Kicker Magnets**		**2 systems - MI Injection Kicker (5 new design magnets), RR Extraction Kicker (1 refurbished magnet)**		
1.0.1.2.4.1	**RR Extraction Kicker Magnets**	**This summary task covers the design of modifications for existing kicker magnets to reconfigure them for their new function as RR Extraction kickers, and also design of a fluorinert cooling system for this kicker system. Drawings of all systems and parts will be produced.**			
1.0.1.2.4.1.1	RR Extraction/MI Injection Kicker Magnet Design Mods to Existing Magnets		ME374021	1773	1773
1.0.1.2.4.1.2	RR Extraction/MI Injection Kicker Design for Fluorinert System		Assume this is different than UID 864.	1784	1784
1.0.1.2.4.2	**MI Injection Kicker Prototype Tail Bumper PS System**				
1.0.1.2.4.2.1	**Design MI Injection Prototype Tail Bumper PS**	**This summary task covers the design of a prototype power supply for the MI Injection Tail Bumper magnet, also a PFL cable spool for this prototype system, and redesign of the bumper power supply based on testing. Drawings of all systems and parts will be produced.**			
1.0.1.2.4.2.1.1	Design Prototype MI Injection Kicker Tail Bumper Power Supply		FTE highly dependant on skill set similar to ME305818A.	1774	1774
1.0.1.2.4.2.1.2	Design MI Injection/RR Extraction/Beam Abort Prototype Magnet PFL Cable Spool Assy		Similar to ME359554 but for larger cable.	1785	1785
1.0.1.2.4.2.1.3	Revise MI Injection Kicker Prototype Tail Bumper PS Design & Fab Revised Parts		Make some new parts for final potting.	1774	1774
1.0.1.2.4.2.2	**Procurement MI Injection Prototype Kicker Tail Bumper Power Supply & Test Magnet**	**This summary task covers the procurement of all parts for the MI Injection Tail Bumper prototype power supply, all parts including capacitors and ferrites for one test magnet, all parts for one fluorinert cooling system skid, all parts for one PFN, and any parts needed to connect a test magnet. The time delay for delivery of parts after placement of orders varies depending on the type of parts, and unpacking and inspection of parts is included in the receiving tasks.**			
1.0.1.2.4.2.2.1	Prep Req & Award PO for Capacitors & Ferrites for 1 Test Magnet		$12,000 for ferrites $2,400 per capacitor design X 3 =$7,200	1771	1771

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.1.2.4.2.2.2	Receive Capacitors & Ferrites for 1 Test Magnet			1771	1771
1.0.1.2.4.2.2.3	MI Inj Resonant Charger Procure			1774	1774
1.0.1.2.4.2.2.4	Prep Req & Award PO for Parts & Fluorinert for Prototype Tail Bumper PS			1774	1774
1.0.1.2.4.2.2.5	Receive Parts & Fluorinert for Prototype Tail Bumper PS			1774	1774
1.0.1.2.4.2.2.6	Pulse Forming Network Porcure Parts for (1) PFN			1481	1481
1.0.1.2.4.2.2.7	Prep Req & Award PO for Parts & Fluorinert for 1 Test Magnet			1771	1771
1.0.1.2.4.2.2.8	Receive Parts & Fluorinert for 1 Test Magnet			1771	1771
1.0.1.2.4.2.2.9	Prep Req & Award PO for Parts & Fluorinert for 1 Prototype Fluorinert		$50K parts, $50K installation T&M pipefitters.	1784	1784
1.0.1.2.4.2.2.10	Receive Parts & Fluorinert for 1 Prototype Fluorinert Cooling Skid			1784	1784
1.0.1.2.4.2.3	**Assembly & Testing MI Injection Prototype Kicker & Pulser System**	**This summary task covers all assembly and testing of the MI Injection kicker test magnet and prototype pulser system, including the assembly and installation of a pulse forming network, fluorinert cooling system and load.**			
1.0.1.2.4.2.3.1	MI Injection Measure Response of Existing Cables			1785	1785
1.0.1.2.4.2.3.2	MI Injection Assemble Test Magnet		Use existing spare ceramic chamber for testing.	1771	1771
1.0.1.2.4.2.3.3	MI Inj Assemble Prototype Tail Bumper PS Pulser			1774	1774
1.0.1.2.4.2.3.4	MI Inj Pulse Forming Network Assemble & Test (1) PFN			1481	1481
1.0.1.2.4.2.3.5	MI Inj Install PFN in Bldg MI-30			1481	1481
1.0.1.2.4.2.3.6	MI Inj Assemble 1 Prototype Load Temperature Control Fluorinert Skid			1784	1784
1.0.1.2.4.2.3.7	MI Inj High Voltage Testing of Prototype Tail Bumper with Test Magnet		Testing in transfer gallery	1786	1786
1.0.1.2.5	**RR Extraction Line Kicker Power Supply System**	**This summary task covers the updating of the current existing design for the RR Extraction Line power supply system. Drawings of all systems and parts will be produced.**			
1.0.1.2.5.1	Extraction Line Kicker PS Update current HV pulser design			1774	1774
1.0.1.2.6	**Recycler Kicker Systems Reviews**	**This summary task covers reviews of the design of the ceramic beam tubes, response data from the cable tests, design of the RR Injection and Gap Clearing pulser, and design of the RR Injection and Gap Clearing kicker magnet. Drawings of all systems and parts will be reviewed and approved.**			
1.0.1.2.6.1	Review ceramic beamtubes Prod Dwgs		Need to review aperture requirements - sign off.	1462	1462
1.0.1.2.6.2	Review on Which Cable to Purchase or Re-use Old Cables		Assume procure. If not purchase have to redesign whole PS.	1785	1785

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.1.2.6.3	Review Design of RR Injection & Gap Clearing Pulsers			1782	1782
1.0.1.2.6.4	Review Final Design of RR Inject Line Kicker Magnet		M&S for travel	1780	1780
1.0.1.2.7	**Recycler Kicker Systems Milestones**				
1.0.1.2.7.1	RR Inj & Gap Clearing Pulser Cables Finalized	Existing cables are measured for impedance vs frequency to determine the pulse response for fall time and droop in voltage. The decision is whether to accept them for the new kicker system or buy new cables with a more desirable impedance. This Milestone is complete when the L4 manager makes the decision.			
1.0.1.2.7.2	RR Ext/MI Inj Pulser Cables Finalized	Existing cables are measured for impedance vs frequency, to determine the pulse response for fall time and droop in voltage. The decision is whether to accept them for the new kicker system or buy new cables with a more desirable impedance. This Milestone is complete when the L4 manager makes the decision.			
1.0.1.2.7.3	RR Existing Design for RR Injection Design Fluorinert System Confirmed	There is an existing design for a fluorinert cooling system used by the NuMI extraction kickers. The decision is whether to accept this design for new kicker systems, or to modify this system, or design an entirely new system. This Milestone is complete when the L4 manager makes the decision.			
1.0.1.2.7.4	RR Extraction MI Injection Kicker Prototype Pulser System Complete	After testing the prototype pulser with a test magnet, the decision is to accept the pulser design for production or to make revisions to the design. After there are no more revisions, the design is ready for procurement of production parts. This Milestone is complete when the L4 manager makes the decision to move forward on procurement based on successful prototyping.			
1.0.1.2.7.5	RR Injection Line Prototype Kicker Complete	After testing the prototype kicker magnet, the decision is to choose the most acceptable of the ferrite designs, make revisions to the design, and accept the kicker design for production. After there are no more revisions, the design is ready for a review and the procurement of parts for two pre-production magnets. This Milestone is complete when the L4 manager makes the decision to move forward on procurement based on successful prototyping.			
1.0.1.2.7.6	RR Ferrite Procurement or Re-design Finalized	After testing the prototype kicker magnet, the decision is to choose the most acceptable of the ferrite designs, make revisions to the design, and accept the ferrite design for production. After there are no more revisions, the design is ready for a review and the procurement of ferrites for all magnets. This Milestone is complete when the L4 manager makes the decision to move forward on procurement based on successful prototyping.	Costs for following tasks assume procure.		
1.0.1.3	**Recycler Instrumentation**	**This summary task covers engineering the upgrades to existing instrumentation including the BPM systems, longitudinal and transverse damper systems, and intensity monitors.**			
1.0.1.3.1	**BPMs**	**This summary task covers the design work for the 53 MHz BPM system cables and transitions boards. It will produce specification documents for the BPM system.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.1.3.1.1	Design BPM Cables & Transition Boards			1927	1927
1.0.1.3.2	**Dampers**	**This summary task covers the design work for the longitudinal and transverse damper systems. It will produce specifications documents for the damper systems.**			
1.0.1.3.2.1	**Longitudinal**				
1.0.1.3.2.1.1	Design Longitudinal Dampers			1929	1929
1.0.1.3.2.2	**Transverse**				
1.0.1.3.2.2.1	Design Transverse Dampers			1928	1928
1.0.1.3.3	**Recycler Instrumentation Reviews**	**This summary task covers the work associated with design review of the instrumentation for the Recycler Ring.**			
1.0.1.3.3.1	Instrumentation Design Review			1930	1930
1.0.1.4	**Recycler Radiation Safety**	**This summary task covers the necessary study time and assessment of the Recycler Ring Radiation Safety. It will produce a shielding assessment document for the running of the Recycler Ring in the Nova era.**			
1.0.1.4.1	Recycler Radiation Shielding Study			1463	1463
1.0.1.4.2	Recycler - Review & Revise Shielding Assessment			1463	1463
1.0.1.4.3	**Recycler Radiation Safety Milestones**				
1.0.1.4.3.1	RR Shielding Assessment Complete	This milestone is defined as the point at which the RR shielding assessment issues for NOvA operation have been addressed in the MI Shielding Assessment.			
1.0.2	**Main Injector Upgrades**	**This summary task covers the modifications to low level RF systems and associated machine timing modifications. It also includes planning for and removal of existing magnets and cavities no longer required. It also covers engineering for upgrades to existing LCW and RF cooling systems. Also included is the engineering and design for two extra MI RF stations.**			
1.0.2.1	**MI Modifications**	**This summary task covers modifications to MI and RR low level RF systems, including engineering for modifications to cooling systems. It also includes planning and removal of existing A1 extraction line and 6 coalescing cavities in the MI.**			
1.0.2.1.1	**Machine Timing**	**This summary tasks covers the modifications to the MI and RR low level rf systems required for slip stacking in the RR along with the asssociated revolution markers and transfer events.**	**All timeline generator issues.**		
1.0.2.1.1.1	**Machine Timing**				
1.0.2.1.1.1.1	Design & modify Beam Swtch Sum Box			1470	1470
1.0.2.1.1.1.2	Design & modify MI beam sync clock			1470	1470
1.0.2.1.1.1.3	Design & modify RR beam sync clock			1470	1470
1.0.2.1.1.1.4	Design & modify TClock			1470	1470

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.2.1.1.1.5	Design & modify MI low level RF system		Assumes reuse of beam transfer modules.	1749	1749
1.0.2.1.1.2	**Design & modify RR low level RF system**				
1.0.2.1.1.2.1	RR Low Level RF System Initial Design			1748	1748
1.0.2.1.1.2.2	RR Low Level RF System Design			1748	1748
1.0.2.1.1.2.3	RR Low Level RF System Develop Hardware/Software			1748	1748
1.0.2.1.1.2.4	RR Low Level RF System Test Prototype			1748	1748
1.0.2.1.1.3	Design & Install Injection Line Controls			1822	1822
1.0.2.1.1.4	Design & Install Extraction Line Controls			1822	1822
1.0.2.1.1.5	**Machine Timing - OP**				
1.0.2.1.1.5.1	Define & install inputs to RR beam permit system		Need to add C200 modules to new buildings.	1470	1470
1.0.2.1.1.5.2	Modify Timeline Generator			1470	1470
1.0.2.1.1.5.3	Configure & install kicker timing controls		Assumes controls' links are installed.	1822	1822
1.0.2.1.1.6	**Modify RR Low Level RF System**				
1.0.2.1.1.6.1	RR Low Level RF System Recover & Test Decommissioned Hardware from			1748	1748
1.0.2.1.1.6.2	RR Low Level RF System Install			1748	1748
1.0.2.1.1.6.3	RR Low Level RF System Test			1748	1748
1.0.2.1.1.6.4	RR Low Level RF System Startup			1748	1748
1.0.2.1.2	**Decommissioning of A1 Line Extraction**	**This summary task covers the removal of the 3 Lambertson magnets and the kicker magnets used to extract anti-protons from the Main Injector, and reconstituting the vacuum.**			
1.0.2.1.2.1	Removal of 3 Lambertson Magnets		Riggers 32 hours. $2K M&S	1472	1472
1.0.2.1.2.2	Remove Kicker Magnet			1472	1472
1.0.2.1.2.3	Align Beam Pipe			1472	1472
1.0.2.1.2.4	Reconstitute Vacuum			1472	1472
1.0.2.1.3	**2.5 Mhz Cavitites (6)**	**This summary task covers the removal of the 6 coalescing cavities from the Mian Injector and reconstituting the vacuum.**			
1.0.2.1.3.1	2.5 Mhz Cavity (6) Removal Incl Cables		6 cavities @ 2 hours/cavity. All cables 1/2 day.	1473	1473
1.0.2.1.3.2	Align Beam Pipe			1473	1473
1.0.2.1.3.3	Reconstitute Vacuum			1473	1473
1.0.2.1.4	**Main Injector Cooling System**	**This summary task covers the verification and analysis of the total cooling needs for all MI modifications, and deciding the appropriateness of all planned cooling system modifications.**			
1.0.2.1.4.1	Analyze MI LCW & Pond Cooling System Capacities		Magnet & RF.	1507	1507

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.2.1.5	**MI Modifications Reviews**	**This sumary tasks covers the reviews of the LCW cooling for the MI and the new RR low level rf system.**			
1.0.2.1.5.1	MI LCW & Pond Cooling System Initial Design Review			1508	1508
1.0.2.1.5.2	Des & Modify RR Low Level RF System Review			1748	1748
1.0.2.1.6	**MI Modifications Milestones**				
1.0.2.1.6.1	MI 2.5 Mhz Cavities Removal Complete	The removal of the 6 coalescing cavities (2.5,5.0MHz) from MI is complete.			
1.0.2.1.6.2	MI Decommissioing of A1 Extraction Line Complete	The removal of the 3 Lambertson magnets and the 2 kickers used for the anti-proton extraction from the MI is complete.			
1.0.2.1.6.3	MI Machine Timing Complete	All the modifications to the MI and RR low level rf systems required for slip stacking in the RR are complete.			
1.0.2.2	**MI RF Cavities**	**This summary task covers engineering, design and testing of bus bar and cavities for 2 new MI RF stations, including cooling systems upgrades.**			
1.0.2.2.1	**MI RF Cavities**	**This summary task covers the engineering design along with the required drawings of the two bus bar needed for the two extra rf stations.**			
1.0.2.2.1.1	**Bus Bar**				
1.0.2.2.1.1.1	MI RF Cavities Start Design of Bus Bar			1511	1511
1.0.2.2.1.1.2	MI RF Cavities Finish Design of Bus Bar			1511	1511
1.0.2.2.1.3	**MI RF Cavity Cooling System**	**This summary task covers the design of all cooling system mods for the RF Cavities, for both the 95°F and 55°F LCW systems.**			
1.0.2.2.1.3.1	Analyze MI Cavity & RF Cooling System Capacities			1504	1504
1.0.2.2.1.3.2	Design RF Cavity Connections Q600 Region			1504	1504
1.0.2.2.1.3.3	Design RF Power Supply Connections MI-61 Gallery			1504	1504
1.0.2.2.2	**MI RF Cavities - OP**	**This summary task covers the upstairs testing of the two extra rf cavities we plan to install in Main Injector**			
1.0.2.2.2.1	MI RF Cavity Pre-install Testing (Existing)		Use 2 of 3 existing spares.	1503	1503
1.0.2.2.2.2	**Equip Gallery Install/Modification**				
1.0.2.2.2.2.1	MI RF Cavities Utility Modifications		Station #4 480V for Bias Supply, Power to 2 Modulators & Racks LCW Piping modifications? Cable Trays Electrical Power Cabling upstairs 1.5 weeks per area. Needs short SD	1486	1486
1.0.2.2.3	**MI RF Cavities Reviews**	**This summary tasks covers the reviews for the cooling water for the rf cavities.**			
1.0.2.2.3.1	MI RF Cavity Cooling System InitialDesign Review			1505	1505

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.2.2.3.2	MI RF Cavity Cooling System Engineering Design Review			1505	1505
1.0.2.2.4	**MI RF Cavities Milestones**				
1.0.2.2.4.1	MI Cavity Pre-install Testing Complete	The testing of the two MI rf cavities up-stairs is complete. Diagnose and fix any problems before installation.			
1.0.2.3	**MI Radiation Safety**	**This summary task covers the necessary study time and assessment of the Main Injector Radiation Safety. It will produce a shielding assessment document for the running of the Main Injector in the Nova era.**			
1.0.2.3.1	MI Review & Revise Shielding Assessment			1454	1454
1.0.2.3.2	**MI Radiation Safety Milestones**				
1.0.2.3.2.1	MI Shielding Assessment Complete	This milestone is defined as the point at which the MI Shielding Assessment has been updated/appended for NOvA operation and is ready to start the approval process.			
1.0.3	**NuMI Upgrades**	**This summary task covers the design and planning for modifications to NuMI Beamline to support 700kW NOvA operation in the medium energy neutrino beam configuration. It includes the primary beam upgrades to support a higher beam cycle time, upgrades to the cooling systems throughout the beamline for the increases power, and electrical infrastructure to support the additional power needs. Also included is the planning, engineering and design for a medium energy target, baffle and carrier and an upgraded hadron monitor. Planning for how the horn 2 will be moved to the medium energy position and the design of the stripline to connect to it in the new position are included.**			
1.0.3.1	**NuMI Primary Proton Beam**	**This summary task includes the engineering design efforts needed for reliable kicker operation at shorter cycle times, recovering 5 quadropoles from the A150 line at the conclusion of the tevatron running, testing these quads and preparing the NuMI quads for removal. Also included is design work for upgrading the NuMI Profile Monitors.**			
1.0.3.1.1	**NuMI Extraction Kicker**	**This summary task includes the engineering design efforts for a faster charging time kicker power supply, as well as for an improved Fluorinert cooling system. These upgrades are needed for reliable kicker operation at shorter cycle times.**			
1.0.3.1.1.1	**Upgraded Charging Power Supply**				
1.0.3.1.1.1.1	Design for Charging PS Upgrades			1884	1884
1.0.3.1.1.2	Design Upgrade for Fluorinert to Water Heat Exchanger			1884	1884
1.0.3.1.2	**3Q120 Quadrupoles**	**This summary task covers the efforts needed to recover QQB style 3Q120 quadrupoles from the A150 transfer line at the conclusion of Tevatron operations. These more robustly cooled quads will replace the five highest current existing NuMI quadrupoles. Also included are testing prior to recovery and preparation of the NumI quads for removal.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.1.2.1	**3Q120 Quadrupoles**				
1.0.3.1.2.1.1	Test 3Q120 Quads to be Recovered			1885	1885
1.0.3.1.2.2	**3Q120 Quadrupoles (5+1)**				
1.0.3.1.2.2.1	Recover A1 Line 3Q120 Quads		$10K for misc materials	1885	1885
1.0.3.1.2.2.2	3Q120 Quads Disconnect Water			1804	1804
1.0.3.1.2.2.3	Components Alignment as Found Old			1804	1804
1.0.3.1.2.2.4	Disconnect Cables for 5 Quads to be Replaced			1804	1804
1.0.3.1.2.2.5	Bleed up Vacuum & Disconnect Flanges for Component Replacement			1804	1804
1.0.3.1.2.2.6	3Q120 Quads: Remove 5 Old Magnets			1804	1804
1.0.3.1.3	**NuMI Profile Monitors**				
1.0.3.1.3.1	Design NuMI Profile Monitors			1959	1959
1.0.3.1.4	**NuMI Primary Proton Beam Reviews**	**This summary task contains the reviews for the profile monitor upgrades. A review of the conceptual design of the profile monitor will occur. Upon completion of the design work, but before procurement begins, a second review will be done. This task includes the labor needed to prepare for the review, participant and review time at the review, and the writing of a review report.**			
1.0.3.1.4.1	Profile Monitors Initial Design Review			1756	1756
1.0.3.1.4.2	Profile Monitors Final Design Review			1756	1756
1.0.3.1.5	**NuMI Primary Proton Beam Milestones**				
1.0.3.1.5.1	NuMI Charging PS Upgrade Design Complete	A review of the conceptual designs for the NuMI Primary Beamline Profile Monitors has been completed and the review committee has written a report on their findings. The modifications to the Profile Monitor design has been determined and agreed to by the L3 and L4 managers.			
1.0.3.1.5.2	NuMI Profile Monitor Conceptual Design Review Complete	A review of the technical design for the NuMI Primary Beamline Profile Monitors has been completed and the review committee has written a report on their findings.			
1.0.3.1.5.3	NuMI Profile Monitor Technical Design Review Complete	A review of the technical design for the NuMI Profile Monitors has been completed and the review committee has written a report on their findings.			
1.0.3.2	**NuMI Target Hall Technical Components**	**This summary task includes all the engineering, design, and drafting needed for the medium energy target, target carrier, baffle and hadron monitor. Also included are the design reviews.**			
1.0.3.2.1	**ME Target, Carrier & Baffle**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.2.1.1	**Medium Energy Target**	**This summary tasks covers all of the R&D, engineering design, and drafting needed to produce a complete drawing set of the medium energy target. A preliminary target design has already been developed at IHEP, Protvino. The design will be reviewed by Fermilab engineers and physicists before writing an Accord with IHEP to build the medium energy target. The task includes labor and the M&S needed to purchase a drawing package from IHEP. Deliverables include a complete drawing package of the medium energy target from IHEP, and a complete set of drawings integrated into the the mechanical engineering drafting system. The purchase of the medium energy target is not included in this task.**			
1.0.3.2.1.1.1	Review of IHEP ME Target Design Study 1			1736	1736
1.0.3.2.1.1.2	IHEP ME Target Design Study 2			1736	1736
1.0.3.2.1.1.3	Assess IHEP ME Target Design Study 2			1736	1736
1.0.3.2.1.1.4	IHEP Drawing Package for ME Target			1736	1736
1.0.3.2.1.1.5	Integrate mechanical drawings from IHEP			1736	1736
1.0.3.2.1.2	**Target Carrier**	**This summary task covers the R&D and engineering needed to design a new carrier for the medium energy target and target baffle. The target carrier hangs below the target module and supports the medium energy target and baffle in the target hall chase. A design of the carrier exists for the presently used low energy target and will be modified to support the medium energy target. The design of the carrier is inter-depedent with the design of the target and baffle. The tasks inlcude the labor for the R&D and design. The procurement of parts and carrier fabrication is not included in this task.**			
1.0.3.2.1.2.1	Analysis of Carrier for 700kW Beam Power			1737	1737
1.0.3.2.1.2.2	Design of new carrier		Assumes no remote Z motion of target and no significant modifications to design of structures. Includes analysis of cooling needs for carrierr hanger.	1737	1737
1.0.3.2.1.3	**Baffle**	**This summary tasks covers all of the R&D, engineering design, and drafting needed to produce a complete drawing set of the medium energy target baffle. A preliminary target design has already been developed at IHEP, Protvino. The design will be reviewed by Fermilab engineers and physicists before writing an Accord with IHEP to build the baffle target. The task includes labor and the M&S needed to purchase a drawing package from IHEP. Deliverables include a complete drawing package of the baffle from IHEP, and a complete set of drawings integrated into the the mechanical engineering drafting system. The purchase of the baffle is not included in this task.**			
1.0.3.2.1.3.1	Analyze Baffle for Higher Heat Loads			1738	1738

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.2.1.3.2	Design Baffle Modifications		Add more cooling fins. Part of IHEP accord for baffle procurement.	1738	1738
1.0.3.2.1.3.3	IHEP Modify Baffle Dwg Package			1738	1738
1.0.3.2.2	**Hadron Monitor**	**This summary tasks covers the analysis of the presently used hadron monitor for use at the higher beam power. The University of Texas, Austin has built the presently used hadron monitor which is adequate for use at 400 kW of beam power. This design will be analyzed to determine the modifications neccessary to handle the higher beam power. The engineering design and fabrication of the hadron monitor is not included in this task.**			
1.0.3.2.2.1	Analyze Current Hadron Monitor Design for Higher Beam Power.			1721	1721
1.0.3.2.3	**NuMI Target Hall Technical Components Reviews**	**This summary tasks contains several reviews of the target hall technical components. The technical components include the medium energy target, target baffle, target carrier, handron monitor, and hadron monitor beam abort. A review of the conceptual designs of the target, baffle, and carrier will occur before begining the design work. Upon completion of the design work, but before procurement begins, a review of target, baffle, and carrier designs will be done. A review of the hadron monitor and hadron monitor beam abort is also planned before procurement and fabrication. These tasks include the labor needed to prepare for the review, participant and review time at the review, and a the writing of a review report.**			
1.0.3.2.3.1	Target, Baffle & Carrier Initial Design Review			1792	1792
1.0.3.2.3.2	Target, Baffle & Carrier Design Review			1792	1792
1.0.3.2.3.3	Hadron Monitor Design Review			1792	1792
1.0.3.2.4	Design Hadron Monitor Beam Abort			1492	1492
1.0.3.2.5	**NuMI Target Hall Technical Components Milestones**				
1.0.3.2.5.1	NuMI Target, Baffle & Carrier Initial Design Review Complete	A review of the conceptual designs for the NuMI Target, Baffle, & Carrier has been completed and the review committee has written a report on their findings.			
1.0.3.2.5.3	NuMI Final Design of Target Carrier Complete	This final design of the target carrier has been completed. The drawings for the carrier have been completed, and the procurement and fabrication of the carrier can begin.			
1.0.3.2.5.9	NuMI Hadron Monitor Initial Re-design Complete	An analysis of the Hadron Monitor performance under ANU operating conditions has been completed. The modifications to the Hadron Monitor design has been determined and agreed to by the L3 and L4 managers.	Assumes no new design for higher power needed.		

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.3	**NuMI Target Hall Infrastructure**	**This summary task covers the planning, engineering, and design/drafting needed to develop a comprehensive new layout plan for moving horn 2 to the medium energy position and includes the design of new equipment needed. It also covers the removal and staging of R-blocks and blue blocks associated with the horn 2 move. It also includes the engineering, design and drafting for the stripline extension, target chase cooling upgrades, and stripline block forced air cooling. It also includes the engineering needed for analyzing radiant heat effects of chase blocks on chase components and design of additional chase temperature monitoring equipment. Also included are the reviews for this design work.**			
1.0.3.3.1	**Target Hall Operations Space Planning**	**This summary task covers the R&D, engineering, and design/drafting needed to develop a comprehensive new layout plan for the various Target Hall operation activities and includes the design of new equipment. The operation activities include preparation and planning for Horn 2 move to the ME. Deliverables include procedures describing the new layout plan together with activity specific drawing sets, and a complete drawing package for the newly designed equipment. The procurement and fabrication of parts is not included in this task.**			
1.0.3.3.1.1	**Target Hall Operations Space Planning**				
1.0.3.3.1.1.1	Design New Equipment for Operations		Could include shielding support structures, additional shielding lifting fixtures, etc.	1767	1767
1.0.3.3.1.2	**Target Hall Operations Space Planning - OP**				
1.0.3.3.1.2.1	Overall Target Hall Layout for Operations			1767	1767
1.0.3.3.2	**Horn2 Re-location to Medium Energy**				
1.0.3.3.2.1	**Stripline Extension**	**This summary task covers the engineering and design/drafting needed to extend the existing Horn 2 stripline, stand and protective fence to the ME position. Most of the design will duplicate the existing stripline and support structure. Deliverables include stripline and fence layout drawings in the Target Hall, and complete drawings packages for the stripline extension, stands, and fence assemblies. The procurement and fabrication of parts is not included in this task.**			
1.0.3.3.2.1.1	Develop Stripline Layout Scheme in Target Hall			1734	1734
1.0.3.3.2.1.2	Engineering & Design of stripline extension & Stands		Includes fence considerations. Don't forget to add gate to access valves.	1734	1734
1.0.3.3.2.1.3	Create Assembly Dwgs for Stripline est & Stands			1734	1734

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.3.2.2	**Shielding Reconfiguration**	**This summary task covers the R&D, engineering, and design/drafting needed for moving Horn 2 to the ME position. Deliverables include: 1) Developing a shielding reconfiguration plan with particular emphasis on R-Block, Blue-Block & T-Block removal and staging, with a final written procedure for the work. 2) Design of a Dummy Module and associated shielding (T-Blocks, End Blocks, & Stripline Block) with complete drawing packages (these designs are based on existing equipment). 3) Design of remote lifting components with a complete drawing package. 4) Design of an air seal over the ME position to minimize air leaks from the chase cooling system, with complete layout drawings. The procurement and fabrication of parts is not included in this task.**			
1.0.3.3.2.2.1	Develop shielding reconfiguration plan		Develop detailed plan for Horn 2 Re-configuration.	1700	1700
1.0.3.3.2.2.2	Develop Blue Block & T-Block Removal/Re-location Plan		Includes remote lifting fixture & camera system assessment.	1700	1700
1.0.3.3.2.2.3	Design of Dummy Module, Associated Shielding & Remote Lifting Components			1700	1700
1.0.3.3.2.3	**Shielding Reconfiguration - OP**	**This summary task covers the removal and staging of R-blocks and radioactive downstream Blue-blocks. Procurement and fabrication of parts is not included in this task.**			
1.0.3.3.2.3.1	Removal & Storage of R-Blocks & Radioactive DS Blue Blocks			1700	1700
1.0.3.3.3	**Target Chase**				
1.0.3.3.3.1	**Target Chase Air Cooling**	**This summary task covers the R&D, engineering, and design/drafting needed for the Target Chase Air Cooling upgrades. Deliverables include: 1) MARS simulation of the target chase to determine energy deposition followed by a 3-D thermal FEA of the chase region, with the results documented in an engineering note. 2) Analyzing chase materials to determine maximum allowable temperature limits, and includes M&S for conducting actual burn tests to determine dry heat resistance of paints and primers. Results will be documented in the form of an engineering note. 3) Design of new chiller cooling coils including modifications to the existing coil box. The final drawing package will include piping layout details, valve and instrumentation specifications, control wiring diagrams, and updating of the existing controls. 4) Design of a new water chiller surface unit and piping to be installed in MI-65. The final drawing package will include piping layout details, valve and instrumentation specifications, control wiring diagrams, and updating of the existing controls. The procurement and fabrication of parts is not included.**			
1.0.3.3.3.1.1	MARs Simulations for Energy Deposition			1465	1465
1.0.3.3.3.1.2	FEM 3-D Thermal Analysis		3D thermal model of chase w/some detail of components. Includes energy deposition model.	1465	1465

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.3.3.1.3	Analyze all components & chase items for temperature limits			1465	1465
1.0.3.3.3.1.4	Design new chiller coils		Incl modifications to chilled water closed loop skid/piping	1465	1465
1.0.3.3.3.1.5	Design New Water Chiller Surface Unit		New penetration or run through shielding block.	1465	1465
1.0.3.3.3.2	**Horn 1 Stripline Block**	**This summary task covers the R&D, engineering, and drafting needed for designing a forced air cooling system for the Horn 1 Stripline Block. Deliverables include: 1) Analyzing the stripline for higher heat loads using MARS estimates and FEA thermal/structural analysis with the results documented in an engineering note. 2) R&D to measure air cooling parameters (around a mock-up of the Horn 1 DS chase area) to determine the level of forced cooling required. M&S has been included for this work. 3) Design of forced air cooling of the Horn 1 chase stripline assembly with a complete drawing package specifying all equipment, hardware, and mounting details including all installation assemblies. The procurement and fabrication of parts is not included.**			
1.0.3.3.3.2.1	Analyze Horn 1 Chase Stripline for Higher Heat Loads (FEA)			1719	1719
1.0.3.3.3.2.2	Quantify Air Convection Coefficients (Testing)			1719	1719
1.0.3.3.3.2.3	Design Forced Air Cooling for Horn 1 Chase Stripline			1719	1719
1.0.3.3.3.3	**Radiant Heat Loads**	**This summary task covers the engineering needed for analyzing radiant heat effects of chase blocks on chase components, and the design of additional chase temperature monitoring equipment. Deliverables include: 1) Using the existing FEA thermal model to compute the amount of radiation heat transfer from chase blocks to sensitive components (such as target, horn, & stripline assembly) with the results documented in an engineering note. 2) Identifying critical locations requiring additional temperature monitoring (e.g. modules, shielding blocks) followed by the design of mounting and routing details of temperature monitoring equipment with a complete drawing package specifying all equipment, hardware, and mounting details including all installation assemblies. The procurement and fabrication of parts is not included.**			
1.0.3.3.3.3.1	Analyze predicted block temperatures' effects on chase components			1797	1797
1.0.3.3.3.3.2	Design Additional Chase Temperature Monitoring Equipment			1797	1797
1.0.3.3.3.4	NuMI - Review & Revise Shielding Assessment			1493	1493

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.3.4	**NuMI Target Hall Infrastructure Reviews**	**This summary tasks contains several reviews of the NuMI target hall infrastructure. The infrastructure tasks include Target Hall Operations Space Planning, Horn 2 Relocation to ME, and Target Chase Cooling upgrades. A review of the conceptual designs for each summary task will occur before beginning the design work. Upon completion of the design work, but before procurement begins, a final review of each design will be done. A safety review of the Blue-Block/T-Block remote lifting fixture is also included before procurement and fabrication. These tasks include the labor needed to prepare for the review, participant and review time at the review, and the writing of a review report.**			
1.0.3.3.4.2	Target Hall Space Planning & Horn 2 Reconfiguration & Equip Initial Design Rev			1791	1791
1.0.3.3.4.4	Target Hall Chase Cooling Iniital Design Review			1791	1791
1.0.3.3.4.5	Target Hall Chase Cooling Design Review			1791	1791
1.0.3.3.4.6	Target Hall Space Planning & Horn 2 Reconfiguration & Equip Design Rev			1791	1791
1.0.3.3.5	**NuMI Target Hall Infrastructure Milestones**				
1.0.3.3.5.1	NuMI Analyze Predicted Block Temperatures Effect on Chase Components Complete	This milestone is the completion of the finite element analysis (FEA) to calculate the amount of radiation heat transfer from chase blocks to sensitive components (such as target, horn, & stripline assembly), with the results documented in an engineering note.			
1.0.3.3.5.2	NuMI Shielding Assessment Complete	This milestone is defined as the point at which the NuMI Shielding Assessment has been updated/appeneded for NOvA operation and is ready to start the approval process.			
1.0.3.3.5.3	NuMI Target Chase Cooling Design Complete	This milestone is the completion of the engineering analysis, design, and drafting of the Target Chase Air Cooling upgrades. It includes completion of the following tasks: 1) Design of new chiller cooling coils including modifications to the existing coil box, with a final drawing package that includes piping layout details, valve and instrumentation specifications, control wiring diagrams, and updating of the existing controls. 2) Design of a new water chiller surface unit and piping to be installed in MI-65, with a final drawing package that includes piping layout details, valve and instrumentation specifications, control wiring diagrams, and updating of the existing controls. After this milestone, the design is ready for review and procurement of parts.			
1.0.3.3.5.11	NuMI FEM 3-D Thermal Analysis Complete	This milestone is the completion of the 3-D thermal Finite Element Analysis (FEA) of the target chase region, with results documented in an engineering note.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.4	**NuMI Decay Pipe/Hadron Absorber/Utilities**	**This task covers the verification and analysis of the total cooling needs for NuMI cooling systems (RAW and non-RAW) deciding the appropriateness of all planned cooling system modifications, and the engineering of said modifications. This also includes engineering and design/drafting effort required to analyze the electrical capacities of the current Cooling Systems, and compare with the expected electrical requirements under the 700kW operation conditions. The design reviews associated with these items is included.**			
1.0.3.4.1	**NuMI RAW Systems**	**This task covers the verification and analysis of the total cooling needs for all NuMI RAW systems, deciding the appropriateness of all planned cooling system modifications, and the engineering of said modifications. This includes instrumentation, pump and heat exhanger capacities, pipe line sizing, ejector pump performance improvements, etc.**			
1.0.3.4.1.1	**Target RAW**		**RAW system expected to handle 700kW, needs study - find references for energy deposition on LE and ME target**		
1.0.3.4.1.1.1	Design Target RAW Instrumentation Upgrade			1701	1701
1.0.3.4.1.2	**Horns RAW**				
1.0.3.4.1.2.1	Analyze horn 1 & horn 2 RAW system capacities			1701	1701
1.0.3.4.1.2.2	Design Horn 1 RAW Skid Upgrade			1701	1701
1.0.3.4.1.2.3	Design Horn 2 RAW Skid Upgrade			1701	1701
1.0.3.4.1.3	**Horn 2 RAW Piping**				
1.0.3.4.1.3.1	Engineering & Design of RAW piping extension for Horn 2 Move			1701	1701
1.0.3.4.1.4	**Decay Pipe RAW**				
1.0.3.4.1.4.1	Design Decay Pipe US & DS RAW skid upgrade			1701	1701
1.0.3.4.1.5	**Hadron Absorber RAW & Intermediate**				
1.0.3.4.1.5.1	Document Hadron Absorber for Full Beam Accident Condition			1701	1701
1.0.3.4.1.5.2	Analyze Hadron Absorber for normal long term operation at 700 KW			1701	1701
1.0.3.4.1.5.3	Design Hadron Absorber skids upgrade			1701	1701
1.0.3.4.2	**NuMI Cooling Water (Non RAW)**	**This task covers the verification and analysis of the total cooling needs for all NuMI Non RAW systems, deciding the appropriateness of all planned cooling system modifications, and the engineering of said modifications. These include the LCW system at MI-62, ICW from CUB, and Ground Water from the NuMI enclosure. This work includes instrumentation, pump and heat echanger capacities, pipe line sizing, other performance improvements, etc.**			
1.0.3.4.2.1	**LCW**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.3.4.2.1.1	Analyze LCW capacity		Flow and heat capacity. Includes pond H capacity.	1740	1740
1.0.3.4.2.1.2	Design LCW Upgrade			1740	1740
1.0.3.4.2.2	**CUB**				
1.0.3.4.2.2.1	Analyze CUB chilled water capacity			1740	1740
1.0.3.4.2.2.2	Design CUB Upgrade			1740	1740
1.0.3.4.2.3	**NuMI Sump Cooling Water System Capacity**				
1.0.3.4.2.3.1	Analyze NuMI Sump Cooling Water System Capacity			1740	1740
1.0.3.4.2.3.2	Design NuMI Sump Cooling Water System Upgrade			1740	1740
1.0.3.4.2.4	**MI-65 Secondary Chilled water capacity**				
1.0.3.4.2.4.1	Analyze Secondary Chilled Water Capacity			1740	1740
1.0.3.4.2.4.2	Design Secondary Skid Upgrade			1740	1740
1.0.3.4.3	**NuMI Electrical Infrastructure**	**This covers the engineering and design/drafting effort required to analyze the electrical capacities of the current Cooling Systems, and compare with the expected electrical requirements under the 700kW operation conditions. Differences in capacities are due to upgrades to the Cooling Systems with larger pumps or other equipment which may require higher electrical loads to operate.**			
1.0.3.4.3.1	Analyze & Design Elect Capacity Upgrades for 700kW, Downstream Systems			1805	1805
1.0.3.4.3.2	Analyze & Design Elect Capacity Upgrades for 700kW, Upstream Systems			1805	1805
1.0.3.4.4	**NuMI Decay Pipe/Hadron Absorber/Utilities Reviews**	**This summary tasks contains several reviews of the NuMI Decay Pipe/Hadron Absorber and Utilities. A review of the conceptual designs for each summary task will occur before beginning the design work. Upon completion of the design work, but before procurement begins, a final review of these sytems will be done. These tasks include the labor needed to prepare for the review, participant and review time at the review, and the writing of a review report.**			
1.0.3.4.4.1	Decay Pipe & Absorber Initial Design Review			1790	1790
1.0.3.4.4.2	NuMI Cooling Systems Initial Design Review			1790	1790
1.0.3.4.4.3	NuMI Utilities Systems & RAW Design Review		RAW Systems, Cooling Water Systems & Electrical	1790	1790
1.0.4	**Beam Physics**	**This summary task is to evaluate the efficacy of Proton Plan upgrades as applied to the ANU project, to perform preparative beam physics measurements, calculations, and simulations of the eventual ANU operation, and to establish and maintain a method of extrapolation to estimate future ANU proton production.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.4.1	**ANU Demands on Proton Plan**	**This summary task is for the evaluation of the efficacy of Proton Plan upgrades as applied to the ANU project. Some of the performance upgrades from the Proton Plan are necessary for ANU; these tasks evaluate the progress towards improvement before the ANU installations occur, and perhaps before the Proton Plan commissioning is complete. Included are labor for physics and mechanical analysis.**			
1.0.4.1.1	Evaluate Booster Performance for ANU			1763	1763
1.0.4.1.2	Evaluate MI-8 Collimator Performance for ANU			1763	1763
1.0.4.1.3	Evaluate Slip-Stacking Performance for ANU			1763	1763
1.0.4.1.4	Evaluate MI Collimator Performance for ANU			1763	1763
1.0.4.2	**Machine & Process Analysis**	**This summary task is to perform preperative beam physics measurements, calculations, and simulations of the eventual ANU operation. These results will be documented in a source book that will be used as reference in commissioning and operation. The tasks consist of mostly physics labor for analysis, but also engineer/technician labor and M&S for instrumentation.**			
1.0.4.2.1	Slip-Stacking Simulation & Optimization for the Recycler			1764	1764
1.0.4.2.2	Recycler & MI Beam Dynamics Simulation			1764	1764
1.0.4.2.3	MI Machine Measurements			1764	1764
1.0.4.2.4	MI Loss Pattern Measurement			1764	1764
1.0.4.2.5	Recycler Machine Measurements			1764	1764
1.0.4.2.6	Electron Cloud Measurement in MI & RR			1764	1764
1.0.4.2.7	Electron Cloud Simulation & Analysis for ANU			1764	1764
1.0.4.2.8	Transfer Line Simulation			1764	1764
1.0.4.2.9	Beam Cleaning Analysis			1764	1764
1.0.4.2.10	Establish Detailed ANU Loss Patterns			1764	1764
1.0.4.3	**Proton Plan Projections**	**This summary task is to establish and maintain a method of extrapolation to estimate future ANU proton production. The extrapolation will be based on design specifications and perfromance measurements of the operating complex. This task will require only physicist labor.**			
1.0.4.3.1	Develop Beam Performance Metrics			1765	1765
1.0.4.3.2	Maintain Measurements & Predictions of Performance			1765	1765
1.0.4.4	**Beam Physics Milestones**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.0.4.4.1	Estimate Limits of Proton Plan Performance	Complete an analysis of the achieved Proton Plan performance and extrapolate its ultimate performance. In particular, several major items of the Proton Plan are evaluated in terms of the anticipated usage in ANU. This is an interim analysis that occurs after all the Proton Plan improvements have been implemented, but before all their gains have been realized. Therefore, a certain amount of extrapolation may be necessary to evaluate them for ANU. One or more reports are generated that document the Proton Plan performance and the ANU extrapolation.			
1.0.4.4.2	Beam Physics Preparative Analysis Complete	All of the general beam physics studies for ANU are completed and documented. The preparative analyses are studies needed to facilitate commissioning and operation of ANU; they involve experimental characterization of the accelerators, optimization and detailing of the ANU stacking scheme, and simulation of intense beam dynamics. One or more reports are generated to document the studies.			
1.0.5	**Project Management**	**This WBS details the management and administrative resources required by ANU during FY07. It includes administrative costs such as travel, computers, training, reviews. Labor for PM, deputy PM, L3, L4 mgrs, project engineers.**			
1.0.5.1	**Fermi Management & Administration**	**This WBS details the management and administrative resources required by ANU during FY07. It includes administrative costs such as travel, computers, training, reviews. Labor for PM, deputy PM, L3, L4 mgrs & project engineers.**			
1.0.5.1.1	Management & Administration - 1HFY07		WBS Description: This details the management and administrative resources required by the Project for the applicable fiscal year. M&S BOE: Admin costs such as computers, software, Review preparation, etc. - $5,000 Travel for inspections, meetings, Reviews, training, etc. - $10,000 Overall having to hire contract techs:assume 2 MT full time - $158,000 Contingency factor includes additional personnel needs if labor becomes M&S due to needing to hire outside people. Labor BOE (costs for managing MIE only): FNAL Physicists = five L2 managers@30%, plus PM @ 100% Mechanical Engineer at 15% = Rob Reilly Electrical Engineer at 15% = Bob Ducar Schedule BOE: N/A Comments/Changes:	1683	1683
1.0.5.1.2	Management & Administration - 2HFY07			1683	1683
1.1	**Site and Building**				
1.1.1	**Site Conditions Investigation**	**Site Conditions Investigation consists of the tasks required to provide a comprehensive understanding of the site conditions.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.1.1	**Topographic Survey**	**This task will result in a topographic survey of the project site and access road to determine the planimetric location and topographic relief of features in three dimesnions. The survey will be suitable for use in subsequent design development of the access road, enclosure and building**		**Cost Estimate based on estimate of $1,500 per acre for survey for 40 acres Report Preperation is assumed to be 25% of the total**	**FESS/E support of consultant based on 25% of consultant cost and includes site visits during execution**
1.1.1.1.1	Prepare request for proposal				
1.1.1.1.2	Issue request for proposal				
1.1.1.1.3	Review received proposals				
1.1.1.1.4	Write requisition				
1.1.1.1.5	Circulate requisition 187068				
1.1.1.1.6	Prepare purchase order 569167				
1.1.1.1.7	Purchase order released				
1.1.1.1.8	Survey site				
1.1.1.1.9	Prepare report				
1.1.1.1.10	Topographic survey complete				
1.1.1.2	**Subsurface Investigation**	**This task will perform a subsurface investigation including a borings, water level tests and related work required to better understand the subsurface conditions**		**Subsurface Investigation estimate based on Short Elliot & Hendrickson proposal dated 7/13/06 for $149,780. Assume 25% of total is for report preperation**	**FESS/E support of consultant is based on 18% of consultant cost. Assumes Site Visit during field work**
1.1.1.2.1	Prepare request for proposal				
1.1.1.2.2	Issue request for proposal				
1.1.1.2.3	Review received proposals				
1.1.1.2.4	Write requisition				
1.1.1.2.5	Circulate requisition 188912				
1.1.1.2.6	Prepare purchase order				
1.1.1.2.7	Purchase order released 570728				
1.1.1.2.8	Perform subsurface borings				
1.1.1.2.9	Prepare report				
1.1.1.2.10	Subsurface investigation completed				
1.1.1.3	**Wetland Delineation**	**This task will deliniate the wetland located on the project site and access roads and prepare**		**Wetland Delineation estimate based on proposal from Short Elliot & Hendrickson proposal dated 06/16/06. Assume 25% of total is used for report writing**	**FESS/E support of consultant is based on 25% of consultant cost**
1.1.1.3.1	Prepare request for proposal				
1.1.1.3.2	Issue request for proposal				
1.1.1.3.3	Review received proposals				
1.1.1.3.4	Write requisition				
1.1.1.3.5	Circulate requisition 188169				
1.1.1.3.6	Revise purchase order 564502				
1.1.1.3.7	Purchase order released 564502				
1.1.1.3.8	Perform wetland delineation				
1.1.1.3.9	Prepare report	See NOVA-doc-1459 for report			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.1.3.10	Prepare report - 2HFY07				
1.1.1.3.11	Wetland delineation completed				
1.1.1.4	**Revise Ash River Environmental Assessment Worksheet**	**This task will revise the existing EAW to reflect site and subsurface conditions identified during site conditions investigation**		**Revisions to EAW based on letter from Short Elliot Hendrickson, dated 06/22/06 stating that they could accommodate the updating within the original purchase order amount. The equaled $27,000 . Assume 25% of total is used for report writing**	**Assume support of consultant will require 25% of the consultant cost. This is based on experience of developing initial EAW.**
1.1.1.4.1	Prepare request for proposal				
1.1.1.4.2	Issue request for proposal				
1.1.1.4.3	Review received proposals				
1.1.1.4.4	Gather data				
1.1.1.4.5	Revise existing EAW				
1.1.1.4.6	NOvA project review				
1.1.1.4.7	Finalize report				
1.1.1.4.8	EAW revisions completed				
1.1.2	**Title 1 Preparation**	**Document Development continues the development of the conceptual design and includes selecting and integrating building systems and materials, developing installation details focused on constructability, and describing the details with technically precise drawings and specifications.**		**Assumes that this Document Development will be 3% of Construction Cost. Assumed that 75% of the Document Development Total will be done by consultants.**	**Assumes that this Document Development will be 3% of Construction Cost. Assumed that 25% of the Document Development Total will be done with in-house forces.**
1.1.2.1	**Site Preparation Advanced Conceptual Design**	**Advanced Technical Design for the Site Preparation package includes the work required to continue design development of the road and site work to produce a design that accommodate known site features and design criteria. The Site Preparation package includes the Brightstar access road, clearing and grubbing the site and excavating the roack for the building.**		**Based on a proposal from Burns and McDonnell, dated 07/17/06 for $260,000**	**Assumes that support of A/E will require 18% of A/E fee**
1.1.2.1.1	Prepare request for proposal				
1.1.2.1.2	Issue RFP				
1.1.2.1.3	Review received proposal				
1.1.2.1.4	Prepare requisition 189633				
1.1.2.1.5	Circulate for signature				
1.1.2.1.6	Prepare purchase order 571506				
1.1.2.1.7	PO released				
1.1.2.1.8	Hold kickoff meeting				
1.1.2.1.9	Prepare drawings				
1.1.2.1.10	Prepare specifications				
1.1.2.1.11	Prepare cost estimate				
1.1.2.1.12	Assemble, print, and distribute documents				
1.1.2.1.13	Comment and compliance review				
1.1.2.1.14	Revise drawings				
1.1.2.1.15	Revise specifications				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.2.1.16	Revise cost estimate				
1.1.2.1.17	Assemble, print, and distribute documents				
1.1.2.1.18	Quality assurance review				
1.1.2.1.19	Finalize documents				
1.1.2.1.20	Assemble, print, and distribute documents				
1.1.2.1.21	Site preparation ACD completed				
1.1.2.2	**Building Design Modifications**	**Building Design Modificiations include the work required to update the Conceptual Design documents to a 30% or Title 1 level.**		**Based on a proposal from Burns and McDonnell, dated 10/25/06 for $486,000**	**Assumes that support of A/E will require 18% of A/E fee**
1.1.2.2.1	Prepare request for proposal				
1.1.2.2.2	Issue RFP				
1.1.2.2.3	Review received proposal				
1.1.2.2.4	Prepare requisition				
1.1.2.2.5	Circulate for signature				
1.1.2.2.6	Prepare purchase order				
1.1.2.2.7	PO released				
1.1.2.2.8	Hold kickoff meeting				
1.1.2.2.9	Review background information				
1.1.2.2.10	Suspend building design modifications	Based on preliminary cost estimate, the work on the building design modifications was halted in January 2007.			
1.1.2.2.11	**Value Engineering**				
1.1.2.2.11.1	Brainstoming session				
1.1.2.2.11.2	Investigate alternatives				
1.1.2.2.11.3	Review alternatives				
1.1.2.2.11.4	Document suggestions				
1.1.2.2.11.5	Value engineering completed				
1.1.2.2.12	**Document Revisions**				
1.1.2.2.12.1	Kickoff meeting				
1.1.2.2.12.2	Revise drawings				
1.1.2.2.12.3	Project review				
1.1.2.2.12.4	Incorporate revisions				
1.1.2.2.12.5	Assemble, print, and distribute documents				
1.1.2.2.12.6	Document revisions completed				
1.1.2.2.12.7	Resume building design modifications				
1.1.2.2.12.8	Kickoff meeting				
1.1.2.2.12.9	Review background information				
1.1.2.2.12.10	Prepare drawings				
1.1.2.2.12.11	Prepare specifications				
1.1.2.2.12.12	Prepare cost estimate				
1.1.2.2.12.13	Assemble, print, and distribute documents				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.2.2.12.14	Comment and compliance review				
1.1.2.2.12.15	Revise drawings				
1.1.2.2.12.16	Revise specifications				
1.1.2.2.12.17	Revise cost estimate				
1.1.2.2.12.18	Assemble, print and distribute documents				
1.1.2.2.12.19	Quality assurance review				
1.1.2.2.12.20	Finalize documents				
1.1.2.2.12.21	Assemble, print and distribute documents				
1.1.2.2.13	Building design modifications completed				
1.1.2.3	Title 1 preparation complete				
1.1.3	(Retired)	Logistics is the process of planning, implementing and controlling the support functions of the project site during the construction phase including site utilities, maintenance, safeguards and security. The R&D Phase will investigate the requirements for the site logistics		Assume Site Logistics in R&D Phase is .2% of comstruction cost. Assume 75% of the total is consultant cost.	
1.1.4	**Management - R&D Phase**	**Management for the R&D phase includes oversight of associated tasks as well as studies and investigations to verify choices or options**		**Assumes R&D Management costs are 0.8% of construction total. Assume 75% of costs will be costed by consultants. Assume cost will be spread evenly over each study.**	**Assumes R&D Management costs are 0.8% of construction total. Assume 25% of costs will be costed by in-house forces. Assume cost will be spread evenly over each study.**
1.1.4.1	**Independent Cost Estimate Review**	**This task will develop independent cost estimates for the Advanced Technical Design of the Site Preperation package and the current status of the Far Detector Building**			
1.1.4.1.1	**Initial Cost Estimate Review**	**This task is the initial cost estimate/schedule review of the Conceptual Design Review documents.**		**This task is based on a proposal from Burns and McDonnell, dated 03/22/06**	**Assumes that support of A/E will require 18% of A/E fee**
1.1.4.1.1.1	Prepare request for proposals				
1.1.4.1.1.2	Issue RFP				
1.1.4.1.1.3	Review proposals				
1.1.4.1.1.4	Write requsition				
1.1.4.1.1.5	Circulate requisition for signatures 186695				
1.1.4.1.1.6	Prepare purchase order				
1.1.4.1.1.7	Purchase order issued 568988				
1.1.4.1.1.8	Prepare request for schedule review				
1.1.4.1.1.9	Issue RFP				
1.1.4.1.1.10	Review proposal				
1.1.4.1.1.11	Write requistion 187494				
1.1.4.1.1.12	Circulate requisition for signatures				
1.1.4.1.1.13	Modify purchase order 568988				
1.1.4.1.1.14	Hold kickoff meeting				
1.1.4.1.1.15	Review background information				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.4.1.1.16	Develop draft report				
1.1.4.1.1.17	Project review of draft report				
1.1.4.1.1.18	Finalize report	See NOVA-doc-1108-v2 for report			
1.1.4.1.1.19	ICE review completed				
1.1.4.1.2	**Update Cost Estimate**	**This task included an update of the July 2006 cost estimate to reflect the current design of the Site Preparation package and the 14DEC06 design revisions**		**This work completed by Burns and McDonnell under WBS 1.1.2.2**	
1.1.4.1.2.1	Kickoff meeting				
1.1.4.1.2.2	Revise cost estimate				
1.1.4.1.2.3	Internal project review				
1.1.4.1.2.4	Cost estimate update completed				
1.1.4.1.3	**Cost Estimate and Schedule Revisions**				
1.1.4.1.3.1	**Burns and McDonnell**				
1.1.4.1.3.1.1	Kickoff meeting				
1.1.4.1.3.1.2	Revise cost estimate				
1.1.4.1.3.1.3	Update schedule				
1.1.4.1.3.1.4	Internal project review				
1.1.4.1.3.1.5	Revision completed				
1.1.4.1.3.2	**J.E.Dunn-North Central**	**In order to provide real world estimating experience, J.E. Dunn was recommended by the University of Minnesota as a reliable resource for this type of estimating work. Their scope included the development of a bottoms up cost estimate and schedule projection**		**Cost for this work was based on a proposal from J.E. Dunn, dated 3/20/07**	**Cost for FESS/E based on previous experience on cost estimating support and two office visits to JE. Dunn offices in Eden Prairie, MN.**
1.1.4.1.3.2.1	Prepare request for proposals				
1.1.4.1.3.2.3	Review proposals				
1.1.4.1.3.2.4	Write requsition (193708)				
1.1.4.1.3.2.5	Circulate requisition for signatures				
1.1.4.1.3.2.6	Prepare purchase order				
1.1.4.1.3.2.7	Purchase order issued (PO 57444)				
1.1.4.1.3.2.8	Hold kickoff meeting				
1.1.4.1.3.2.9	Review background information				
1.1.4.1.3.2.10	Develop draft estimate				
1.1.4.1.3.2.11	Develop draft schedule				
1.1.4.1.3.2.12	Project review of draft report				
1.1.4.1.3.2.13	Finalize documents				
1.1.4.1.3.2.14	A/E cost estimate completed				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.4.1.3.3	**Constructive Ideas**	**In order to provide real world estimating experience, Constructive Ideas was recommended by a contractor familar with the University of Minnesota as a reliable resource for this type of estimating work. Their scope included the development of a bottoms up cost estimate and schedule projection**		**Cost for this work was based on a proposal from Constructive Ideas proposal dated 04/02/07**	**Cost for FESS/E based on previous experience on cost estimating support and one office visits to Constructive Ideas offices inSt. Paul, MN.**
1.1.4.1.3.3.1	Prepare request for proposals				
1.1.4.1.3.3.3	Review proposals				
1.1.4.1.3.3.4	Write requsition (193688)				
1.1.4.1.3.3.5	Circulate requisition for signatures				
1.1.4.1.3.3.6	Prepare purchase order				
1.1.4.1.3.3.7	Purchase order issued (PO 57428)				
1.1.4.1.3.3.8	Hold kickoff meeting				
1.1.4.1.3.3.9	Review background information				
1.1.4.1.3.3.10	Develop draft estimate				
1.1.4.1.3.3.11	Develop draft schedule				
1.1.4.1.3.3.12	Project review of draft report				
1.1.4.1.3.3.13	Finalize documents				
1.1.4.1.3.3.14	A/E cost estimate completed				
1.1.4.2	**Secondary Containment Study**	**This study will investigate the epoxy coating on the concrete walls as seconard containment and report on the reliability of the system or other proposed methods**		**Task based on a proposal from Burns and McDonnell dated 4/13/06**	**FESS/E support based on minimal support of A/E**
1.1.4.2.1	Prepare request for proposals				
1.1.4.2.2	Issue RFP				
1.1.4.2.3	Review proposals				
1.1.4.2.4	Write requsition				
1.1.4.2.5	Circulate requsition for signatures 186834				
1.1.4.2.6	Prepare purchase order				
1.1.4.2.7	Purchase order issued 568982				
1.1.4.2.8	Hold kickoff meeting				
1.1.4.2.9	Review background information				
1.1.4.2.10	Develop draft report				
1.1.4.2.11	Project review of draft report	See NOVA-doc-1121-v3 for report			
1.1.4.2.12	Finalize report				
1.1.4.2.13	Secondary containment study completed				
1.1.4.3	**Overburden Study**	**The VM task will study means and methods of balancing the cut and fill for the detector enclosure**			
1.1.4.3.1	Perform study				
1.1.4.3.2	Perform study - 2HFY07				
1.1.4.3.3	Write report				
1.1.4.3.4	Overburden study completed				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.1.4.4	FY06 Site and Building R&D			Line item to approximately cover FESS YTD R&D actuals (Oct05-Mar06), since activities prior to April 06 were removed when Design/Build schedule was instituted.	
1.1.4.5	**Risk Management Assessment**				
1.1.4.5.1	Develop action plan				
1.1.4.5.2	Present plan at collaboration meeting				
1.1.4.5.3	Develop risks				
1.1.4.5.4	Risk identification activity				
1.1.4.5.5	Risk analysis activity				
1.1.4.5.6	Present preliminary results				
1.1.4.5.7	Finalize analysis				
1.1.4.5.8	Finalize risk assessment forms				
1.1.4.5.9	Risk management assessment completed				
1.1.4.6	FY07 Site and Building R&D			Line item to approximately cover FESS YTD R&D actuals (Oct05-Mar06), since activities prior to April 06 were removed when Design/Build schedule was instituted.	
1.2	**Liquid Scintillator R&D**				
1.2.1	Requirements	Requirements document detailing experiment requirements on the liquid scintillator			
1.2.2	**Scintillator Composition Studies**	**studies of light yield as a function of pseudocumene content; studies of light yield as a function of fluor (PPO, POPOP, bis-MSB) content; simulations of requirements on mineral oil attenuation length; measurements of mineral oil attenuation length; studies of light yield in an a-cell; studies of light yield in a test extrusion cells with scintillator mixed with mineral oil of varying attenuation lengths**			
1.2.2.1	Study light yield as a function of pseudocumene content	accelerated aging studies of the effect of pseudocumene content on fiber; accelerated aging studies of the effect of pseudocumene content on PVC; accelerated aging studies of the effect of pseudocumene content on glue joints			
1.2.2.2	Study light yield as a function of fluor content				
1.2.2.3	Study light yield in an alpha-cell				
1.2.2.4	Study mineral oil attenuation length requirements via simulations				
1.2.2.5	Study mineral oil attenuation length of samples				
1.2.2.6	Produce scintillator for light yield studies in test extrusion cells				
1.2.2.7	Continue scintillator composition studies - value engineering - 1HFY07				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.2.8	Continue scintillator composition studies - value engineering - 2HFY07				
1.2.3	**Accelerated Aging Studies**	**studies of the effect of pseudocumene content on fiber; studies of the effect of pseudocumene content on PVC; studies of the effect of pseudocumene content on glue joints**			
1.2.3.1	Study effects of psuedocumene on fiber				
1.2.3.2	Study effects of psuedocumene on PVC				
1.2.3.3	Study effects of psuedocumene on glue joints				
1.2.3.4	Continue accelerated aging studies - value engineering - 1HFY07				
1.2.3.5	Continue accelerated aging studies - value engineering - 2HFY07				
1.2.4	**Scintillator Production Method Studies**	**Development of plan for scintillator production at Fermilab (a) production of complete scintillator with premixed fluors (Eljen or Bicron) + mineral oil - mixing fluor mix with mineral oil (b) production of complete scintillator from mineral oil, psuedocumene, & waveshifters - mixing waveshifters and pseudocumene - mixing fluor mix with mineral oil**			
1.2.4.1	Study mixing methods for waveshifters and pseudocumene - FY06				
1.2.4.2	Study mixing methods for waveshifters and pseudocumene - 1HFY07				
1.2.4.3	Study mixing methods for waveshifters and pseudocumene - 2HFY07				
1.2.4.4	Study mixing methods for fluor (pre) mix with mineral oil - FY06				
1.2.4.5	Study mixing methods for fluor (pre) mix with mineral oil - 1HFY07				
1.2.4.6	Study mixing methods for fluor (pre) mix with mineral oil - 2HFY07				
1.2.5	**Development of QC Methods**	**develop reliable, accurate QC testing procedures for mineral oil arriving at mixing facility; develop reliable, accurate QC testing procedures for pseudocumene arriving at mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the mixing facility; develop reliable, accurate QC testing procedures for testing mixed scintillator light yield at the far detector site**			
1.2.5.1	**Procedures**				
1.2.5.1.1	Develop test procedures for mineral oil delivered from vendor - FY06				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.5.1.2	Develop test procedures for psuedocumene delivered from vendor				
1.2.5.1.3	Develop test procedures for waveshifters delivered from vendor				
1.2.5.1.4	Develop test procedures for mixed scintillator at mixing facility				
1.2.5.1.5	Develop test procedures for mixed scintillator delivered to far detector site				
1.2.5.1.6	Continue QC procedure development - value engineering - 1HFY07				
1.2.5.1.7	Continue QC procedure development - value engineering - 2HFY07				
1.2.5.2	**QC Hardware Development**				
1.2.5.2.1	**QC Hardware Development - IU**				
1.2.5.2.1.1	Design				4 hours per week
1.2.5.2.1.2	Procure			tintometer: $15k light yield tester, two attenuation length testers: $20K	8 hours per week tech time.
1.2.5.2.1.3	Fabricate				8 hours per week tech time.
1.2.5.2.1.4	Evaluate - FY06				8 hours per week tech time
1.2.5.2.1.5	Evaluate - 1HFY07				8 hours per week tech time
1.2.5.2.1.6	Evaluate - 2HFY08				8 hours per week tech time
1.2.5.2.2	**QC Hardware Development - SMU**				
1.2.5.2.2.1	Design				
1.2.5.2.2.2	Procure				
1.2.5.2.2.3	Fabricate				
1.2.5.2.2.4	Evaluate-1HFY07				
1.2.5.2.2.5	Evaluate-2HFY07				
1.2.6	**Scintillator Transportation Studies**	**delivering: mineral oil to Fermilab production facility by truck or rail delivering: (a) premix from Eljen or Bicron to the Fermilab production facility, or (b) fluors by commercial shipper and pseudocumene by truck or rail to the Fermilab production facility delivering: mixed scintillator 'just-in-time' to (a) near detector by truck (b) far detector by rail or truck if optimum procedure is to deliver scintillator by rail to far detector, delivery of mixed scintillator from rail head to experiment specifications: (a) for heated tankers (truck or rail) for mineral oil and mixed scintillator (b) for heated ISO tankers**			
1.2.6.1	**Studies of Transport to Mixing Facility**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.6.1.1	Study transport of mineral oil to mixing facility - FY06				
1.2.6.1.2	Study transport of mineral oil to mixing facility - 1HFY07				
1.2.6.1.3	Study transport of mineral oil to mixing facility - 2HFY07				
1.2.6.1.4	Study transport of psuedocumene to mixing facility FY06 -				
1.2.6.1.5	Study transport of fluors to mixing facility - FY06				
1.2.6.2	**Studies of Transport to Detector Sites**				
1.2.6.2.1	Study transport methods to near detector site - FY06				
1.2.6.2.3	Study transport methods to far detector site - FY06				
1.2.6.2.4	Study transport methods to far detector site - 1HFY07				
1.2.6.2.5	Study transport methods to far detector site - 2HFY07				
1.2.7	**Blending Investigations**	**Bicron (Saint-Gobain) for mixed scintillator -- can they produce enough materail to our specs? Q/C? Eljen or Bicron for premix -- can they make it to our specs? How will they handle Q/C on quantities they have probably not dealt with Mineral oil for premix or homebrew -- Penrico, Sonneborne, ... -- RFP already released Pseudocumene for homebrew -- RFP in draft form PPO, POPOP, bis-MSB form Curtisslab or European vendor -- RFP to be released**			
1.2.7.1	Investigate toll blenders - FY06				
1.2.7.2	Investigate in-house blending option - FY06				
1.2.7.3	Continue blending option investigations - 1HFY07				
1.2.7.4	Baseline blending option selected				
1.2.7.5	Continue blending option investigations - 2HFY07				
1.2.8	**Component Aquisition Investigations**				
1.2.8.1	**Mineral Oil Vendors**				
1.2.8.1.1	Investigate mineral oil vendors				
1.2.8.1.2	Prepare and issue RFP for mineral oil				
1.2.8.1.3	Evaluate vendor proposals for mineral oil				
1.2.8.1.4	Continue investigation of mineral oil vendors for production - 1HFY07				
1.2.8.1.5	Continue investigation of mineral oil vendors for production - 2HFY07				
1.2.8.2	**Pseudocumene Vendors**				
1.2.8.2.1	Investigate pseudocumene vendors				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.8.2.2	Prepare and issue RFP for pseudocumene				
1.2.8.2.3	Evaluate vendor proposals for pseudocumene				
1.2.8.2.4	Continue investigation of pseudocumene vendors for production - 1HFY07				
1.2.8.2.5	Continue investigation of pseudocumene vendors for production - 2HFY07				
1.2.8.3	**Waveshifter Vendors**				
1.2.8.3.1	Investigate waveshifter vendors				
1.2.8.3.2	Prepare and issue RFP for waveshifters				
1.2.8.3.3	Evaluate vendor proposals for waveshifters				
1.2.8.4	**Premix Vendors**				
1.2.8.4.1	Investigate premixed fluor vendors				
1.2.8.4.2	Prepare and issue RFP for premixed fluors				
1.2.8.4.3	Evaluate vendor proposals for premixed fluors				
1.2.8.5	**Complete Scintillator Vendors**				
1.2.8.5.1	Investigate scintillator vendors				
1.2.8.5.3	Prepare and issue RFP for scintillator				
1.2.8.5.4	Evaluate vendor proposals for scintillator				
1.2.9	**Integration Prototype Detector Scintillator Production**	**delivery of scintillator components to Fermilab production facility production of mixed scintillator - fluors + mineral oil, or - waveshifters, pseudocumene, mineral oil delivery of mixed scintillator to the integration prototype near detector**			
1.2.9.1	**ISO Tanks**				
1.2.9.1.1	Investigate tank vendors				
1.2.9.1.2	Prepare purchase req and PO				
1.2.9.1.3	PO issued for ISO tanks				
1.2.9.1.4	ISO tanks delivery and leasing			5 ISO tanks from january07-prototype filling which is assumed to be completed by july1,07; 2 ISOs from april07-july07; 1 ISO june 07 5 ISOs (2 mineral oil, 1 pseudo, 2 mixed scint) + chassis x $24 ISO/day x 180 days = $21.6k 2 ISOs (mixed scint) + chassis x $24/day x 90 days = $4.32k 1 ISO (mixed scint) x $12/day x 30 days = $0.36k 8 ISOs x $1k cleaning fee = $8k ---------- total: = $34.28k	
1.2.9.2	**Infrastructure**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.9.2.1	**Secondary Containment For Blending Facility**				
1.2.9.2.1.1	Purchase secondary containment			$7k per berm for an isotank x 4 tanks = $28k (1 tank pseudocumene, 1 tank mineral oil, 1 tank blended scintillator, 1 for excess oil)	
1.2.9.2.1.2	Set up and install secondary containment				
1.2.9.2.2	**Blending System**				
1.2.9.2.2.1	Design IPND blending system				
1.2.9.2.2.2	Procure blending system parts (pumps, hoses, instrumentation, scales)				
1.2.9.2.2.3	Assemble blending system				
1.2.9.2.2.4	Electrical hook-up of blending system				
1.2.9.2.3	Procure fire protection equipment			8 extinguishers x $62.50 per = $0.5k	
1.2.9.2.5	Commission blending system				
1.2.9.2.6	Prototype blending system facility completed				
1.2.9.2.7	Decommission prototype blending infrastructure				
1.2.9.2.8	Prepare specifications for production blending facility				
1.2.9.3	**Mineral Oil**				
1.2.9.3.3	Prepare purchase req and PO				
1.2.9.3.4	Mineral oil PO issued				
1.2.9.3.5	Deliver batch 1			2 x 4520 gals x3.50 per gal = 31,640	
1.2.9.3.6	Mineral oil batch 1 for IPND delivered				
1.2.9.3.7	QC batch 1				
1.2.9.3.8	Deliver batch 2			2 x 4520 gals x3.50 per gal = 31,640	
1.2.9.3.9	Mineral oil batch 2 for IPND delivered				
1.2.9.3.10	QC batch 2				
1.2.9.3.11	Deliver batch 3			3642 gallons at 3.50 per gal = 12,747	
1.2.9.3.12	Mineral oil batch 3 for IPND delivered				
1.2.9.3.13	QC batch 3				
1.2.9.4	**Pseudocumene**				
1.2.9.4.1	**Pseudocumene- vendor 1**				
1.2.9.4.1.1	Prepare purchase req and PO				
1.2.9.4.1.2	Pseudocumene PO issued				
1.2.9.4.1.3	Deliver pseudocumene				
1.2.9.4.1.4	QC pseudocumene				
1.2.9.4.2	**Pseudocumene- vendor 2**				
1.2.9.4.2.1	Prepare purchase req and PO				
1.2.9.4.2.2	Pseudocumene PO issued				
1.2.9.4.2.3	Deliver pseudocumene				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.9.4.2.4	QC pseudocumene				
1.2.9.5	**Waveshifters**				
1.2.9.5.1	Prepare purchase req and PO				
1.2.9.5.2	Waveshifter PO issued				
1.2.9.5.3	Deliver waveshifters				
1.2.9.5.4	QC waveshifters				
1.2.9.6	**Blending**				
1.2.9.6.1	Blend psuedocumene and waveshifters-batch 1				
1.2.9.6.2	QC fluor blend-batch 1				
1.2.9.6.3	Blend psuedocumene and waveshifters-batch 2				
1.2.9.6.4	QC fluor blend-batch 2				
1.2.9.6.5	Blend mineral oil with fluor blend-batch 1				
1.2.9.6.6	QC scintillator blend-batch 1				
1.2.9.6.7	Blend mineral oil with fluor blend-batch 2				
1.2.9.6.8	QC scintillator blend-batch 2				
1.2.9.6.9	Blend mineral oil with fluor blend-batch 3				
1.2.9.6.10	QC scintillator blend-batch 3				
1.2.9.6.11	Prototype scintillator production completed				
1.2.9.7	**Transport**				
1.2.9.7.1	Batch 1 to integration prototype site				
1.2.9.7.2	Batch 2 to integration prototype site				
1.2.9.7.3	Batch 3 to integration prototype site				
1.2.10	**Production Scintillator Specifications**	**Technical specification document for procurement of production quantities of liquid scintillator**			
1.2.10.1	Evaluate R&D results				
1.2.10.2	Prepare final specifications document for production scintillator				
1.2.10.3	Liquid scintillator final specifications completed				
1.2.11	**Management - R&D Phase**	**Subproject management activties for the liquid scintillator R&D phase**			
1.2.11.1	**FY06**				
1.2.11.1.1	Labor				
1.2.11.1.2	Travel				
1.2.11.1.3	Equipment				
1.2.11.1.4	Materials and supplies				
1.2.11.2	**FY07**				
1.2.11.2.1	**1HFY07**				
1.2.11.2.1.1	Labor				
1.2.11.2.1.2	Travel				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.2.11.2.1.3	Equipment				
1.2.11.2.1.4	Materials and supplies				
1.2.11.2.2	**2HFY07**				
1.2.11.2.2.1	Labor				
1.2.11.2.2.2	Travel				
1.2.11.2.2.3	Equipment				
1.2.11.2.2.4	Materials and supplies				
1.2.11.3	**FY08**				
1.2.11.3.1	Labor				
1.2.11.3.2	Travel				
1.2.11.3.3	Equipment				
1.2.11.3.4	Materials and supplies				
1.2.11.4	FY06 Liquid Scintillator R&D				
1.2.11.5	FY07 Liquid Scintillator R&D				
1.3	**Wave-Length-Shifting Fiber R&D**				
1.3.1	Requirements				
1.3.2	**Vendor Investigations**				
1.3.2.1	Identify possible production vendors and establish corporate contacts				
1.3.2.2	Determine vendor qualifications and capabilities				
1.3.2.3	Work with vendors to achieve requirements - FY06				
1.3.2.4	Work with vendors to achieve requirements - 1HFY07				
1.3.2.5	Work with vendors to achieve requirements - 2HFY07				
1.3.2.6	Work with vendors to achieve requirements - FY08				
1.3.2.7	Coordinate sample fiber procurements - FY06				
1.3.2.8	Coordinate sample fiber procurements - 1HFY07				
1.3.2.9	Coordinate sample fiber procurements - 2HFY07				
1.3.2.10	Document vendor interactions and performance				
1.3.3	**WLS Fiber Optimization Studies**				
1.3.3.1	**R&D Fiber Procurement**				
1.3.3.1.1	Procure fiber for R&D - FY06				
1.3.3.1.2	Procure fiber for R&D - 1HFY07				
1.3.3.1.3	Procure fiber for R&D - 2HFY07				
1.3.3.2	**Diameter Constraints**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.3.3.2.1	Define fiber samples needed (coordinate with vendor manager)				
1.3.3.2.2	Define tests and equipment				
1.3.3.2.3	Procure test equipment				
1.3.3.2.4	Setup test equipment				
1.3.3.2.5	Determine allowable bend radius of fiber samples				
1.3.3.2.6	Investigate mitigation methods				
1.3.3.2.7	Document test results				
1.3.3.3	**Fluorescent Dye and Concentration Studies**				
1.3.3.3.1	**Fluorescent Dye and Concentration Studies - MSU**				
1.3.3.3.1.1	Define WLS dye type, concentration tests, and equipment				
1.3.3.3.1.2	Define fiber samples needed (coordinate with vendor manager)				
1.3.3.3.1.3	**Phase 1 - MSU**		**pre-April 1, 2007 studies**		
1.3.3.3.1.3.1	Procure test equipment				
1.3.3.3.1.3.2	Setup test equipment				
1.3.3.3.1.3.3	Perform spectral analyses @ 15 m length				
1.3.3.3.1.3.4	Document results				
1.3.3.3.1.4	**Phase 2 - MSU**		**post April 1, 2007 studies**		
1.3.3.3.1.4.1	Procure test equipment				
1.3.3.3.1.4.2	Setup test equipment				
1.3.3.3.1.4.3	Perform spectral analyses @ 15 m length				
1.3.3.3.1.4.4	Document results				
1.3.3.3.2	**Fluorescent Dye and Concentration Studies - UT Dallas**				
1.3.3.3.2.1	**Phase 1 - UT Dallas**		**pre-April 1, 2007 studies**		
1.3.3.3.2.1.1	Procure test equipment				
1.3.3.3.2.1.2	Setup test equipment				
1.3.3.3.2.1.3	Perform spectral analyses @ 15 m length				
1.3.3.3.2.1.4	Document results				
1.3.3.3.2.2	**Phase 2- UT Dallas**		**post-April 1, 2007 studies**		
1.3.3.3.2.2.1	Procure test equipment				
1.3.3.3.2.2.2	Setup test equipment				
1.3.3.3.2.2.3	Perform spectral analyses @ 15 m length				
1.3.3.3.2.2.4	Document results				
1.3.3.4	**Chemical and Environmental Stability Testing**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.3.3.4.1	Define fiber samples needed (coordinate with vendor manager)				
1.3.3.4.2	Define and obtain liquid scintillator samples				
1.3.3.4.3	Define tests and equipment				
1.3.3.4.4	Procure test equipment				
1.3.3.4.5	Setup test equipment				
1.3.3.4.6	Perform bending tests in liquid scintillator - 1HFY07				
1.3.3.4.7	Perform bending tests in liquid scintillator - 2HFY07				
1.3.3.4.8	Perform accelerated aging tests in liquid scintillator - 1H FY07				
1.3.3.4.9	Perform accelerated aging tests in liquid scintillator - 2H FY07				
1.3.3.4.10	Determine survival limits during shipping and handling	constraints include temperature, vibration, and abrasion resistance			
1.3.3.4.11	Document results				
1.3.3.5	Baseline (IPND) WLS fiber diameter chosen				
1.3.3.6	Baseline (IPND) WLS fiber composition chosen				
1.3.4	**Development of QA Methods**				
1.3.4.1	Develop QA procedures				
1.3.4.2	Develop QA test equipment for fiber acceptance			$10k - two 32-meter-fiber scanning machines (one for MSU and one for Kuraray). at $5k each engineer's estimate.	
1.3.4.3	Develop QA documentation tool				
1.3.4.4	Document results				
1.3.5	**Integration Prototype Detector Fiber Production**				
1.3.5.1	Procure fiber for integration prototype		2 weeks to prepare req and release PO; 40 working days for production and delivery	based on $0.63 per meter x 90,000 m = $56, 700	
1.3.5.2	QA fiber		assumes fiber delivered to UMINN and short samples extracted and sent to MSU for QA testing		
1.3.5.3	IPND WLS fiber production completed				
1.3.6	**Production WLS Fiber Specifications**				
1.3.6.1	Review results of fiber diameter studies				
1.3.6.2	Review results of composition studies				
1.3.6.3	Review results of environmental tests				
1.3.6.4	Review results of IPND fiber QA				
1.3.6.5	Production WLS fiber diameter confirmed				
1.3.6.6	Production WLS fiber composition confirmed				
1.3.6.7	Prepare specification document for production WLS fiber				
1.3.7	**Management - R&D Phase**	**Subproject management activties for the WLS Fiber R&D phase**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.3.7.1	**FY06**				
1.3.7.1.1	Labor				
1.3.7.1.2	Travel			two foreign trips at $2.5 k per trip.	
1.3.7.1.3	Equipment				
1.3.7.1.4	Materials and supplies				
1.3.7.2	**FY07**				
1.3.7.2.1	**1HFY07**				
1.3.7.2.1.1	Labor				
1.3.7.2.1.2	Travel			1 foreign trip at $2.5k per trip.	
1.3.7.2.1.3	Equipment				
1.3.7.2.1.4	Materials and supplies				
1.3.7.2.2	**2HFY07**				
1.3.7.2.2.1	Labor				
1.3.7.2.2.2	Travel			1 foreign trip at $2.5k per trip.	
1.3.7.2.2.3	Equipment				
1.3.7.2.2.4	Materials and supplies				
1.3.7.3	**FY08**				
1.3.7.3.1	Labor				
1.3.7.3.2	Travel				
1.3.7.3.3	Equipment				
1.3.7.3.4	Materials and supplies				
1.3.7.4	FY06 WLS Fiber R&D				
1.3.7.5	FY07 WLS Fiber R&D				
1.4	**PVC Extrusion R&D**				
1.4.1	**Physical Properties Determination and Test Method Development**	**Measure optical and mechanical properties of extrusions and compare to NOvA specifications.**			
1.4.1.1	**Extrusion Optical Properties**	**Reflectivity of inner surfaces and light attenuation through outer surfaces. Optimal blend for reflectivity and minimal thickness and blend for capstocking material. Expose to liquid scintillator.**			
1.4.1.1.1	**General Consulting on PVC Reflectivity Issues**				
1.4.1.1.1.1	Consulting on PVC reflectivity issues - FY06				
1.4.1.1.1.2	Consulting on PVC reflectivity issues - 1HFY07				
1.4.1.1.1.3	Consulting on PVC reflectivity issues - H2FY07				
1.4.1.1.2	**Reflectivity Test Methods - FNAL**				
1.4.1.1.2.1	Investigate methods of measuring reflectivity				
1.4.1.1.2.2	Develop/purchase equipment needed for reflectivity tests	Evaluate and purchase reflectometer device.		Hunter labs reflectometer $8K Misc. Fixturing for making measurments. $2K	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.1.1.2.3	Investigate extruding process properties and surface effects on reflectivity of new material-1HFY07				
1.4.1.1.2.4	Investigate extruding process properties and surface effects on reflectivity of new material-2HFY07				
1.4.1.1.2.5	**Reflectivity Tests on New Materials**	**Perform systematic reflectivity measuremnts on developed PVC samples as a basis for measuring optical performance.**			
1.4.1.1.2.5.1	Perform reflectivity tests on new materials - FY06				
1.4.1.1.2.5.2	Perform reflectivity tests on new materials - 1H FY07				
1.4.1.1.2.5.3	Perform reflectivity tests on new materials - 2HFY07				
1.4.1.1.3	**Reflectivity Measurements - CT**				
1.4.1.1.3.1	Develop light output tests to correlate/confirm reflectivity measurements	Light output tests from a NOvA cell constructed using baseline material (PET-B) to compare against light reflectivity measurements.		$2K MANDS for misc. fixturing components to set-up tests	2 weeks effort to prepare test set-up 2 weeks effort to perform first series of tests of baseline material.
1.4.1.1.3.2	**Light Output Tests on New Materials**	**Perfrom light output studies using developed PVC materials to confirm reflectivity measurements.**			
1.4.1.1.3.2.1	Perform light output tests on new materials - FY06				
1.4.1.1.3.2.2	Perform light output tests on new materials - 1HFY07				
1.4.1.1.3.2.3	Perform light output tests on new materials - 2HFY07				
1.4.1.1.4	Document extrusion optical properties				
1.4.1.2	**Extrusion Mechanical Properties**	**Determine mechanical properties of extrusions and structural properties of the profiles. Allow exposure to liquid scintillator as a variable.**			
1.4.1.2.1	**Tensile Properties**				
1.4.1.2.1.1	Perform tensile tests - FY06				
1.4.1.2.1.2	Perform tensile tests - 1HFY07			$5K misc. fixturing and DAQ purchases	
1.4.1.2.1.3	Perform tensile tests - 2HFY07			$5K misc. fixturing and DAQ purchases	
1.4.1.2.2	**Creep Tests**				
1.4.1.2.2.1	**Creep Tests-FNAL**				
1.4.1.2.2.1.1	Construct stands for long-term creep tests				
1.4.1.2.2.1.2	Construct stands for accelerated temperature creep tests				
1.4.1.2.2.1.3	Perform long-term creep tests - 1HFY07				
1.4.1.2.2.1.4	Perform long-term creep tests - 2HFY07				
1.4.1.2.2.2	**Creep Tests-ANL**				
1.4.1.2.2.2.1	Investigate methods for accelerated creep tests			$5K fixturing devices for setting up tests, readout devices	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.1.2.2.2	Perform long-term creep tests - 1HFY07				
1.4.1.2.2.3	Perform long-term creep tests - 2HFY07				
1.4.1.2.2.4	Perform long-term creep tests - FY08				
1.4.1.2.2.5	Perform accelerated creep tests - 1HFY07	Peform tests to develop master time-temperature curve of baseline material for prediction of long term creep properties.		$1.8K for consulting and lab services to perform tests.	
1.4.1.2.2.6	Perform accelerated creep tests - 2HFY07	Peform tests to develop master time-temperature curve of baseline material for prediction of long term creep properties.		$1.8K for consulting and lab services to perform tests.	
1.4.1.2.2.7	Analyze creep test data - 1HFY07				
1.4.1.2.2.8	Analyze creep test data - 2HFY07				
1.4.1.2.2.9	Analyze creep test data - FY08				
1.4.1.2.3	**Impact/ Fracture Toughness Properties**				
1.4.1.2.3.1	Develop methods for measuring impact strength				
1.4.1.2.3.2	Develop/purchase equipment for measuring impact			Purchase/fabricate equipment and fixturing to perfrom drop dart mpact tests	
1.4.1.2.3.3	Characterize impact properties of PVC compounds - 1HFY07				
1.4.1.2.3.4	Characterize impact properties of PVC compounds - 2HFY07				
1.4.1.2.4	**Scintillator Exposure Tests**				
1.4.1.2.4.1	Define methods of testing for effects of liquid scintillator				
1.4.1.2.4.2	Investigate environmental effects on PVC compounds - 1HFY07	Assume tensile and impact tests repeated for exposed samples as well as accelerated creep.		$3k misc. costs for data taking and fixturing, and surface tests	
1.4.1.2.4.3	Investigate environmental effects on PVC compounds - 2HFY07	Assume tensile and impact tests repeated for exposed samples as well as accelerated creep.		$3k misc. costs for data taking and fixturing, and surface tests	
1.4.1.2.4.4	Investigate environmental effects on PVC compounds - 1HFY08	Assume tensile and impact tests repeated for exposed samples as well as accelerated creep.		$3k misc. costs for data taking and fixturing, and surface tests	
1.4.1.3	**Quality Control and Assurance**				
1.4.1.3.1	Determine frequency and type of mechanical tests done at extruder for QC				
1.4.1.3.2	Develop/purchase equipment for QC tests at extruder			$25k to purchase/fabricate special mechanical QC testing at the factory.	
1.4.1.3.3	Perform mechanical tests for quality assurance - horizontal extrusions - 1HFY07				
1.4.1.3.4	Perform mechanical tests for quality assurance - horizontal extrusions - 2HFY07				
1.4.1.3.40	Perform mechanical tests for quality assurance - vertical extrusions				
1.4.1.3.50	Perform reflectivity tests for quality assurance - horizontal extrusions -1HFY07				
1.4.1.3.60	Perform reflectivity tests for quality assurance - horizontal extrusions-2HFY07				
1.4.1.3.70	Perform reflectivity tests for quality assurance - vertical extrusions				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.1.3.80	Investigate additional QA equipment				
1.4.1.3.90	Purchase additional QA equipment			reflectometer: $10k Optical sensor: $10k Ultrasound: $40k ---------- Total: $60k	
1.4.1.3.100	Perform QA on prototype extrusions				
1.4.1.4	**PVC Resin Tests**	**Select PVC blends and capstock blends based on raw materials tests .**			
1.4.1.4.1	Define raw material tests for acceptance				
1.4.1.4.2	Perform tests to characterize raw material	Lab services to perform Organic and and other material tests such as density measurements of developed compounds.		10 tests at $1.5K each= $15K	
1.4.2	**Raw Materials**	**Select PVC blend and capstocking blend for prototype extrusion production.**			
1.4.2.1	**Requirements**	**PVC blend (PVC + TiO2) reflectivity. PVC blend and capstock blend meet NOvA material strength and light transmission standards. Define purity standards and outline Q/C procedures**			
1.4.2.1.1	Draft requirements document for raw materials				
1.4.2.1.2	Raw materials requirements document released				
1.4.2.2	**PVC Material Development**	**Identify possible vendors for PVC blend and black capstocking blend.**			
1.4.2.2.1	**Baseline PVC Material**				
1.4.2.2.1.1	Identify, contact, and meet with prospective vendors				
1.4.2.2.1.2	Draft RFI for baseline material (PET B)				
1.4.2.2.1.3	Review and release RFI for baseline material				
1.4.2.2.1.4	Evaluate vendor information				
1.4.2.2.2	**Custom PVC Development**				
1.4.2.2.2.1	**Custom PVC Development - ANL**				
1.4.2.2.2.1.1	Identify specific vendors for developing custom PVC compounds				
1.4.2.2.2.1.2	Solicit proposals for PVC resin development work				
1.4.2.2.2.1.3	Work with vendors to develop custom PVC compounds - FY06				
1.4.2.2.2.1.4	Work with vendors to develop custom PVC compounds - 1HFY07				
1.4.2.2.2.1.5	Work with vendors to develop custom PVC compounds - 2HFY07				
1.4.2.2.2.1.6	Evaluate PVC compound studies - FY06				
1.4.2.2.2.1.7	Evaluate PVC compound studies - 1HFY07				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.2.2.2.1.8	Evaluate PVC compound studies - 2HFY07				
1.4.2.2.2.2	**Custom PVC Development - FNAL**				
1.4.2.2.2.2.1	Work with consultant and lab to develop custom PVC - FY06	Work with PVC consultant and polymer development lab to perfrom designed experment varying formulations with intent of understanding and improving light reflectivity properties.		Preparation of 30 batches ($0.5K/ batch) at Polymer Lab $15K (PDI)	5 days effort + travel for PVC conslutant $10K (P3 Consultants),
1.4.2.2.2.2.2	Work with consultant and lab to develop custom PVC - 1HFY07	Work with PVC consultant and polymer development lab to perfrom designed experment varying formulations with intent of understanding and improving light reflectivity properties.		Preparation of 30 batches ($0.5K/ batch) at Polymer Lab $15K (PDI)	5 days effort + travel for PVC conslutant $10K (P3 Consultants),
1.4.2.2.2.2.3	Work with consultant and lab to develop custom PVC - 2HFY07	Work with PVC consultant and polymer development lab to perfrom designed experment varying formulations with intent of understanding and improving light reflectivity properties.		Preparation of 30 batches ($0.5K/ batch) at Polymer Lab $15K (PDI)	5 days effort + travel for PVC conslutant $10K (P3 Consultants),
1.4.2.2.2.2.4	Issue PO's to selected vendors - FY06	Procurement of PVC compounds from various vendors for the purpose of checking mechanical, and optical properties as well as extrudability.		8 runs, averaging 1000 lbs of material. PVC purchase price in small quantities is $5 per lb includes devlopment costs of custom formulations. 8 * 1000 lbs * $5/lb = $40K	
1.4.2.2.2.2.5	Issue PO's to selected vendors - 1HFY07	Procurement of PVC compounds from various vendors for the purpose of checking mechanical, and optical properties as well as extrudability.		8 runs, averaging 1000 lbs of material. PVC purchase price in small quantities is $5 per lb includes devlopment costs of custom formulations. 8 * 1000 lbs * $5/lb = $40K	
1.4.2.2.2.2.6	Issue PO's to selected vendors - 2HFY07	Procurement of PVC compounds from various vendors for the purpose of checking mechanical, and optical properties as well as extrudability.		8 runs, averaging 1000 lbs of material. PVC purchase price in small quantities is $5 per lb includes devlopment costs of custom formulations. 8 * 1000 lbs * $5/lb = $40K	
1.4.2.2.2.2.7	Evaluate PVC compound studies - FY06				
1.4.2.2.2.2.8	Evaluate PVC compound studies - 1HFY07				
1.4.2.2.2.2.9	Evaluate PVC compound studies - 2HFY07				
1.4.2.2.2.3	Prototype 16-cell PVC horizontal extrusion compound specified				
1.4.2.2.2.4	Prototype 16-cell PVC vertical extrusion compound specified				
1.4.2.3	**Procurement of Raw Material for Prototype 16-Cell Horizontal Extrusions**	**Purchase a variety of blends for evaluation. Purchase the optimal blends for extruding prototypes, specified in 1.4.2.5**			
1.4.2.3.1	**Procurement of Raw Material for Prototype 16-Cell Horizontal Extrusions -**				
1.4.2.3.1.1	Develop RFP for 16-cell horizontal extrusions				
1.4.2.3.1.2	RFP issued for raw PVC resin				
1.4.2.3.1.3	Review proposals				
1.4.2.3.2	**Procurement of Raw Material for Prototype 16-Cell Horizontal Extrusions - FNAL**				
1.4.2.3.2.1	Prepare purchase order				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.2.3.2.2	PO for raw PVC resin for 16-cell horizontal extrusions released				
1.4.2.3.2.3	Produce raw PVC resin			Purchase ~112000 lbs. PVC @ 0.89 /lb = $ 100k	
1.4.2.4	**Procurement of Raw Material for Prototype 16-Cell Vertical Extrusions**	**Purchase a variety of blends for evaluation. Purchase the optimal blends for extruding prototypes, specified in 1.4.2.5**			
1.4.2.4.1	**Procurement of Raw Material for Prototype 16-Cell Vertical Extrusions -**				
1.4.2.4.1.1	Develop RFP for 16-cell vertical extrusions				
1.4.2.4.1.2	RFP issued for raw PVC resin				
1.4.2.4.1.3	Review proposals				
1.4.2.4.2	**Procurement of Raw Material for Prototype 16-Cell Vertical Extrusions -**				
1.4.2.4.2.1	Prepare purchase order				
1.4.2.4.2.2	PO for raw PVC resin for 16-cell vertical extrusions released				
1.4.2.4.2.3	Produce raw PVC resin			Purchase ~120000 lbs. PVC @ 0.89 /lb = $ 108k	
1.4.2.5	**Procurement of Raw Material for Additional 16-Cell Horizontal Extrusions**	**Purchase a variety of blends for evaluation. Purchase the optimal blends for extruding prototypes, specified in 1.4.2.5**			
1.4.2.5.1	Prepare purchase order				
1.4.2.5.2	PO for raw PVC resin for 16-cell horizontal extrusions released				
1.4.2.5.3	Produce raw PVC resin			Purchase ~112000 lbs. PVC @ 0.89 /lb = $ 100k	
1.4.2.6	**Procurement of Raw Material for Additional 16-Cell Vertical Extrusions**	**Purchase a variety of blends for evaluation. Purchase the optimal blends for extruding prototypes, specified in 1.4.2.5**			
1.4.2.6.1	Prepare purchase order				
1.4.2.6.2	PO for raw PVC resin for 16-cell vertical extrusions released				
1.4.2.6.3	Produce raw PVC resin			Purchase ~112000 lbs. PVC @ 0.89 /lb = $ 100k	
1.4.2.7	Final Documentation	Document the procedures for testing and basis for deciding on the chosen PVC. Specify the possible raw materials vendors.			
1.4.3	**Extrusions**	**Identify extruders capable of producing NOvA (full or half-width) profiles. Select an extruder to produce prototype profiles. Develop methods for assuring the quality of extruded products, specifically the reflectivity and geometrical dimensions. Develop a shipping and handling plan for delivery of extrusions.**			
1.4.3.1	Prepare requirements	Define requirements to insure that extrusions satisfy NOvA geometrical tolerances and reflectivity.			
1.4.3.2	**Vendor Investigations**	**Identify possible vendors with the capability to produce 16- and 32-cell extrusions**			
1.4.3.2.1	Investigate production vendors - FNAL				
1.4.3.2.2	Investigate production vendors - ANL	Identify possible vendors to produce 32-cell extrusions			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.3.3	**Vendor Extrusion Tests with Existing Tooling**	**Determine NOvA Q/C procedures and obtain necessary testing devices. Design and build prototype detectors to measure reflectivity and light attenuation (capstocking) at extruding facilities**			
1.4.3.3.1	Prepare purchase reqs and POs				
1.4.3.3.2	Extrude raw materials				
1.4.3.3.3	Evaluate extrusions				
1.4.3.4	**16-cell Horizontal (thin-wall) Extrusion Prototypes**	**Purchase sample-quantity extrusions for testing properties. Write RFP for 3-cell and 16-cell extrusions with optional black co-extrusion. Write RFP for 32-cell extrusions with co-extrusion option.**			
1.4.3.4.1	Prepare and issue RFP				
1.4.3.4.2	Evaluate proposals and select vendor				
1.4.3.4.5	**Horizontal Extrusion Fabrication**				
1.4.3.4.5.1	Prepare purchase order				
1.4.3.4.5.2	Purchase order released (16-cell horizontals)				
1.4.3.4.5.3	Fabricate tooling				
1.4.3.4.5.4	Fabricate test extrusions				
1.4.3.4.5.5	Fabricate test extrusions - 2HFY07				
1.4.3.4.5.6	Adjust die				
1.4.3.4.5.7	Adjust die - 2HFY07		Vendor tech time and machining expenses	Vendor tech time and machining expenses	
1.4.3.4.5.8	Finalize resin compound for horizontal extrusion prototypes				
1.4.3.4.5.9	16-cell horizontal extrusion prototypes specifications completed				
1.4.3.4.5.10	Fabricate remaining extrusions				
1.4.3.4.5.11	16-cell horizontal extrusions for IPND completed				
1.4.3.5	**16-cell Vertical (thick-wall) Extrusion Prototypes**	**Produce the requisite number of extrusions for tests, prototype near detector, prototype far detector wall and 32-cell prototypes. Arrange shipping and handling procedures to receive orders.**			
1.4.3.5.1	Finalize specifications for vertical extrusion prototypes				
1.4.3.5.2	16-cell vertical extrusion prototype specifications completed				
1.4.3.5.3	Prepare PO for die inserts				
1.4.3.5.4	PO for die inserts released (16-cell verticals)				
1.4.3.5.5	Fabricate vertical die inserts				
1.4.3.5.6	Modify die for vertical inserts				
1.4.3.5.7	Fabricate test extrusions				
1.4.3.5.8	Adjust die				
1.4.3.5.9	Finalize resin compound for vertical extrusion prototypes				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.3.5.10	16-cell vertical extrusion prototypes specifications completed				
1.4.3.5.11	Fabricate remaining extrusions				
1.4.3.5.12	16-cell vertical extrusions for IPND completed				
1.4.3.6	**Additional 16-cell Horizontal Extrusions**				
1.4.3.6.1	Swap die inserts				
1.4.3.6.2	Fabricate test extrusions to adjust die				
1.4.3.6.3	Fabricate additional horizontal test extrusions				
1.4.3.7	**Additional 16-cell Vertical Extrusions**				
1.4.3.7.1	Swap die inserts				
1.4.3.7.2	Fabricate test extrusions to adjust die				
1.4.3.7.3	Fabricate additional vertical test extrusions				
1.4.4	**Shipping & Handling**				
1.4.4.1	Develop requirements				
1.4.4.2	Design preproduction prototype pallet system				
1.4.4.3	Build preproduction prototype pallet system				
1.4.4.4	Build preproduction prototype pallet system - 2HFY07				
1.4.4.40	Test preproduction prototype pallet system				
1.4.4.41	Test preproduction prototype pallet system - 2HFY07				
1.4.4.50	Finalize preproduction prototype pallet system design				
1.4.4.60	Document shipping and handling plan				
1.4.4.70	Design preproduction motion system				
1.4.4.71	Design preproduction motion system - 2HFY07				
1.4.4.80	Procure preproduction motion system				
1.4.4.90	Build and test preproduction motion system				
1.4.4.100	Finalize design of preproduction motion system				
1.4.4.110	Document shipping and handling system design for production				
1.4.5	**Quality Assurance Hardware Modifications**				
1.4.5.1	Adapt prototype QA hardware to preproduction process-horizontal				
1.4.5.2	Adapt prototype QA hardware to preproduction process-vertical				
1.4.6	**Management - R&D Phase**	**Subproject management activities for the PVC extrusion R&D phase**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.4.6.1	**FY06**				
1.4.6.1.1	Labor				
1.4.6.1.2	Travel			vendor visits/oversight: 10 trips at 500 per trip = $5000	
1.4.6.1.3	Equipment				
1.4.6.1.4	Materials and supplies				
1.4.6.2	**FY07**				
1.4.6.2.1	**1HFY07**				
1.4.6.2.1.1	Labor				
1.4.6.2.1.2	Travel			vendor visits: 10 trips at 500 per trip = $5000	
1.4.6.2.1.3	Equipment				
1.4.6.2.1.4	Materials and supplies				
1.4.6.2.2	**2HFY07**				
1.4.6.2.2.1	Labor				
1.4.6.2.2.2	Travel			vendor visits: 10 trips at 500 per trip = $5000	
1.4.6.2.2.3	Equipment				
1.4.6.2.2.4	Materials and supplies				
1.4.6.3	**FY08**				
1.4.6.3.2	Labor				
1.4.6.3.3	Travel				
1.4.6.3.4	Equipment				
1.4.6.3.5	Materials and supplies				
1.4.6.4	FY06 PVC Extrusion R&D Cost Account				
1.4.6.5	FY07 PVC Extrusion R&D On-Project Cost Account				
1.5	**PVC Module R&D**				
1.5.1	Requirements				
1.5.2	**End Seal R&D**				
1.5.2.1	**Fiber Manifold R&D**	**Pursue 2 designs through prototype stage**			
1.5.2.1.1	**Fiber Manifold Component R&D**				
1.5.2.1.1.1	Design conceptual prototype manifolds	Communication prototype: A prototype whose primary intent is to communicate the appearance of the device to collaborators; may not be functional.			
1.5.2.1.1.2	Manufacture conceptual prototype manifolds				
1.5.2.1.1.3	Design functional prototype manifolds	Functional prototype: A prototype whose primary intent is to test the functionality of the device; is not constructed using mass production methods.			
1.5.2.1.1.4	Manufacture functional prototype manifolds				
1.5.2.1.1.5	Test functional prototype manifolds				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.2.1.1.6	Design integration prototype manifold candidates	Integration prototype: A prototype whose primary intent is to ensure that a system properly interfaces with all related systems.			
1.5.2.1.1.7	Integration prototype manifold concept selected				
1.5.2.1.1.8	Finalize integration prototype design	Integration prototype: A prototype whose primary intent is to ensure that a system properly interfaces with all related systems.			
1.5.2.1.1.9	**Integration Prototype Manifold Manufacturing**			**first 25 manifolds for IPND**	
1.5.2.1.1.9.1	Manufacture snout				
1.5.2.1.1.9.2	Manufacture manifold covers				
1.5.2.1.1.9.3	Manufacture fill tubes				
1.5.2.1.1.9.4	Manufacture side and center seals				
1.5.2.1.1.9.5	Fiber raceways				
1.5.2.1.1.9.6	Fiber cover				
1.5.2.1.1.10	Test integration prototype manifolds	Note: Testing of integration manifold begins with delivery of first set of 1/2 width extrusions			
1.5.2.1.1.11	Review design				
1.5.2.1.1.12	Finalize design of preproduction prototype (for IPND)	reproduction prototype: A fully functional prototype having similar material and geometry to the final design, but fabricated with medium quantity manufacturing processes and final manufacturing processes where appropriate.			
1.5.2.1.1.13	Preproduction prototype manifold design (for IPND) completed				
1.5.2.2	**End Plate R&D**	**Pursue 2 designs through prototype stage**			
1.5.2.2.1	Design conceptual prototype	Conceptual prototype: A prototype whose primary intent is to communicate the appearance of the device to collaborators; may not be functional.			
1.5.2.2.2	Manufacture conceptual prototype				
1.5.2.2.3	Design functional prototype	Functional prototype: A prototype whose primary intent is to test the functionality of the device; is not constructed using mass production methods.			
1.5.2.2.4	Manufacture functional prototype				
1.5.2.2.5	Test functional prototype				
1.5.2.2.6	End plate integration prototype concept selected				
1.5.2.2.7	Design integration prototype	Integration prototype: A prototype whose primary intent is to ensure that a system properly interfaces with all related systems.			
1.5.2.2.8	Manufacture end plate				
1.5.2.2.9	Manufacture side and center seals				
1.5.2.2.10	Test integration prototype end plate	Note: Testing of integration prototype begins with delivery of first set of 1/2 width extrusions			
1.5.2.2.11	Review design				
1.5.2.2.12	Finalize design of preproduction prototype (for IPND)				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.2.2.13	Design of preproduction prototype bottom plate (for IPND) completed				
1.5.2.3	**Joining Technology R&D**				
1.5.2.3.1	Generate joining system concepts				
1.5.2.3.2	Test adhesive joining technologies				
1.5.2.3.3	IPND adhesive selected				
1.5.2.3.4	Test RF welding technologies				
1.5.2.3.5	RF welding go/no go decision made				
1.5.2.3.6	Mechanical lifetime tests of joining systems				
1.5.2.3.7	Chemical lifetime tests of joining systems				
1.5.2.3.8	Document lifetime tests				
1.5.3	**Photo Detector Interface R&D**				
1.5.3.1	Conceptual design-optical connector/manifold integration				
1.5.3.2	Conceptual design-optical connector/APD module integration	Note: Requires APD interface design from electronics group			
1.5.3.3	Design functional prototype				
1.5.3.4	Manufacture functional prototype				
1.5.3.5	Test functional prototype				
1.5.3.6	Integration prototype optical connector design concept selected				
1.5.3.7	Design integration prototype				
1.5.3.8	Manufacture integration prototype (not needed)				
1.5.3.9	Test integration prototype (not needed)				
1.5.3.10	Review design				
1.5.4	**Module Factory R&D**				
1.5.4.1	**Assembly Methods R&D**				
1.5.4.1.1	Develop plan for unpacking extrusions from truck	Developing a plan for efficiently removing extrusions from the truck to the factory and loading finished modules on a truck			
1.5.4.1.2	Develop plan for extrusion warehousing	Developing a plan for buffer space for extrusions and finished extrusion modules			
1.5.4.1.3	Investigate methods for extrusion fiber-stringing	Method for putting fibers into extrusion cells			
1.5.4.1.4	Investigate methods for manifold threading	method for routing fibers through the manifolds			
1.5.4.1.5	Investigate methods for manifold gluing and sealing	Method for gluing and sealing manifold			
1.5.4.1.6	Investigate methods for end plate gluing and sealing	Method for gluing and sealing end plate			
1.5.4.1.7	Develop methods to assemble two 16 cell extrusions into a 32 cell extrusion				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.4.2	**Factory Material Handling, Tooling, & Fixtures R&D**	**American Automotive Equipment: SS7000XLT prototype extrusion lifter 1-Material Flow: EJB25** **prototype cantilevered shelves-D.C. Graves:** **dollies for tests 2-C&H** **prototype fiber spooling machine 1-Built to order** **Prototype Pressure Test Machine 1-Built to order** **Prototype Fiber Continuity Machine 1-Built to order** **Prototype Fiber Mapping Test Machine 1-Built to order** **Glue Machine 1-Sealant Equipment & Engineering, Inc.**			
1.5.4.2.1	Investigate cart/dollies options	$300/each			
1.5.4.2.2	Investigate shelving options	Holds extrusions			
1.5.4.2.3	Investigate extrusion lifter options				
1.5.4.2.4	Investigate work platform options	Vertically moving			
1.5.4.2.5	Develop functional prototype thread spooling machine				
1.5.4.2.6	Develop pre-production prototype extrusion fiber-stringing machine				
1.5.4.2.7	Prototype extrusion fiber-stringing machine for IPND ready to operate				
1.5.4.2.8	Develop extrusion puck and fiber mount				
1.5.4.2.9	Develop fiber facing machine	MINOS design			
1.5.4.2.10	Prototype fiber facing machine for IPND ready to operate				
1.5.4.2.11	Develop end seal and manifold gluing machine				
1.5.4.2.12	Prototype gluing machine for IPND ready to operate				
1.5.5	**Quality Assurance and Quality Control Methods Development**				
1.5.5.1	Develop methods for extrusion quality checkout				
1.5.5.2	Develop methods for pressure testing				
1.5.5.3	Develop methods for pressure testing - 2HFY07				
1.5.5.4	Pressure-testing hardware for IPND production ready to operate				
1.5.5.5	Develop methods for verifying fiber mapping and fiber continuity				
1.5.5.6	Develop methods for verifying fiber mapping and fiber continuity - 2HFY07				
1.5.5.7	Fiber mapping and continuity hardware for IPND production ready to operate				
1.5.5.8	Develop methods for assuring fiber-face tolerance				
1.5.6	Module shipping and storage R&D - 2HFY07				
1.5.7	**Integration Prototype Detector (IPND) Modules**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.7.1	**Factory Preparation for Integration Prototype Near Detector Production**				
1.5.7.1.1	Identify and acquire factory space		Assumes that factory space is free, (no rent)		
1.5.7.1.2	Acquire and install factory tools, fixtures, and other infrastructure	Includes cabinets, work benches, misc tools		Crane: 40k Fixtures: 70k materials and supplies: 5k electrician: 1.2k ---------- total:116.2k	
1.5.7.1.3	Install and setup additional infrastructure and factory machines				
1.5.7.1.4	Develop initial versions of machine operating procedures	thread spooling, gluing, fiber facing			
1.5.7.3	**Integration Prototype Near Detector (IPND) Module Manufacturing**				
1.5.7.3.1	**IPND Manifold Components**				
1.5.7.3.1.1	Manufacture snout				
1.5.7.3.1.2	Manufacture manifold covers				
1.5.7.3.1.3	Manufacture fill tubes				
1.5.7.3.1.4	Manufacture side and center seals				
1.5.7.3.1.5	Manufacture fiber raceways				
1.5.7.3.1.6	Manufacture fiber covers				
1.5.7.3.2	Assemble and test IPND manifolds	Note: Requires delivery of extrusions			
1.5.7.3.3	**IPND End Plate Components**				
1.5.7.3.3.1	Manufacture IPND end plates			First 50 modules use machined parts to finalize design for injection molding and extrusion Part — Cost per module — Comments ---- End seal — $28 — 2 parts/module; machined Center seal — $21 — machined Bottom plate — $48 — machined Adhesive — $40 --- Total cost per module: $137	
1.5.7.3.3.2	Manufacture side and center seals				
1.5.7.3.4	Assemble and test preproduction prototype (IPND) end plates and seals				
1.5.7.3.5	Design, manufacture and document preproduction prototype (IPND) optical				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.7.3.6	Produce IPND modules	25,000 cc ($0.05/cc)		Next 450 modules (costs not yet in for mass production) Bottom Seal: Part Cost per module Comments ---------- ---------- End seal $28 2 parts/module; machined Center seal $21 machined Bottom plate $51 extruded Adhesive $40 --- cost per module: $140 Die cost: $11,800 Sample parts: $11,160 (includes initial 450 pieces) Manifolds: Part Cost per module Comments ---------- ---------- Side seal & hangar $42 2 parts/module; machined Center seal & hangar $28 machined Manifold cover, far $50 injection molded Manifold cover, near $50 injection molded Snout, back $44 injection molded Snout, front $44 injection molded Bottom raceway $150 machined Top raceway $175 machined Fiber cover $40 machined Optical connector, front $200 machined Optical connector, back $100 machined Piccolo tube $50 cost averaged across 2 mods Adhesive $50 ---------- cost per module: $1023 Total cost per module $1163	
1.5.7.3.7	IPND modules for first 8-plane segment completed				
1.5.7.3.8	IPND module production 50% complete				
1.5.7.3.9	IPND module production completed				
1.5.8	**Initial Production Module Specifications**	**Note: predecessor is assemble integration prototype**			
1.5.8.1	Document preproduction (IPND) prototype manifold				
1.5.8.2	Review manifold design				
1.5.8.3	Document preproduction (IPND) prototype bottom plate				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.5.8.4	Review bottom plate design				
1.5.9	**Initial Factory Tooling Specifications**	**Note: predecessor is assemble integration prototype**			
1.5.9.1	Document assembly process, procedures, and training				
1.5.9.2	Review assembly process, procedures, and training				
1.5.9.3	Document factory machines and functioning				
1.5.9.4	Review factory machines and functioning				
1.5.10	**Management - R&D Phase**	**Management tasks and budget for PVC module subproject during the R&D phase**			
1.5.10.1	**FY06**				
1.5.10.1.1	Labor				
1.5.10.1.2	Travel				
1.5.10.1.3	Equipment				
1.5.10.1.4	Materials and supplies				
1.5.10.2	**FY07**				
1.5.10.2.6	**H1FY07**				
1.5.10.2.6.1	Labor				
1.5.10.2.6.2	Travel				
1.5.10.2.6.3	Equipment				
1.5.10.2.6.4	Materials and supplies				
1.5.10.2.8	**H2FY07**				
1.5.10.2.8.1	Labor				
1.5.10.2.8.2	Travel				
1.5.10.2.8.3	Equipment				
1.5.10.2.8.4	Materials and supplies				
1.5.10.3	**FY08**				
1.5.10.3.1	Labor				
1.5.10.3.2	Travel				
1.5.10.3.3	Equipment				
1.5.10.3.4	Materials and supplies				
1.5.10.4	FY06 PVC Module R&D				
1.5.10.5	FY07 PVC Module R&D				
1.6	**Electronics R&D**				
1.6.1	**APD Modules**	**Module that provides fiber alignment, cooling, connection to FEB**			
1.6.1.1	**Prototypes**	**Prototype for APD modules**			
1.6.1.1.1	Prepare prototype specifications				
1.6.1.1.2	**First Prototype**	**10 modules for proof of principle and thermal/mechanical and optical tests**			
1.6.1.1.2.1	**PCB**				
1.6.1.1.2.1.1	Design	Design PCB to meet requirements			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.1.1.2.1.2	**Fabricate**	**Procure PCB**			
1.6.1.1.2.1.2.1	Fabricate (HU)				
1.6.1.1.2.1.2.2	Fabricate (MINN)				
1.6.1.1.2.1.2.3	Fabricate (FNAL)				
1.6.1.1.2.1.3	Process	machine slots			
1.6.1.1.2.1.4	Qualify for mounting	measure flatness and other spec			
1.6.1.1.2.1.5	Ship to manufacturer	Ship to Hamamatsu for mechanical and ultimately APD mounting upon acceptance			
1.6.1.1.2.2	**APD Detector Array**				
1.6.1.1.2.2.1	Specify	Set dimensions/characteristics of APD array			
1.6.1.1.2.2.2	Manufacture	Hamamatsu Fab Wafers, mount, deliver 10 APD arrays			
1.6.1.1.2.3	**Module**	**Heat exchanger and clamshell containment**			
1.6.1.1.2.3.1	Design	Design module			
1.6.1.1.2.3.2	Fabricate prototype	Produce prototype			
1.6.1.1.2.3.3	Assemble	Test cooling characteristics			
1.6.1.1.2.3.4	Test	Test cooling characteristics			
1.6.1.1.2.4	Assemble detector	Assemble TEC, carrier board, containment			
1.6.1.1.2.5	Test	Test modules and APDs			
1.6.1.1.2.6	Qualify	Report tests			
1.6.1.1.2.7	APD module first prototypes qualified				
1.6.1.1.2.8	APD module value engineering - prototype 1				
1.6.1.1.3	**Second Prototype**				
1.6.1.1.3.1	Procure prototype APDs	Revise APD design as needed			
1.6.1.1.3.2	Revise module design	Revise containment/interface as needed			
1.6.1.1.3.3	Fabricate second module	Manufacture components			
1.6.1.1.3.4	Assemble module				
1.6.1.1.3.5	Assemble prototype	Assemble Prototype 2			
1.6.1.1.3.6	Test second prototype	Test prototype 2			
1.6.1.1.3.7	APD modules second prototype completed				
1.6.1.1.3.8	APD module value engineering - prototype 2				
1.6.1.2	**QA/QC Stations**				
1.6.1.2.1	Specify	Specify reqs for QA/QC stations			
1.6.1.2.2	Design - 1	Design QA/QC station			
1.6.1.2.3	Design - 2	Design QA/QC station			
1.6.1.2.4	Manufacture	Manufacture #1			
1.6.1.2.5	Program	Program station			
1.6.1.2.6	Qualify	Test/Qualify station			
1.6.1.2.7	Document				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.1.2.8	First QA/QC station ready				
1.6.1.2.9	Manufacture two copies	Manfacture 2 copies of station for total of 3			
1.6.1.2.10	**Quick Tester for Installation**	**Pass/Fail tester**			
1.6.1.2.10.1	Design	Design Pass/Fail tester			
1.6.1.2.10.2	Build	Build 2 copies			
1.6.1.3	**Water Cooling**				
1.6.1.3.1	Model water flow				
1.6.1.3.2	Design test for model				
1.6.1.3.3	Procure manifolds			16 * (2 * 600) = $19,200	
1.6.1.3.4	Procure other components			1 * 4800 = $4800	
1.6.1.3.5	Assemble and test hardware				
1.6.1.3.6	Water cooling value engineering				
1.6.1.4	**Direct Refrigerant Cooling**				
1.6.1.4.1	Prepare specifications				
1.6.1.4.2	Design system				
1.6.1.4.3	Procure components			1 * 4800 = $4800	
1.6.1.4.4	Assemble and test hardware				
1.6.1.4.5	Document results			16 * (2 * 600) = $19,200	
1.6.1.5	**Electronics Box**				
1.6.1.5.1	Design electronics box - 1				
1.6.1.5.2	Design electronics box - 2				
1.6.1.5.3	Prototype electronics box				
1.6.1.5.4	Qualify electronics box for production				
1.6.1.6	**Integration Prototype Detector**	**~400 modules for integration prototype detector**			
1.6.1.6.1	**Module Production**	**Procure 400 APD modules from Hamamatsu, part of main procurement, so same price**		**335 pieces at 1600 per piece= 536,000**	
1.6.1.6.1.1	APD module production for IPND started				
1.6.1.6.1.2	APD engineering run				
1.6.1.6.1.3	**Module Manufacture**	**Manufacture**			
1.6.1.6.1.3.1	Design for manufacture				
1.6.1.6.1.3.2	Prototype mold				
1.6.1.6.1.3.3	Pilot fabrication run	May decide to machine these			
1.6.1.6.1.4	PCB manufacture	Manufacture PCB			
1.6.1.6.1.5	Assemble	Assemble modules			
1.6.1.6.1.6	Test	Rigorous testing of 400 modules			
1.6.1.6.1.7	APD modules for 8-plane segment completed				
1.6.1.6.1.8	Review				
1.6.1.6.1.9	APD modules for IPND completed				
1.6.1.6.2	**Water Cooling (4 loops)**				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.1.6.2.1	Procure manifolds			40 * (2*600) = $48,000	
1.6.1.6.2.2	Procure other components			4* 4800 = $19,200	
1.6.1.6.2.3	Assemble and test hardware				
1.6.2	**FEB**	**Front End Board:**			
1.6.2.1	**ASIC**	**NOvA custom ASIC**			
1.6.2.1.1	**ASIC Prototype I**				
1.6.2.1.1.1	Design	Design, simulation, layout & verification			
1.6.2.1.1.2	Fabricate				
1.6.2.1.1.3	Test				
1.6.2.1.1.4	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.1.1.5	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.1.2	**ASIC Prototype II**				
1.6.2.1.2.1	Design	Design, simulation, layout & verification			
1.6.2.1.2.2	Fabricate				
1.6.2.1.2.3	Test				
1.6.2.1.2.4	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.1.2.5	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.1.3	**Near Detector ASIC Prototype**				
1.6.2.1.3.1	Design	Design, simulation, layout & verification			
1.6.2.1.3.2	Fabricate				
1.6.2.1.3.3	Test				
1.6.2.1.3.4	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.1.3.5	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.1.4	**IPND ASIC Production**				
1.6.2.1.4.1	Fabricate				
1.6.2.1.4.2	Test				
1.6.2.2	**FEB Prototype I**	**CERN Chip/Ideas ADC evaluation, test and evaluation of NOvA FEB architecture, DSP algorithm testing. USB i/o**			
1.6.2.2.1	Design	Component evaluation, circuit analysis and simulations, schematic creation, conceptual designs, and pcb CAD layout design			
1.6.2.2.2	Fabricate PCB				
1.6.2.2.3	Procure parts				
1.6.2.2.4	Assemble	Reflow solder, wire bond, mechanical assembly as necessary			
1.6.2.2.5	Develop firmware	Logic conceptual design, VHDL implementation and simulation, download and test			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.2.2.6	Develop software	Software to run test apparatus, data display, and data analysis code			
1.6.2.2.7	Test	Bench top electrical tests, system integration tests.			
1.6.2.2.8	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.2.9	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.3	**FEB Prototype II**	**Contains NOvA Front End ASIC and connector to APD module, DSP development, NOvA detector tests, USB i/o**			
1.6.2.3.1	Design	Component evaluation, circuit analysis and simulations, schematic creation, conceptual designs, and pcb CAD layout design			
1.6.2.3.2	TEC regulator design	Design circuit for control,monitor and regulation of TEC			
1.6.2.3.3	Fabricate PCB				
1.6.2.3.4	Procure parts				
1.6.2.3.5	Assemble	Reflow solder, wire bond, mechanical assembly as necessary			
1.6.2.3.6	Develop firmware	Logic conceptual design, VHDL implementation and simulation, download and test			
1.6.2.3.7	Develop software	Software to run test apparatus, data display, and data analysis code			
1.6.2.3.8	Test	Bench top electrical tests, system integration tests.			
1.6.2.3.9	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.3.10	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.3.11	FEB prototype II released to DAQ				
1.6.2.4	**FEB Prototype III**	**Contains NOvA Front End ASIC and connector to APD module, DSP development, NOvA detector tests, NOvA specific i/o interface to DAQ combiner**			
1.6.2.4.1	Design	Component evaluation, circuit analysis and simulations, schematic creation, conceptual designs, and pcb CAD layout design			
1.6.2.4.2	Fabricate PCB				
1.6.2.4.3	Procure parts				
1.6.2.4.4	Assemble	Reflow solder, wire bond, mechanical assembly as necessary			
1.6.2.4.5	Develop firmware	Logic conceptual design, VHDL implementation and simulation, download and test			
1.6.2.4.6	Develop software	Software to run test apparatus, data display, and data analysis code			
1.6.2.4.7	Test	Bench top electrical tests, system integration tests.			
1.6.2.4.8	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.4.9	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.4.10	FEB prototype III released to DAQ				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.2.5	**FEB Prototype IV (IPND)**	**Pre-production FEB**			
1.6.2.5.1	FEB modules for IPND started				
1.6.2.5.2	Design	Component evaluation, circuit analysis and simulations, schematic creation, conceptual designs, and pcb CAD layout design			
1.6.2.5.3	Fabricate PCB				
1.6.2.5.4	Procure parts				
1.6.2.5.5	Produce electronics boxes				
1.6.2.5.6	Assemble	Reflow solder, wire bond, mechanical assembly as necessary			
1.6.2.5.7	Develop firmware	Logic conceptual design, VHDL implementation and simulation, download and test			
1.6.2.5.8	Develop software	Software to run test apparatus, data display, and data analysis code			
1.6.2.5.9	Test	Bench top electrical tests, system integration tests.			
1.6.2.5.10	FEB modules for 8-plane segment completed				
1.6.2.5.11	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.5.12	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.5.13	FEB modules for IPND completed				
1.6.2.6	**FEB Prototype V (Near Detector)**	**Contains NOvA Front End ASIC and connector to APD module, DSP development, NOvA detector tests, NOvA specific i/o interface to DAQ combiner**			
1.6.2.6.1	Design	Component evaluation, circuit analysis and simulations, schematic creation, conceptual designs, and pcb CAD layout design			
1.6.2.6.2	Fabricate PCB				
1.6.2.6.3	Procure parts				
1.6.2.6.4	Assemble	Reflow solder, wire bond, mechanical assembly as necessary			
1.6.2.6.5	Develop firmware	Logic conceptual design, VHDL implementation and simulation, download and test			
1.6.2.6.6	Develop software	Software to run test apparatus, data display, and data analysis code			
1.6.2.6.7	Test	Bench top electrical tests, system integration tests.			
1.6.2.6.8	Documentation	Spec documents, user's manuals, technical reference manuals, test reports			
1.6.2.6.9	Administration	Project oversight, collaboration meetings, telecons, reviews, technical and cost reporting			
1.6.2.6.10	FEB prototype V for near detector released to DAQ				
1.6.3	**Power Distribution**				
1.6.3.1	**Low Voltage**				
1.6.3.1.1	Specify LV requirements				
1.6.3.1.2	Specify LV power supply				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.3.1.3	Procure LV power supply			Based on vendor (wiener) quote of Oct 11, 2006	
1.6.3.1.4	Test LV power supply				
1.6.3.2	**High Voltage**				
1.6.3.2.1	Specify HV requirements				
1.6.3.2.2	Specify HV power supply				
1.6.3.2.3	Procure HV power supply			based on Aug 06 vendor (Caen) of 14,436x1.022 (M&S escalation to FY07= 14,754	
1.6.3.2.4	Test HV power supply				
1.6.3.3	**Cabling Hardware**				
1.6.3.3.1	Specify and design PDB to FEB harness				
1.6.3.3.2	Procure PDB to FEB harness			vendor quote	
1.6.3.3.3	Specify LV supply to PDB cable				
1.6.3.3.4	Procure LV supply to PDB cable			vendor quote	
1.6.3.3.5	Specify LV sense cables				
1.6.3.3.6	Procure LV sense cables			catalog price	
1.6.3.3.7	Specify HV supply to PDB cable				
1.6.3.3.8	Procure HV supply to PDB cable			mainly catalog items + patch panel items	
1.6.3.3.9	Specify PDB to DCM cable				
1.6.3.3.10	Procure PDB to DCM cable				
1.6.3.4	**Power Distribution Box**				
1.6.3.4.1	Preliminary specifications for power distribution box				
1.6.3.4.2	Initial design of PDB backplane				
1.6.3.4.3	Initial design of PDB card				
1.6.3.4.4	Initial design of PDB crate				
1.6.3.4.5	Procure parts			catalog prices (see backup worksheet for itemized list)	
1.6.3.4.6	Build prototype				
1.6.3.4.7	Test and finalize design of prototype				
1.6.3.5	**IPND Electronics Infrastructure**				
1.6.3.5.1	**Low Voltage**				
1.6.3.5.1.1	Specify LV racks				
1.6.3.5.1.2	Procure LV racks			catalog item	
1.6.3.5.1.3	Procure LV power supplies			vendor quote at 4 wiener supplies x 7793 per supply= 31,172	
1.6.3.5.1.4	Define LV power supply test procedures				
1.6.3.5.1.5	Setup LV power supply test stand				
1.6.3.5.1.6	Test LV power supplies				
1.6.3.5.2	**High Voltage**				
1.6.3.5.2.1	Procure HV power supply			1 mainframe/ 1 A1520P = $15,500	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.3.5.2.2	Define HV power supply test procedures				
1.6.3.5.2.3	Setup HV power supply test stand				
1.6.3.5.2.4	Test HV power supply				
1.6.3.5.3	**Power Cables**				
1.6.3.5.3.1	Procure PDB to FEB cables			vendor quote	
1.6.3.5.3.2	Procure LV supply to PDB cable			vendor quote	
1.6.3.5.3.3	Procure LV sense cables			catalog price	
1.6.3.5.3.4	Procure HV supply to PDB cable				
1.6.3.5.3.5	Procure PDB to DCM cable				
1.6.3.5.3.6	Procure ground cable			physicist estimate	
1.6.3.5.3.7	Define cable test procedures				
1.6.3.5.3.8	Setup cable test stand				
1.6.3.5.3.9	Specify cable tray				
1.6.3.5.3.10	Procure cable tray			vendor quote (verbal)	
1.6.3.5.4	**Power Distribution Box**				
1.6.3.5.4.1	Procure PDB parts			vendor quote for small quantities	
1.6.3.5.4.2	Define test procedure for PDBs				
1.6.3.5.4.3	Setup PDB test stand				
1.6.3.5.4.4	Assemble and test PDBs				12 hours per crate assumed
1.6.3.5.5	Ship PDBs, cables, and supplies to Fermilab			quote from shipping company	
1.6.3.5.6	Power Distribution System Test				
1.6.3.5.7	Integrate with detector control system				
1.6.3.5.8	IPND power distribution system online				
1.6.4	**Management - R&D Phase**				
1.6.4.1	**FY06**				
1.6.4.1.1	Labor				
1.6.4.1.2	Travel			2 foreign trips @2500 per trip + 8 domestic trips at 500 per trip= 9000 domestic trips a combo of short trips to FNAL plus a couple of others	
1.6.4.1.3	Equipment				
1.6.4.1.4	Materials and supplies			solder and tools	
1.6.4.2	**FY07**				
1.6.4.2.1	**1HFY07**				
1.6.4.2.1.1	Labor				
1.6.4.2.1.2	Travel			2 foreign trips @2500 per trip + 8 domestic trips at 500 per trip= 9000 domestic trips a combo of short trips to FNAL plus a couple of others	
1.6.4.2.1.3	Equipment				
1.6.4.2.1.4	Materials and supplies			solder and tools	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.6.4.2.2	**2HFY07**				
1.6.4.2.2.1	Labor				
1.6.4.2.2.2	Travel			2 foreign trips @2500 per trip + 8 domestic trips at 500 per trip= 9000 domestic trips a combo of short trips to FNAL plus a couple of others	
1.6.4.2.2.3	Equipment				
1.6.4.2.2.4	Materials and supplies			solder and tools	
1.6.4.3	**FY08**				
1.6.4.3.1	Labor				
1.6.4.3.2	Travel				
1.6.4.3.3	Equipment				
1.6.4.3.4	Materials and supplies				
1.6.4.4	FY06 Electronics R&D				
1.6.4.5	FY07 Electronics R&D				
1.6.5	**Vertical Slice Tests**				
1.6.5.1	**Vertical Slice Test 1**				
1.6.5.1.1	Prepare apparatus				
1.6.5.1.2	Operate apparatus				
1.6.5.2	**Vertical Slice Test 2**				
1.6.5.2.1	Prepare apparatus				
1.6.5.2.2	Operate apparatus - 2HFY07				
1.6.5.2.3	Operate apparatus-FY08				
1.6.5.2.4	Prepare fiber testing apparatus				
1.6.5.2.5	Test vertical slice fibers - 2HFY07				
1.6.5.2.6	Test vertical slice fibers - FY08				
1.7	**DAQ System R&D**				
1.7.1	**DAQ Software**	**Includes software to run on buffering/triggering hardware for archival of selected time frames and required online database**			
1.7.1.1	**DAQ Software Standards and Tools**	**Specification of coding standards, development tools, review process, development cycle procedures.**			
1.7.1.1.1	**DAQ Software Standards**	**Specification of coding standards, testing requirements, general development cycle, release procedures, and review processes.**			
1.7.1.1.1.1	DAQ software coding standards document	Write document specifying coding standards for all software in the DAQ system. Rules should cover naming conventions, format, code documentation, testing requirements, etc.			
1.7.1.1.1.2	DAQ software development cycle document	Write document defining the DAQ software development cycle. This will define any requirements and procedures for each stage of the cycle including when testing and reviews are required.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.1.1.3	DAQ software review procedures document	Write a document defining the procedures and standards for document and code reviews. Should cover both formal and informal reviews, requirements of those involved and criteria for determining when a review is required.			
1.7.1.1.2	**DAQ Software Tools**	**Specification of the tools used for developing and maintaining the DAQ software, and any other tools for management of the development process.**			
1.7.1.1.2.1	DAQ software general tools	Write specification and selection of general tools, including debugger, compiler, source code repository, coding standards checking tools, automated documentation generating tools			
1.7.1.1.2.2	DAQ software languages	Evaluation, specification and selection of programming languages used for the development process. Produce a document on languages.			
1.7.1.2	**Error Handling System**	**Error handling system for Nova DAQ.**			
1.7.1.2.1	**Error Handling System Requirements**	**Requirements for the Error Handling System**			
1.7.1.2.1.1	Error handling system requirements document draft 1	Write Error Handling System requirements document draft.			
1.7.1.2.1.2	Review error handling system requirements document	Review requirements document for the error handling system.			
1.7.1.2.1.3	Draft 2 error handling system requirements document	Complete and update Error Handling System requirements document based on review comments.			
1.7.1.2.1.4	Finalize error handling system requirements document	Complete and update Error Handling System requirements document based on review comments.			
1.7.1.2.2	**Error Handling System Design**	**Requirements for the Error Handling System**			
1.7.1.2.2.1	Error handling system design document draft	Write Error Handling System design document draft.			
1.7.1.2.2.2	Review error handling system design document	Review design document for the error handling system.			
1.7.1.2.2.3	Finalize error handling system design document	Complete and update Error Handling System design document based on review comments.			
1.7.1.2.3	**Error Handling Systems Evaluation**	**Examine existing implementations of error handling software to see if any can be used for Nova.**			
1.7.1.2.3.1	Find candidates error handling system software	Search for existing Error Handling Software packages and identify potentially applicable candidates for evaluation.			
1.7.1.2.3.2	Evaluate error handling system candidates	Evaluate identified candidate Error Handling Software and prepare summary of how the well they address the requirements			
1.7.1.2.3.3	Review error handling system evaluations	Review evaluation of error handling software and select candidate for use in Nova.			
1.7.1.2.4	**Error Handling System-First Release**				
1.7.1.2.4.1	Develop initial error logger	Write initial error logger including server to collect errors and minimal logging.			
1.7.1.2.4.2	Develop error handling system client interface	Write client interface for the error handling system.			
1.7.1.2.4.3	Develop error handling system top level interface	Write the top level interface code for the Error Handling System. This is the layer application developer use to interact with the system.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.2.4.4	Develop error handling system test and verification suite	Write the test and verification suite for the Error Handling System software. Include tests and verification for servers and clients.			
1.7.1.2.4.5	Write error handling system user documentation	Write the user document for the Error Handling System so application developers can use the system.			
1.7.1.2.4.6	Perform error handling system tests and verification for first release	Perform the tests and verifications for the First Release of the Error Handling System software.			
1.7.1.2.4.7	Review error handling system software, tests and documentation for first release	Review the code, test results and documentation for the First Release of the Error Handling System.			
1.7.1.2.4.8	Error handling system for first software release	Milestone: First Release contribution of the error logger, includes server to collect errors and minimal logging, server framework for error reporting integrated with other readout packages (e.g. message passing system), client interface, test and verific			
1.7.1.3	**Message Passing System**	**Message Passing System for Nova DAQ.**			
1.7.1.3.1	**Message Passing System Requirements**	**Requirements for the Message Passing System**			
1.7.1.3.1.1	Message passing system requirements document draft	Write Message Passing System requirements document draft.			
1.7.1.3.1.2	Review message passing system requirements document	Review requirements document for the Message Passing System.			
1.7.1.3.1.3	Finalize message passing system requirements document	Complete and update Message Passing System requirements document based on review comments.			
1.7.1.3.2	**Message Passing System Design**	**Design for the Message Passing System**			
1.7.1.3.2.1	Message passing system design document draft	Write Message Passing System design document draft.			
1.7.1.3.2.2	Review message passing system design document	Review design document for the Message Passing System.			
1.7.1.3.2.3	Finalize message passing system design document	Complete and update Message Passing System design document based on review comments.			
1.7.1.3.3	**Message Passing Systems Evaluation**	**Examine existing implementations of Message Passing software to see if any can be used for Nova.**			
1.7.1.3.3.1	Find candidates for the message passing system software	Search for existing Message Passing Software packages and identify potentially applicable candidates for evaluation.			
1.7.1.3.3.2	Evaluate message passing system candidates	Evaluate identified candidate Message Passing Software and prepare summary of how the well they address the requirements			
1.7.1.3.3.3	Review message passing system evaluations	Review evaluation of Message Passing software and select candidate for use in Nova.			
1.7.1.3.4	**Message Passing System-First Release**				
1.7.1.3.4.1	Develop message passing system message framework	Develop code for message format for the Message Passing System that includes and encoding and decoding.			
1.7.1.3.4.2	Develop message passing system client	Develop client code for the Message Passing System			
1.7.1.3.4.3	Develop message passing system server code	Develop server code for the Message Passing System			
1.7.1.3.4.4	Develop message passing system test and verification suite	Write the test and verification suite for the Message Passing System software. Include tests and verification for servers and clients.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.3.4.5	Write message passing system user documentation	Write the user document for the Message Passing System so application developers can use the system.			
1.7.1.3.4.6	Perform message passing system tests and verification for first release	Perform the tests and verifications for the First Release of the Message Passing System software.			
1.7.1.3.4.7	Review message passing system software, tests and documentation for first	Review the code, test results and documentation for the First Release of the Message Passing System.			
1.7.1.3.4.8	Message passing system for software first release	Milestone: First Release contribution of the Message Passing System includes client and server code, test and verification suite, user documentation.			
1.7.1.4	**Run Control System**	**Run control system for Nova DAQ. The software necessary to control data taking, initialize the system, manage starting and stopping of the acquisition of data. Includes framework for configuring runs. User interface to the control system. State manager is**			
1.7.1.4.1	**Run Control System Requirements**	**Requirements for the Run Control System**			
1.7.1.4.1.1	Run control system requirements document draft	Write Run Control System requirements document draft.			
1.7.1.4.1.2	Review run control system requirements document	Review requirements document for the Run Control System.			
1.7.1.4.1.3	Finalize run control system requirements document	Complete and update Run Control System requirements document based on review comments.			
1.7.1.4.2	**Run Control System Design**	**Design for the Run Control System**			
1.7.1.4.2.1	Run control system design document draft	Write Run Control System design document draft.			
1.7.1.4.2.2	Review run control system design document	Review design document for the Run Control System.			
1.7.1.4.2.3	Finalize run control system design document	Complete and update Run Control System design document based on review comments.			
1.7.1.4.3	**Run Control Systems Evaluation**	**Examine existing implementations of run control software to see if any can be used for Nova.**			
1.7.1.4.3.1	Find candidates for run control system software	Search for existing Run Control Software packages and identify potentially applicable candidates for evaluation.			
1.7.1.4.3.2	Evaluate run control system candidates	Evaluate identified candidate Run Control Software and prepare summary of how the well they address the requirements			
1.7.1.4.3.3	Review run control system evaluations	Review evaluation of Run Control Software and select candidate for use in Nova.			
1.7.1.4.4	**Run Control System-First Release**				
1.7.1.4.4.1	Develop initial run control system framework	Develop framework code to alllow a simple configuration, start and stop of the data acquisition system. Support for a single trigger and processor node and a few combiner boards.			
1.7.1.4.4.2	Develop initial run control command line interface	Develop code for a simple command line interface for initial detector activities and support for minimum functions to configure, start and stop the data acquisition system.			
1.7.1.4.4.3	Develop run control system test and verification suite	Write the test and verification suite for the Run Control System software. Include tests and verification for framework and initial command line interface.			
1.7.1.4.4.4	Write run control system user documentation	Write the user document for the Run Control System so application developers can use the system.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.4.4.5	Perform run control system tests and verification for first release	Perform the tests and verifications for the First Release of the Run Control System software.			
1.7.1.4.4.6	Review run control system software, tests and documentation for first release	Review the code, test results and documentation for the First Release of the Run Control System.			
1.7.1.4.4.7	Run control system for software first release	Milestone: First Release contribution of the Run Control System includes command line interface for configuring, starting and stopping one trigger and buffer node and a few combiner boards.			
1.7.1.5	**DAQ Software Architecture Overview**	**Overview architecture of the entire software DAQ system detailing at a high level the structure of the system.**			
1.7.1.5.1	DAQ software architecture overview draft document	Write DAQ software architecture overview design document draft.			
1.7.1.5.2	Review DAQ software architecture overview document	Review the DAQ software architecture overview design document.			
1.7.1.5.3	Finalize DAQ software architecture overview document	Complete and update DAQ software architecture overview design document based on review comments.			
1.7.1.6	**Event Buffer Farm Software**	**Software that runs on the event buffer farm nodes to receive data from the combiner nodes, buffer the data in memory, and allow for triggered events to be read out.**			
1.7.1.6.1	**Event Buffer Farm Software Requirements**	**Requirements for the Event Buffer Farm Software**			
1.7.1.6.1.1	Event buffer farm software requirements document draft	Write Event Buffer Farm software requirements document draft.			
1.7.1.6.1.2	Review event buffer farm software requirements document	Review requirements document for the Event Buffer Farm software.			
1.7.1.6.1.3	Finalize event buffer farm software requirements document	Complete and update Event Buffer Farm software requirements document based on review comments.			
1.7.1.6.2	**Event Buffer Farm Software Design**	**Requirements for the Event Buffer Farm Software**			
1.7.1.6.2.1	Event buffer farm software design document draft	Write Event Buffer Farm software design document draft.			
1.7.1.6.2.2	Review event buffer farm software design document	Review design document for the Event Buffer Farm software.			
1.7.1.6.2.3	Finalize event buffer farm software design document	Complete and update Event Buffer Farm software design document based on review comments.			
1.7.1.6.3	**Event Buffer Farm Core Software**	**Buffer & manager; event builder; network interface; monitor interface; SN trigger framework; event builder; event writer; global trigger --- Separate out to more lines?**			
1.7.1.6.3.1	**Event Buffer Farm Core Software-First Release**				
1.7.1.6.3.1.1	Develop initial circular memory buffer - 1	Circular memory buffer to hold data. Used as primary buffer for events waiting for trigger decision and in software write queue. Not the full featured management of the buffer yet, supports reading and writing.			
1.7.1.6.3.1.2	Develop initial circular memory buffer - 2	Circular memory buffer to hold data. Used as primary buffer for events waiting for trigger decision and in software write queue. Not the full featured management of the buffer yet, supports reading and writing.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.6.3.1.3	Develop network manager	Management of network connections in the Event Buffer Farm, integrated with the Message Passing System			
1.7.1.6.3.1.4	Develop software event builder	Write code that can build time slice data from subsets spread across a large number of aggregate data containers.			
1.7.1.6.3.1.5	Integrate error handling and monitoring support in the event buffer farm core software	Write code to support integration with the error handling system, handling of error conditions, monitoring information gathering and reporting.			
1.7.1.6.3.1.6	Develop trigger handling code	Write the code that will receive triggers, process the signal to determine time slices to select, and copy data from the buffer.			
1.7.1.6.3.1.7	Develop support for sending events to the data logger	Write software for managing the connection to the data logger and sending events.			
1.7.1.6.3.1.8	Integrate run control support in the event buffer farm core software	Write code to support receiving, acting on, and replying to Run Control commands			
1.7.1.6.3.1.9	Write event buffer farm core software test and verification suite for first release	Write the test and verification suite for the Event Buffer Farm core software for the First Release.			
1.7.1.6.3.1.10	Write event buffer farm core software user documentation for first release	Write the user document for the Event Buffer Farm core software so application developers can use the system.			
1.7.1.6.3.1.11	Perform event buffer farm core software tests and verification for first release	Perform the tests and verifications for the First Release of the Event Buffer Farm core software contribution.			
1.7.1.6.3.1.12	Review event buffer farm core software, tests and documentation for first release	Review the code, test results and documentation for the First Release of the Event Buffer Farm core software.			
1.7.1.6.3.1.13	Event buffer farm core software for software first release	Milestone: First Release contribution of the Event Buffer Farm core software, includes basic circular buffer memory and management for reads and writes, network interface integrated with the message passing system, includes error handing and reporting, m			
1.7.1.6.4	**Event Buffer Farm Server**	**Build Event Buffer Farm servers from the core code.**			
1.7.1.6.4.1	**Event Buffer Farm Server-First Release**				
1.7.1.6.4.1.1	Write first release event buffer farm server code	Write Event Buffer Farm Server using the First Release of the Event Buffer Farm server.			
1.7.1.6.4.1.2	Write event buffer farm server test and verification suite for first release	Update the test and verification suite for the Event Buffer Farm server for the First Release.			
1.7.1.6.4.1.3	Write event buffer farm server user documentation for software first release	Update the user document for the Event Buffer Farm server so application developers can use the system.			
1.7.1.6.4.1.4	Perform event buffer farm server tests and verification for software first release	Perform the tests and verifications for the First Release of the Event Buffer Farm server.			
1.7.1.6.4.1.5	Review event buffer farm server, tests and documentation for software first	Review the code, test results and documentation for the First Release of the Event Buffer Farm server.			
1.7.1.6.4.1.6	Event buffer farm server for software first release	Milestone: First Release contribution of the Event Buffer Farm server, includes features of Event Buffer Farm core software, test and verification suite, user documentation.			
1.7.1.6.5	**Linux Kernel Support for Trace**	**Build Linux Kernel to Support Trace**			
1.7.1.6.5.1	Build kernel with support for trace	Build kernel with support for the Trace package			
1.7.1.6.5.2	Write trace kernel support test and verification suite for software first release	Write the test and verification suite for the Trace Kernel support for the First Release.			
1.7.1.6.5.3	Write trace kernel support user documentation for software first release	Write the user document for the Trace kernel support so application developers can use the system.			
1.7.1.6.5.4	Perform trace kernel support tests and verification for software first release	Perform the tests and verifications for the First Release of the Trace Kernel support.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.6.5.5	Review trace kernel support, tests and documentation for software first release	Review the code, test results and documentation for the First Release of the Trace Kernel support.			
1.7.1.6.5.6	Trace kernel support for software first release	Milestone: First Release contribution of the Trace Kernel support, test and verification suite, user documentation.			
1.7.1.7	**Data Logger**	**Application that writes data to files on disk.**			
1.7.1.7.1	**Data Logger Requirements**	**Requirements for the data logger.**			
1.7.1.7.1.1	Data logger requirements document draft	Write data logger requirements document draft.			
1.7.1.7.1.2	Review data logger requirements document	Review requirements document for the data logger.			
1.7.1.7.1.3	Finalize data logger requirements document	Complete and update data logger requirements document based on review comments.			
1.7.1.7.2	**Data Logger Design**	**Design for the data logger.**			
1.7.1.7.2.1	Data logger design document draft	Write data logger design document draft.			
1.7.1.7.2.2	Review data logger design document	Review design document for the data logger.			
1.7.1.7.2.3	Finalize data logger design document	Complete and update data logger design document based on review comments.			
1.7.1.8	**Global Trigger System**	**System that generates triggers and sends them to the Event Buffer Farm Servers. Receives signals externally for beam trigger, calculates combined software trigger based on information from the individual servers and determines window if trigger conditions**			
1.7.1.8.1	**Global Trigger System Requirements**	**Requirements for the global trigger system.**			
1.7.1.8.1.1	Global trigger system requirements document draft	Write global trigger system requirements document draft.			
1.7.1.8.1.2	Review global trigger system requirements document	Review requirements document for the global trigger system.			
1.7.1.8.1.3	Finalize global trigger system requirements document	Complete and update global trigger system requirements document based on review comments.			
1.7.1.8.2	**Global Trigger System Design**	**Design for the global trigger system.**			
1.7.1.8.2.1	Global trigger system design document draft	Write global trigger system design document draft.			
1.7.1.8.2.2	Review global trigger system design document	Review design document for the global trigger system.			
1.7.1.8.2.3	Finalize global trigger system design document	Complete and update global trigger system design document based on review comments.			
1.7.1.8.3	**Global Trigger System-First Release**				
1.7.1.8.3.1	Develop initial global trigger server framework	Develop framework for the global trigger system that can process a psuedo beam trigger via software signal and generate time slice window and send signal to Event Buffer Farm Servers.			
1.7.1.8.3.2	Write global trigger system test and verification suite for software first release	Write the test and verification suite for the Global Trigger System for the First Release.			
1.7.1.8.3.3	Write global trigger system user documentation for software first release	Write the user document for the Global Trigger System so application developers can use the system.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.8.3.4	Perform global trigger system tests and verification for software first release	Perform the tests and verifications for the First Release of the Global Trigger System.			
1.7.1.8.3.5	Review global trigger system, tests and documentation for software first release	Review the code, test results and documentation for the First Release of the Global Trigger System.			
1.7.1.8.3.6	Global trigger system for software first release	Milestone: First release contribution of the Global Trigger System, includes software based pseudo beam trigger, test and verification suite, user documentation.			
1.7.1.8.4	**Global Trigger System-Second Release**				
1.7.1.8.4.1	Develop beam signal trigger	Add support for processing of real beam trigger and defining time slice window and sending signal to Event Buffer Farm Servers.			
1.7.1.8.4.2	Integrate error handling and monitoring support in the global trigger server	Write code to support integration with the error handling system, handling of error conditions, monitoring information gathering and reporting.			
1.7.1.8.4.3	Integrate run control support in the global trigger server	Write code to support receiving, acting on, and replying to Run Control commands			
1.7.1.8.4.4	Update global trigger system test and verification suite for software second	Update the test and verification suite for the Global Trigger System for the second release.			
1.7.1.8.4.5	Update global trigger system user documentation for software second release	Update the user document for the Global Trigger System so application developers can use the system.			
1.7.1.8.4.6	Perform global trigger system tests and verification for software second release	Perform the tests and verifications for the second release of the Global Trigger System.			
1.7.1.8.4.7	Review global trigger system, tests and documentation for software second release	Review the code, test results and documentation for the second release of the Global Trigger System.			
1.7.1.8.4.8	Global trigger system for software second release	Milestone: Second release contribution of the Global Trigger System, includes includes support for real beam trigger, integration with monitoring and error handling systems and support for receiving, acting on, and replying to Run Control commands, test a			
1.7.1.9	**DAQ Monitor System**	**Monitor system for the health and performance of the DAQ.**			
1.7.1.9.1	**DAQ Monitor System Requirements**	**Requirements for the DAQ Monitor System.**			
1.7.1.9.1.1	DAQ monitor system requirements document draft	Write DAQ Monitor System requirements document draft.			
1.7.1.9.1.2	Review DAQ monitor requirements document	Review requirements document for the DAQ Monitor System.			
1.7.1.9.1.3	Finalize DAQ monitor requirements document	Complete and update DAQ Monitor System requirements document based on review comments.			
1.7.1.9.2	**DAQ Monitor System Design**	**Design for the DAQ Monitor System.**			
1.7.1.9.2.1	DAQ monitor system design document draft	Write DAQ Monitor System design document draft.			
1.7.1.9.2.2	Review DAQ monitor system design document	Review design document for the DAQ Monitor System.			
1.7.1.9.2.3	Finalize DAQ monitor system design document	Complete and update DAQ Monitor System design document based on review comments.			
1.7.1.9.3	**DAQ Monitor Software and Development Languages Evaluation**	**Examine existing implementations of DAQ Monitor software and development software they support to see if any can be used for Nova.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.9.3.1	Find candidates for DAQ monitor software and development languages	Search for existing DAQ monitor software and development languages and identify potentially applicable candidates for evaluation.			
1.7.1.9.3.2	Evaluate DAQ monitor software and development languages	Evaluate identified candidate DAQ monitor software and development languages and prepare summary of how the well they address the requirements			
1.7.1.9.3.3	Review DAQ monitor software and development languages evaluations	Review evaluation of DAQ monitor software and development languages and select candidate for use in Nova.			
1.7.1.10	**Online Databases**	**Databases used in the online DAQ system. Should include instances of production, integration and development.**			
1.7.1.10.1	**General Online Database Infrastructure**	**Covers requirements, infrastructure, procedures, etc that are common to all databases in the online system.**			
1.7.1.10.1.1	**General Online Database Requirements**	**Requirements in general for online databases**			
1.7.1.10.1.1.1	General online database requirements document draft	Write general online database requirements document draft.			
1.7.1.10.1.1.2	Review general online database requirements document	Review requirements document for the general online database requirements.			
1.7.1.10.1.1.3	Finalize general online database requirements document	Complete and update general online database requirements document based on review comments.			
1.7.1.10.1.2	**Online Database Backup & Failover Requirements**	**Requirements for backups and failover of online databases**			
1.7.1.10.1.2.1	Online database backup & falilover requirements document draft	Write general online database requirements document draft.			
1.7.1.10.1.2.2	Review online database backup & failover requirements document	Review requirements document for the general online database requirements.			
1.7.1.10.1.2.3	Finalize online database backup & faliover requirements document	Complete and update general online database requirements document based on review comments.			
1.7.1.10.1.5	**Database Deployment to Development**	**Deployment of databases in the development environment**			
1.7.1.10.1.5.1	Deploy databases on development server	Review database structure based on hardware, identify minimal database needs for initial startup, define database scripts, identify instance support level, deploy databases on development server			
1.7.1.10.1.5.2	Configure development database servers	Configure development database servers based on the general and specific requirements			
1.7.1.10.1.5.3	Development database servers released for use	Milestone: First release contribution of deployment databases for general use.			
1.7.1.10.2	**Database Applications**	**These are applications that are affiliated with the construction of Nova.**			
1.7.1.10.2.2	**Online Hardware Database Application**	**Database application and schema for online hardware (FEBs, Combiners).**			
1.7.1.10.2.2.1	**Online Hardware Application Specification**	**Online hardware application specification**			
1.7.1.10.2.2.1.1	Develop online hardware application specification	Draw ER diagram (iterative process), document and review overall design strategy, generate data dictionary, identify database sub-schema interactions, write data flow diagram.			
1.7.1.10.2.2.1.2	Review online hardware application specification	Review ER diagram, overall design strategy, data dictionary, database sub-schema interactions, data flow diagram.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.1.10.2.2.1.3	Finalize online hardware application specification	Complete and update online hardware specification based on review comments.			
1.7.1.10.2.2.3	Prototype online hardware application and database access	Generate DDL, SQL scripts. Separate server functionality from client.			
1.7.1.10.2.2.4	Implement & test online hardware application in the development environment	Does ER diagram match DDL. Write code modules, write and run test suites, create test data, revise schema, design application monitoring and diagnostic tools.			
1.7.1.11	DAQ software ready for IPND				
1.7.2	**DAQ Hardware**	**Hardware for receiving signals from FEB, buffering and archival, delivery of clock/timing signals**			
1.7.2.1	**Data Concentrator**	**Hardware for receiving signals from FEBs, delivery of timing and control signals to FEBs, buffering and delivery of data to network.**			
1.7.2.1.1	**Requirements**	**Data Concentrator system requirements**			
1.7.2.1.1.1	Prepare requirements document	Write Requirements document			
1.7.2.1.1.2	Review requirements	Review Requirements document			
1.7.2.1.1.3	Requirements approved	Approve Requirements document			
1.7.2.1.2	**Design**	**Design phase for prototype Data Concentrators**			
1.7.2.1.2.1	**Evaluation**	**Determine basic architecture for Data Concentrators**			
1.7.2.1.2.1.1	Order evaluation kits	FPGA and embedded processor evaluation boards			
1.7.2.1.2.1.2	Benchmark evaluation kits	Obtain performance measurements for architecture options			
1.7.2.1.2.1.3	Select architecture	Choose Data Concentrator architecture			
1.7.2.1.2.2	**Specifications**	**Specifications for Data Concentrator hardware and firmware**			
1.7.2.1.2.2.1	Prepare specifications document	Write Specifications document			
1.7.2.1.2.2.2	Review specifications	Review Specifications document			
1.7.2.1.2.2.3	Specifications approved	Approve Specifications document			
1.7.2.1.2.3	**Circuit Design**	**Design Data Concentrator circuitry**			
1.7.2.1.2.3.1	Generate schematic symbols	Generate symbols for FPGA, embedded processor, etc			
1.7.2.1.2.3.2	Enter schematic	Circuit design and schematic entry			
1.7.2.1.2.3.3	Review schematic	Circuit design review			
1.7.2.1.2.3.4	Schematic approved	Circuit design approval for prototype			
1.7.2.1.2.4	**Firmware Design**	**Design Data Concentrator firmware and embedded software**			
1.7.2.1.2.4.1	Design FPGA firmware	Write input multiplexing firmware for FPGA(s)			
1.7.2.1.2.4.2	Design OS port	Port OS (Linux) to Data Concentrator			
1.7.2.1.2.4.3	Design embedded software	Write basic buffer management software for embedded processor			
1.7.2.1.2.5	Board design	Data Concentrator board layout			
1.7.2.1.2.6	Packaging design	Data Concentrator packaging			
1.7.2.1.2.7	Simulation	Circuit and firmware simulation			
1.7.2.1.2.8	Data concentrator design completed				
1.7.2.1.3	**Prototype Manufacture**	**Manufacturing phase for prototype Data Concentrators**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.2.1.3.1	Prepare PCB manufacturing requirements document	Write manufacturing requirements			
1.7.2.1.3.2	Review PCB manufacturing	Review manufacturing requirements and specifications			
1.7.2.1.3.3	PCB manufacturing approved	Approve prototype manufacture			
1.7.2.1.3.4	**Order Prototype Manufacture**	**Place order for prototype Data Concentrators**			
1.7.2.1.3.4.1	Write purchase requisitions	Prototype printed circuit boards and components for local assembly			
1.7.2.1.3.4.2	Obtain project approvals	Project level purchase request approvals			
1.7.2.1.3.4.3	Write purchase orders	Write PCB and components purchase orders			
1.7.2.1.3.4.4	Place purchase orders	Place PCB and components purchase orders		10 DCM boards @ 2000 ea = $20k	
1.7.2.1.3.5	Prototype data concentrator PCBs and components received	Manufacturer delivery of prototype Data Concentrator components			
1.7.2.1.3.6	Assemble prototype data concentrators	In-house assembly of prototype Data Concentrators			
1.7.2.1.4	**Prototype Test**	**Acceptance testing of Data Concentrators**			
1.7.2.1.4.1	Write test procedures document	Data Concentrator test procedures			
1.7.2.1.4.2	Perform standalone board tests	Self-test and internal operation verification			
1.7.2.1.4.3	Perform interface tests	Communication and external operation verification			
1.7.2.1.4.4	DCM prototype completed				
1.7.2.1.5	**Pre-production Design Modifications**	**Design modifications based on prototype testing**			
1.7.2.1.5.1	**Specifications**	**Revise specifcations as necessary**			
1.7.2.1.5.1.1	Prepare specifications document	Update Specifications document			
1.7.2.1.5.2	**Circuit Design**	**Revise Data Concentrator circuit design as necessary**			
1.7.2.1.5.2.1	Schematic entry	Update schematics			
1.7.2.1.5.3	Board design	Revise Data Concentrator board layout as necessary			
1.7.2.1.5.4	Simulation	Resimulate circuit and firmware design			
1.7.2.1.6	**Integration Prototype Near Detector DCM**	**Manufacturing phase for pre-production Data Concentrators**			
1.7.2.1.6.1	**IPND DCM Procurement**	**Place order for pre-production Data Concentrators**			
1.7.2.1.6.1.1	Write purchase requests	Pre-production printed circuit boards and components for local assembly			
1.7.2.1.6.1.2	Obtain project approvals	Project level purchase request approvals			
1.7.2.1.6.1.3	Write purchase orders	Write PCB and components purchase orders			
1.7.2.1.6.1.4	Place purchase orders	Place PCB and components purchase orders		10 DCM boards @ 2000 ea = $20k	
1.7.2.1.6.2	IPND data concentrator PCBs and components received	Manufacturer delivery of pre-production Data Concentrator components			
1.7.2.1.6.3	Assemble IPND data concentrators	In-house assembly of pre-production Data Concentrators			
1.7.2.1.7	**Test Integ**	**Acceptance testing of pre-production Data Concentrators**			
1.7.2.1.7.1	Perform standalone boards tests	Self-test and internal operation verification			
1.7.2.1.7.2	Perform interface tests	Communication and external operation verification			
1.7.2.1.7.3	Review test results				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.2.1.8	IPND data concentrators ready for installation	Data Concentrator design approved for production			
1.7.2.2	**Control and Timing System**	**Hardware for delivery of timing and control signals to Data Concentrators, readout of status.**			
1.7.2.2.1	**Requirements**	**Control and Timing system requirements**			
1.7.2.2.1.1	Prepare requirements document	Write Requirements document			
1.7.2.2.1.2	Review requirements	Review Requirements document			
1.7.2.2.1.3	Requirements approved	Approve Requirements document			
1.7.2.2.2	**Design**	**Design phase for prototype Control and Timing**			
1.7.2.2.2.1	**Evaluation**	**Determine basic architecture for Control and Timing**			
1.7.2.2.2.1.1	Order evaluation kits	FPGA, GPS evaluation boards			
1.7.2.2.2.1.2	Benchmark evaluation kits	Obtain performance measurements for architecture options			
1.7.2.2.2.1.3	Select architecture	Choose Control and Timing architecture			
1.7.2.2.2.2	**Specifications**	**Specifications for Control and Timing hardware and firmware**			
1.7.2.2.2.2.1	Prepare specifications document	Write Specifications document			
1.7.2.2.2.2.2	Review specifications	Review updated requirements and specifications			
1.7.2.2.2.2.3	Specifications approved	Approve Specifications document			
1.7.2.2.2.3	**Circuit Design**	**Design Control and Timing circuitry**			
1.7.2.2.2.3.1	Generate schematic symbols	Generate symbols for FPGA, etc			
1.7.2.2.2.3.2	Enter schematic	Circuit design and schematic entry			
1.7.2.2.2.3.3	Review schematic	Circuit design review			
1.7.2.2.2.3.4	Schematic approved	Circuit design approval for prototype			
1.7.2.2.2.4	**Firmware Design**	**Design Control and Timing firmware**			
1.7.2.2.2.4.1	Design FPGA firmware	Write timing signal distribution firmware for FPGA(s)			
1.7.2.2.2.4.2	Design embedded software	Control and Timing software for host computer interface			
1.7.2.2.2.5	Board design	Control and Timing board layouts			
1.7.2.2.2.6	Packaging design	Control and Timing system packaging			
1.7.2.2.2.7	Simulation	Circuit and firmware simulation			
1.7.2.2.3	**Prototype Manufacture**	**Manufacturing phase for prototype Control and Timing**			
1.7.2.2.3.1	Prepare PCB manufacturing requirements document	Write manufacturing requirements			
1.7.2.2.3.2	Review PCB manufacturing	Review manufacturing requirements and specifications			
1.7.2.2.3.3	PCB manufacturing approved	Approve prototype manufacture			
1.7.2.2.3.4	**Prototype Procurement**	**Place order for prototype Control and Timing**			
1.7.2.2.3.4.1	Write purchase requests	Prototype printed circuit boards and components for local assembly			
1.7.2.2.3.4.2	Obtain project approvals	Project level purchase request approvals			
1.7.2.2.3.4.3	Write purchase orders	Write PCB and components purchase orders			
1.7.2.2.3.4.4	Place purchase orders	Place PCB and components purchase orders		4 timing + fanout boards @ 4000 ea = $16k	
1.7.2.2.3.5	Prototype PCBs and components received for control and timing system	Manufacturer delivery of prototype Control and Timing components			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.2.2.3.6	Assemble prototypes	In-house assembly of prototype Control and Timing system			
1.7.2.2.4	**Prototype Test**	**Acceptance testing of Control and Timing**			
1.7.2.2.4.1	Write test procedures document	Control and Timing system test procedures			
1.7.2.2.4.2	Perform standalone board tests	Self-test and internal operation verification			
1.7.2.2.4.3	Perform interface tests	Communication and external operation verification			
1.7.2.2.4.4	Control and timing prototype tests completed				
1.7.2.3	**Network**	**Networking equipment to connect Data Concentrators to Processors and Data Storage, external routers.**			
1.7.2.3.1	**Requirements**	**General networking, switch and router requirements**			
1.7.2.3.1.1	Prepare requirements document	Write Requirements document			
1.7.2.3.1.2	Review requirements	Review Requirements document			
1.7.2.3.1.3	Requirements approved	Approve Requirements document			
1.7.2.3.2	Order network test equipment	Place orders for pre-production/evaluation equipment		1 ethernet analyzer @ 20000 ea = $20k	
1.7.2.3.3	Order evaluation network equipment	Place orders for pre-production/evaluation equipment		4 ethernet switches @ 2000 ea = $8k	
1.7.2.3.4	Evaluation components received	Vendor delivery of pre-production/evaluation equipment			
1.7.2.3.5	Test evaluation components	Acceptance testing of pre-production/evaluation equipment			
1.7.2.4	**Control Room Equipment and Infrastucture**	**Computers and Displays for Control Room, Run Control, Database server applications. Control Room furnishings and infrastructure.**			
1.7.2.4.1	**Requirements**	**Processor and peripheral requirements**			
1.7.2.4.1.1	Prepare requirements document	Write Requirements document			
1.7.2.4.1.2	Review requirements	Review Requirements document			
1.7.2.4.1.3	Requirements approved	Approve Requirements document			
1.7.2.4.2	Order evaluation components	Place orders for pre-production/evaluation equipment		4 PCs with monitors, control room@2.5k ea = $10k	
1.7.2.4.3	Evaluation components received	Vendor delivery of pre-production/evaluation equipment			
1.7.2.4.4	Test evaluation components	Acceptance testing of pre-production/evaluation equipment			
1.7.2.5	**Buffer Farm**	**Processor Farm for Trigger**			
1.7.2.5.1	**Requirements**	**Processor and peripheral requirements**			
1.7.2.5.1.1	Prepare requirements document	Write Requirements document			
1.7.2.5.1.2	Review requirements	Review Requirements document			
1.7.2.5.1.3	Requirements approved	Approve Requirements document			
1.7.2.5.2	Order evaluation components	Place orders for pre-production/evaluation equipment	not a quantity buy	10 rack-mounted PCs, DAQ nodes @ 2k ea = 20k	
1.7.2.5.3	Evaluation components received	Vendor delivery of pre-production/evaluation equipment			
1.7.2.5.4	Test evaluation components	Acceptance testing of pre-production/evaluation equipment			
1.7.2.6	**Data Storage**	**Network attached storage system**			
1.7.2.6.1	**Requirements**	**Disk or tape interface and capacity requirements**			
1.7.2.6.1.1	Prepare requirements document	Write Requirements document			
1.7.2.6.1.2	Review requirements	Review Requirements document			
1.7.2.6.1.3	Requirements approved	Approve Requirements document			
1.7.2.6.2	Order evaluation components	Place orders for pre-production/evaluation equipment	not a quantity buy	3 TB of NAS disk array @ 2k per TB = $6k	

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1.7.2.6.3	Evaluation components received	Vendor delivery of pre-production/evaluation equipment			
1.7.2.6.4	Test evaluation components	Acceptance testing of pre-production/evaluation equipment			
1.7.2.7	**Cabling**	**All data acquisition and network cabling**			
1.7.2.7.1	**Requirements**	**Cable type, length, labeling requirements**			
1.7.2.7.1.1	Prepare requirements document	Write Requirements document			
1.7.2.7.1.2	Review requirements	Review Requirements document			
1.7.2.7.1.3	Requirements approved	Approve Requirements document			
1.7.2.7.2	Order evaluation components	Place orders for pre-production/evaluation equipment	several lengths to test	48 Cat5E cables @ 40 ea = $2k	
1.7.2.7.3	Evaluation components received	Vendor delivery of pre-production/evaluation cables			
1.7.2.7.4	Test evaluation components	Acceptance testing of pre-production/evaluation cables			
1.7.2.8	**Databases**				
1.7.2.8.1	Procure database computers			2 computers at $2.5k each = $5k	
1.7.3	**Integration**	**Integration testing of DAQ and trigger electronics hardware and software. It assumes a single, central test facility and all test equipment, computers, and displays have been purchased in 1.7.1.**			
1.7.3.1	Install and test integration test facility (ITF)	Install and configure ITF components including network switch and development computers			
1.7.3.2	**Buffer Farm Evaluation**	**Establish performance criteria and benchmark tests needed for the trigger farm RFP. Software suite will be available to run on candidate hardware.**			
1.7.3.2.1	Write performance requirements and benchmark tests document	Requirements document			
1.7.3.2.2	Write benchmark tests	Test suite			
1.7.3.2.3	Perform benchmark tests				
1.7.3.3	**Readout Electronics Integration Testing**				
1.7.3.3.1	Integrate data concentrators	Integration testing of prototype Data Concentrator interfaces to control and timing networks			
1.7.3.3.2	Integrate data and control network	Integration testing of network interfaces to DCBs and trigger farm			
1.7.3.3.3	Integrate timing system	Integration testing of prototype timing system to front end electronics			
1.7.3.4	**Software Integration Testing**	**I've made up releases and functionality pending releases listed in 1.7.1**			
1.7.3.4.1	Integrate RCS single node	Includes configuration management, software event builder			
1.7.3.4.2	Integrate event building	what are the releases here?			
1.7.3.4.3	Integrate trigger				
1.7.3.5	Consultation	General support of the installation and integration of the trigger/daq system at the near and far detectors.			
1.7.4	**Detector Control System**	**Slow control system for Nova DAQ.**			
1.7.4.1	**Detector Control System Requirements**	**Requirements for the Slow Control System**			
1.7.4.1.1	Prepare detector control system requirements document draft	Write Slow Control System requirements document draft.			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.4.1.2	Review detector control system requirements document	Review requirements document for the Slow Control System.			
1.7.4.1.3	Finalize detector control system requirements document	Complete and update Slow Control System requirements document based on review comments.			
1.7.4.2	**Detector Control System Design**	**Design for the Slow Control System**			
1.7.4.2.1	Detector control system design document draft	Write Slow Control System design document draft.			
1.7.4.2.2	Review detector control system design document	Review design document for the Slow Control System.			
1.7.4.2.3	Finalize detector control system design document	Complete and update Slow Control System design document based on review comments.			
1.7.4.3	**Detector Control System Evaluation**	**Examine existing implementations of Slow Control Software to see if any can be used for Nova.**			
1.7.4.3.1	Find candidates for detector control system software	Search for existing Slow Control Software packages and identify potentially applicable candidates for evaluation.			
1.7.4.3.2	Find candidates for detector control system hardware monitoring/readout				
1.7.4.3.3	**Detector Control System Candidate Evaluation**	**Evaluate identified candidate Slow Control Software and prepare summary of how the well they address the requirements**			
1.7.4.3.3.1	Evaluate DCM detector controls readout methods				
1.7.4.3.3.2	Evaluate FEB detector controls readout methods				
1.7.4.3.3.3	Evaluate high voltage controls readout interfaces				
1.7.4.3.3.4	Evaluate low voltage controls readout interfaces				
1.7.4.3.3.5	Evaluate water cooling system controls readout interfaces				
1.7.4.3.3.6	Evaluate enviromental sensor system readout interfaces				
1.7.4.3.4	Review detector control system evaluations	Review evaluation of Slow Control Software and select candidate for use in Nova.			
1.7.4.3.5	**Detector Controls System Prototype Hardware Procurement**				
1.7.4.3.5.1	Purchase prototype detector controls channel server computer				
1.7.4.3.5.2	Purchase prototype detector controls monitoring computer				
1.7.4.3.5.3	Purchase prototype readout interface boards for channel server				
1.7.4.3.5.4	Obtain and assemble prototype DCM for detector controls testing				
1.7.4.3.5.5	Obtain and assemble prototype FEB for detector controls testing				
1.7.4.3.5.6	Procure and assemble prototype high voltage system for detector controls testing				
1.7.4.3.5.7	Procure and assemble prototype low voltage system for detector controls testing				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.4.3.5.8	Procure and assemble prototype water cooling sensor pack for detector controls				
1.7.4.3.5.9	Procure and assemble prototype enviromental monitoring system for detector controls testing				
1.7.4.3.6	Develop detector controls test stand				
1.7.4.4	**Detector Control Software Configuration For Experiment**	**Any Slow Control System selected will need to be configured for the specifics of the experiment.**			
1.7.4.4.1	Develop channel server master (EPICs)				
1.7.4.4.2	**Channel Server Master IOC (input output controller) Modules Development**				
1.7.4.4.2.1	Develop DCM IOC				
1.7.4.4.2.2	Develop FEB IOC				
1.7.4.4.2.3	Develop HV IOC				
1.7.4.4.2.4	Develop LV IOC				
1.7.4.4.2.5	Develop water cooling IOC				
1.7.4.4.2.6	Develop enviromental sensors IOC				
1.7.4.4.3	**Detector Controls System Intergration On Test Stand**				
1.7.4.4.3.1	Determine load scaling				
1.7.4.4.3.2	Develop system failure and fall over recovery				
1.7.4.4.4	**Client Application Prototypes Development**				
1.7.4.4.4.1	Develop individual system controls clients ("expert" clients)				
1.7.4.4.4.2	Develop general intergrated basic controls clients				
1.7.4.4.4.3	Develop individual system alarm clients				
1.7.4.4.4.4	Develop general intergrated alarms client				
1.7.4.5	**Detector Controls Graphical User Interfaces Development**	**Any Slow Control System monitoring tools will need to be configured for the experiment.**			
1.7.4.5.1	Develop detector controls monitoring GUI				
1.7.4.5.2	Develop detector controls logging and history GUI				
1.7.4.5.3	Develop detector controls remote inspect client (web browser based)				
1.7.4.6	Develop detector control diagnostics and test suite	Write the test and verification suite for the Run Control System software. Include tests and verification for framework and initial command line interface.			
1.7.4.7	**User and Expert Level System Documentation**	**Write the user document for the Run Control System so application developers can use the system.**			
1.7.4.7.1	Write detector controls user documentation				
1.7.4.7.2	Write system monitoring user documentation				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.4.8	**Detector Control System Tests And Verification For Release**	**Perform the tests and verifications for the First Release of the Run Control System software.**			
1.7.4.8.1	Perform high voltage controls and monitoring verification for release				
1.7.4.8.2	Perform low voltage controls and monitoring verification for release				
1.7.4.8.3	Perform DCM controls and monitoring verification for release				
1.7.4.8.4	Perform FEB controls and monitoring verification for release				
1.7.4.8.5	Perform water cooling system controls and monitoring verification for release				
1.7.4.8.6	Perform enviromental system controls and monitoring verification for release				
1.7.4.8.7	Perform logging and database intergration verification for release				
1.7.4.9	Review detector control system software, tests and documentation for first release	Review the code, test results and documentation for the First Release of the Run Control System.			
1.7.4.10	Perform security audit for detector control system				
1.7.4.11	Detector control system released	Milestone: First release contribution of the Slow Control System tailored to the needs of the experiment			
1.7.4.12	**Detector Control System Procurement and Fabrication (IPND)**				
1.7.4.12.1	Procure detector controls counting house computing hardware and infrastructure (IPND)				
1.7.4.12.2	Procure detector controls readout systems and sensor packs (IPND)				
1.7.4.12.3	**Detector Controls Computing Setup (IPND)**				
1.7.4.12.3.1	Setup and configure DCS master server				
1.7.4.12.3.2	Setup and configure DCS readout servers				
1.7.4.12.3.3	Setup and configure DCSNet for IPND				
1.7.4.12.3.4	Install servers and switches in IPND electronics and control facilities				
1.7.4.12.4	**Detector Controls Readout Systems Setup (IPND)**				
1.7.4.12.4.1	Setup water cooling monitors and sensors				
1.7.4.12.4.2	Setup power supply monitors and sensors				
1.7.4.12.4.3	Setup general environmental and detector sensors				
1.7.4.12.4.4	Setup DCM/FEB monitors				
1.7.4.12.5	Test DCS systems on IPND				
1.7.4.12.6	Certify DCS for production operations				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.7.4.12.7	Conduct DCS production readiness review				
1.7.5	**Management - R&D Phase**				
1.7.5.1	**FY06**				
1.7.5.1.1	Labor				
1.7.5.1.2	Travel				
1.7.5.1.3	Equipment				
1.7.5.1.4	Materials and supplies				
1.7.5.2	**FY07**				
1.7.5.2.1	**H1FY07**				
1.7.5.2.1.1	Labor				
1.7.5.2.1.2	Travel				
1.7.5.2.1.3	Equipment				
1.7.5.2.1.4	Materials and supplies				
1.7.5.2.2	**H2FY07**				
1.7.5.2.2.1	Labor				
1.7.5.2.2.2	Travel				
1.7.5.2.2.3	Equipment				
1.7.5.2.2.4	Materials and supplies				
1.7.5.3	**FY08**				
1.7.5.3.1	Labor				
1.7.5.3.2	Travel				
1.7.5.3.3	Equipment				
1.7.5.3.4	Materials and supplies				
1.7.5.4	FY06 DAQ R&D				
1.7.5.5	FY07 DAQ R&D				
1.8	**Detector Assembly R&D**	**Perform R&D work to validate and optimize the mechanical designs and installation procedures for the NOvA Near and Far Detectors. This includes structural engineering calculations of the fully and partially assembled detectors, the mechanical design and prototyping of detector assembly mechanical systems and tooling, and the construction and testing of prototypes of both Near and Far Detectors. This task will select and document the baseline designs that will be used as the basis for the NOvA CDR and TDR.**			

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.1	**Plane Assembly Adhesive R&D**	**The goal of this task is to choose an adhesive that is suitable for bonding extrusion modules together into 31-plane blocks for the far detector. The same adhesive will be used to construct the 7/8-plane segments for the near detector. This task is performed in close coordination with the determination of detector structural requirements (WBS 1.8.2) and design of the adhesive dispenser (under WBS 1.8.6). WBS 1.8.1 involves the specification of adhesive requirements, the development of adhesive test procedures, and the identification and testing of suitable adhesive candidates.**			**engineering estimates**
1.8.1.1	Develop requirements document				
1.8.1.2	Develop plane assembly adhesive test procedures				
1.8.1.3	Procure sample adhesives and other test materials				
1.8.1.4	Develop test jigs				
1.8.1.5	Perform plane assembly adhesive tests				
1.8.1.6	Baseline plane assembly adhesive selected				
1.8.1.7	Develop plane assembly adhesive QA procedures				
1.8.1.8	Document and review test results and procedures				
1.8.1.9	Review and validate plane baseline adhesive selection				
1.8.1.10	Value engineering of alternative bonding methods				
1.8.1.11	Baseline adhesive changed to Devcon 60				
1.8.1.12	Prepare final specifications for plane assembly adhesive				
1.8.1.13	Optimize Devcon 60 application procedures - 1				
1.8.1.14	Optimize Devcon 60 application procedures - 2				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.2	**Structural Design and Validation**	**The goal of this task is to develop and optimize the structural design of the far detector, which is assembled from vertical planes of alternating horizontal and vertical extrusion modules and filled with liquid scintillator. This task involves the Finite Element Analyses (FEAs) of different candidate structures during assembly, before and after filling with liquid scintillator. The analysis will provide mechanical strength requirements for PVC extrusions, the adhesive that bonds them together and the bottom end seals on the vertical extrusion modules that support the weight of the detector. A series of small-scale and large-scale prototype structures will be constructed to check FEA predictions of the behavior of candidate structures. This task will be carried out in close coordination with the choice of adhesive (WBS 1.8.1) and the design of assembly fixtures (WBS 1.8.6). The large-scale prototype structures built under WBS 1.8.8 will provide a final validation of the structural analysis calculations performed under this task.**		**engineering estimates**	**engineering estimates**
1.8.2.1	Develop requirements document				
1.8.2.2	**Conceptual and Engineering Designs**				
1.8.2.2.1	Develop designs for far detector blocks				
1.8.2.2.2	Develop designs for far detector block spacers				
1.8.2.2.3	Develop designs for near detector segments				
1.8.2.2.4	Far detector structural concept selected				
1.8.2.3	**Small Structure Prototypes**				
1.8.2.3.1	**Small Prototypes with Commercial Materials**				
1.8.2.3.1.1	Design prototypes				
1.8.2.3.1.2	Develop test procedures				
1.8.2.3.1.3	Procure materials and components				
1.8.2.3.1.4	Fabricate prototypes				
1.8.2.3.1.5	Test prototypes				
1.8.2.3.1.6	Document results				
1.8.2.3.2	**Small Prototypes with Nova 16-cell Extrusions**				
1.8.2.3.2.1	Final design of structures				
1.8.2.3.2.2	Perform and document FEA of prototype structures				
1.8.2.3.2.3	Fabricate end seals				
1.8.2.3.2.4	Install end seals				
1.8.2.3.2.5	Assemble 3x3 extrusion structure				
1.8.2.3.2.6	**3x3 Extrusion Structure Testing**				
1.8.2.3.2.6.1	Intiial pressure test at 20 psi				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.2.3.2.6.2	Test with pressure and weight				
1.8.2.3.2.6.3	Pressure test to failure				
1.8.2.3.2.7	Assemble large prototype structures				
1.8.2.3.2.8	Test large prototype structures - 1				
1.8.2.3.2.9	Test large prototype structures - 2				
1.8.2.4	**Half-scale Far Detector Prototype**				
1.8.2.4.1	Design prototype				
1.8.2.4.2	Develop test procedures				
1.8.2.4.3	Develop fixtures and tooling				
1.8.2.4.4	Procure materials				
1.8.2.4.5	Fabricate components				
1.8.2.4.6	Assemble components				
1.8.2.4.7	Test prototype				
1.8.2.4.8	Document lessons learned				
1.8.2.5	Perform FEA of prototype structures - 1				
1.8.2.6	Perform FEA of prototype structures - 2				
1.8.2.7	Build and test IPND prototype structures - 1				
1.8.2.8	Build and test IPND prototype structures - 2				
1.8.2.9	Develop environmental requirements for far detector assembly - 1				
1.8.2.10	Develop environmental requirements for far detector assembly - 2				
1.8.2.11	Review and validate far detector structural design				
1.8.2.12	Structural design validated				
1.8.3	**Liquid Scintillator Filling & Handling R&D**	**The goal of this task is to develop techniques and semi-automatic equipment for filling the near and far detector extrusion modules with liquid scintillator. This task provides specifications for the far detector liquid scintillator supply system, which is being built by WBS 2.1. It also makes use of the scintillator quality assurance equipment that is provided by WBS 2.2. The required rate of filling modules must be coordinated with both the scintillator production schedule of WBS 2.2 and the detector-filling rate specified by the far detector installation tasks, WBS 1.8.7 and 2.9.4.**	**work done by IU personnel and project mechanical engineer;**		**physicists estimates**
1.8.3.1	**Near Detector Scintillator Supply and Filling**				
1.8.3.1.1	Develop ND scintillator supply and filling requirements document				
1.8.3.1.2	Develop engineering design of ND scintillator system				
1.8.3.2	**Far Detector Scintillator Supply System**				
1.8.3.2.1	Develop FD scintillator supply requirements document				

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1.8.3.2.2	Develop design of FD scintillator supply system (with WBS 1.1)				
1.8.3.3	**Far Detector Filling Machine**				
1.8.3.3.1	Develop FD filling machine requirements document				
1.8.3.3.2	Develop conceptual and engineering designs				
1.8.3.3.3	Perform safety review of far detector scintillator handling techniques				
1.8.3.3.4	Safety review of far detector scintillator handling techniques completed				
1.8.3.3.5	Develop operating procedures				
1.8.3.3.6	Document final FD filling machine design				
1.8.3.3.7	FD filling machine design completed				
1.8.3.4	Design far detector horizontal module overflow tanks				
1.8.3.5	Measure liquid scintillator minimum ignition energy (outside contractor)				
1.8.3.6	Build and operate vertical module splash-fill prototype - 1				
1.8.3.7	Build and operate vertical module splash-fill prototype - 2				
1.8.4	**Near Detector Assembly R&D**	**The goal of this task is to develop the procedures and for assembling the near detector. This includes specification of the near detector dimensions so that the components can be moved down the existing shaft and installed in the existing underground tunnel. This task includes the design of rigging equipment to move detector components into position and the moving system that allows it to be moved along the tunnel after it is filled with liquid scintillator. The task also includes the design of an assembly facility and associated procedures and equipment for assembling extrusion modules into 7/8-plane segments that can be moved underground. Finally, this task will design the steel-plate muon-catcher segment of the near detector, along with associated support structures and assembly equipment.**			**engineering estimates**
1.8.4.1	**Mechanical Systems Development**				
1.8.4.1.1	Develop requirements documents				
1.8.4.1.2	Determine ND dimensions using as-built tunnel measurements				
1.8.4.1.3	Develop designs for modular detector structure				
1.8.4.1.4	Develop designs for muon catcher section				
1.8.4.1.5	Develop designs for detector support structure				
1.8.4.1.6	Develop designs for detector moving system				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.4.1.7	Develop fixture designs for moving components underground				
1.8.4.1.8	Document mechanical systems designs				
1.8.4.1.9	Review conceptual design of near detector mechanical systems				
1.8.4.1.10	Conceptual design review of near detector mechanical systems completed				
1.8.4.2	**Assembly Fixtures and Tooling Development**				
1.8.4.2.1	Develop requirements document				
1.8.4.2.2	Develop tooling designs for horizontal assembly of planes				
1.8.4.2.3	Develop tooling designs for installation of planes in blocks				
1.8.4.2.4	Develop tooling designs for assembling muon steel block				
1.8.4.2.5	Develop near detector assembly alignment procedures				
1.8.4.2.6	Document assembly fixtures and tooling designs				
1.8.4.3	**Near Detector Installation Procedures**				
1.8.4.3.1	Develop materials handling procedures - 1				
1.8.4.3.2	Develop materials handling procedures - 2				
1.8.4.3.3	Develop module handling procedures - 1				
1.8.4.3.4	Develop module handling procedures - 2				
1.8.4.3.5	Develop detector assembly procedures - 1				
1.8.4.3.6	Develop detector assembly procedures - 2				
1.8.4.3.7	Develop alignment procedures - 1				
1.8.4.3.8	Develop alignment procedures - 2				
1.8.4.3.9	Develop QA procedures - 1				
1.8.4.3.10	Develop QA procedures - 1				
1.8.4.3.11	Document ND installation procedures				
1.8.4.4	**Near Detector Underground Infrastructure Design**				
1.8.4.4.1	Develop requirements document				
1.8.4.4.2	Develop near detector tunnel excavation plan				
1.8.4.4.3	Develop lighting design				
1.8.4.4.4	Develop HVAC design				
1.8.4.4.5	Develop electrical power design				
1.8.4.4.6	Develop fire protection design				
1.8.4.4.7	Develop chilled water design				

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1.8.4.4.8	Develop computer networks				
1.8.4.4.9	Document infrastructure designs				
1.8.4.5	Near detector assembly CD-2 design completed				
1.8.4.6	**Near Detector Preconstruction Design**				
1.8.4.6.1	Design near detector tunnel excavation				
1.8.4.6.2	Update existing near detector layout				
1.8.4.6.3	Design near detector cooling layout				
1.8.4.6.4	Design near detector scintillator supply layout				
1.8.4.6.5	Specify near detector cooling system				
1.8.5	**Integration Prototype Near Detector (IPND)**	**The goal of this task is to design, fabricate and install the Integration prototype Near Detector (IPND). The IPND will be structurally very similar to the Near Detector (ND) itself and it is likely that some components of the IPND will be reused for the ND, including the muon-catcher steel plates and perhaps some or all of the extrusion module segments. For this reason, IPND components will be designed so that they can be moved to the underground tunnel location of the ND. The IPND will be installed and operated at ground level in the MINOS Service Building, where it will be exposed to an off-axis beam of muon and electron neutrinos. It may also be moved to a charged particle test beam for further calibration at a later time. It is likely that the segment assembly facility for the IPND will be reused for the ND. The construction and installation schedule of the IPND will be closely coordinated with the suppliers of extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). The schedule for construction and operation of the IPND will be coordinated with planning for the ND (WBS 2.8), because some IPND components will be re-used for the ND.**				
1.8.5.1	**Requirements Documents**				**physicsts estimates**
1.8.5.1.1	Develop requirements document for IPND				
1.8.5.1.2	Develop requirements document for IPND segment assembly facility				
1.8.5.1.3	Develop requirements document for IPND infrastructure in MINOS surface building				
1.8.5.1.4	**Requirements Documents for Associated ND Systems**				
1.8.5.1.4.1	Lifting fixture for moving down shaft - Reqs				
1.8.5.1.4.2	Segment support structure - Reqs				
1.8.5.1.4.3	ND moving system - Reqs				
1.8.5.1.4.4	ND segment assembly tooling - Reqs				
1.8.5.1.4.5	ND adhesive application system - Reqs				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.5.1.4.6	ND scintillator supply and filling systems - Reqs				
1.8.5.1.5	IPND requirements documents completed				
1.8.5.2	**IPND Systems Design**				**engineering estimates**
1.8.5.2.1	Preliminary design of IPND block structure				
1.8.5.2.2	Final design of IPND block structure				
1.8.5.2.3	Design block support frame and lifting fixtures				
1.8.5.2.4	Design detector support structure				
1.8.5.2.5	Design IPND block assembly table and fixtures				
1.8.5.2.6	Review IPND systems design				
1.8.5.2.7	IPND systems review completed				
1.8.5.2.8	Design IPND block assembly facility - 1				
1.8.5.2.9	Design IPND block assembly facility - 2				
1.8.5.2.10	**MINOS Service Building Infrastructure**				
1.8.5.2.10.1	Design electrical system				
1.8.5.2.10.2	Design APD cooling system				
1.8.5.2.10.3	Design detector enclosure				
1.8.5.2.10.4	Design detector room base (floor load)				
1.8.5.2.10.5	Design scintillator containment				
1.8.5.2.10.6	Design fire protection system				
1.8.5.2.10.7	Design IPND scintillator supply and filling equipment		FNAL Proj Mech engineer; effort in managment		
1.8.5.2.10.8	Document MSB infrastructure design				
1.8.5.2.11	Review IPND systems final designs				
1.8.5.2.12	IPND systems designs completed				
1.8.5.3	**IPND Equipment**			**engineering estimates**	**engineering estimates**
1.8.5.3.1	Fabricate block support carriages				
1.8.5.3.2	Fabricate lifting fixtures		The steel plate material will be obtained at zero cost from the FNAL railhead.	25k support structure; includes fabrication cost of support structure	
1.8.5.3.3	Fabricate detector support structure			28 segments x 1.5k per segment = 42k (includes material and fabrication)	
1.8.5.3.4	**IPND Block Assembly Tooling**				
1.8.5.3.4.1	Fabricate block assembly table				
1.8.5.3.4.2	Procure glue machine				
1.8.5.3.4.3	Assemble glue machine				
1.8.5.3.5	Fabricate IPND scintillator supply and filling equipment		Labor is Project Mech engineer		
1.8.5.4	**IPND Block Assembly Facility Setup**			**engineering estimates**	**engineering estimates**
1.8.5.4.1	Set up building infrastructure			20k scintillator secondary containment, scaled from isotank containment system in WBS 2 10k other infrastructure	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.5.4.2	Install adhesive ventilation system				
1.8.5.4.3	Install IPND assembly equipment				
1.8.5.4.4	Review IPND assembly facility for operational readiness				
1.8.5.4.5	IPND block assembly facility completed				
1.8.5.5	**IPND Block Fabrication**			**engineering estimates**	**engineering estimates**
1.8.5.5.1	Procure adhesive				
1.8.5.5.2	Fabricate prototype 8-plane block				
1.8.5.5.3	Install and test prototype APD-electronics-readout hardware on prototype block				
1.8.5.5.4	Fabricate IPND block 1				
1.8.5.5.5	Fabricate remaining IPND blocks				
1.8.5.5.6	IPND blocks completed				
1.8.5.6	**MINOS Service Building Infrastructure Installation**			**physicists estimates**	**physicists estimates**
1.8.5.6.1	Install IPND electrical supply system				
1.8.5.6.2	Install IPND enclosure				
1.8.5.6.3	Install IPND scintillator containment				
1.8.5.6.4	Install IPND cooling system				
1.8.5.6.5	Install detector support			M&S for riggers	
1.8.5.6.6	IPND detector support installed in MSB				
1.8.5.6.7	Install liquid scintillator storage and supply system				
1.8.5.6.8	Review MINOS service building infrastructure for operational readiness				
1.8.5.6.9	MINOS service building infrastructure installation completed				
1.8.5.7	**Installation, Commissioning and Operation In MINOS Service Building**			**physicists estimates**	**physicists estimates**
1.8.5.7.1	Assemble and install IPND blocks at MSB				
1.8.5.7.2	Fill IPND modules with liquid scintillator			IU travel; 3k	
1.8.5.7.3	IPND module filling completed				
1.8.5.7.4	Install APD-electronics-readout hardware		Phys labor from MINN	IU Travel: 5K	
1.8.5.7.5	Perform QA checks and commission Integration Prototype at MSB		phys labor form MINN		
1.8.5.7.6	Review IPND for operational readiness				
1.8.5.7.7	IPND ready to take data				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.6	**Far Detector Assembly Engineering**	**The goal of this task is to specify and design the equipment needed to assemble and install the far detector. This includes cranes and other moving equipment required at the far detector site, as well as specialized equipment such as the block raiser and adhesive dispenser. This task will be closely coordinated with far detector installation planning (WBS 1.8.7), far detector prototype construction (WBS 1.8.8), as well as WBS 1.8.1, 1.8.2 and 1.8.3, which specify the adhesive requirements, detector structure, and liquid scintillator filling equipment.**			
1.8.6.1	**Far Detector Mechanical Systems**				**engineering estimates**
1.8.6.1.1	Develop requirements documents				
1.8.6.1.2	Develop designs for detector block pallets - 1				
1.8.6.1.3	Develop designs for detector block pallets - 2				
1.8.6.1.4	Develop designs for cranes and moving equipment - 1				
1.8.6.1.5	Develop designs for cranes and moving equipment - 2				
1.8.6.1.6	Develop designs for fixtures - 1				
1.8.6.1.7	Develop designs for fixtures - 2				
1.8.6.1.8	Develop procedures for moving components - 1				
1.8.6.1.9	Develop procedures for moving components - 2				
1.8.6.1.10	Mechanical systems CD-1 design completed				
1.8.6.1.11	Design cosmic ray shield wall				
1.8.6.1.12	Update 3D integration CAD drawing				
1.8.6.1.13	Design detector cooling line layouts				
1.8.6.1.14	Design detector cabling layout				
1.8.6.1.15	Design scintillator piping and overflow tank layout				
1.8.6.1.16	Document mechanical system designs				
1.8.6.2	**Far Detector Assembly Fixtures and Tooling**				**engineering estimates**
1.8.6.2.1	Develop requirements documents				
1.8.6.2.2	Develop block pivoter design - 1				
1.8.6.2.3	Develop block pivoter design - 2				
1.8.6.2.4	Review CD-2 design of block pivoter				
1.8.6.2.5	Develop block assembly platform design				
1.8.6.2.6	Develop glue machine design - 1				
1.8.6.2.7	Develop glue machine design - 2				
1.8.6.2.8	Develop module flipping station design				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.6.2.9	Develop fixtures and procedures for block assembly - 1				
1.8.6.2.10	Develop fixtures and procedures for block assembly - 2				
1.8.6.2.11	Develop tooling for block installation - 1				
1.8.6.2.12	Develop tooling for block installation - 2				
1.8.6.2.13	Develop tooling for FD block alignment - 1				
1.8.6.2.14	Develop tooling for FD block alignment - 2				
1.8.6.2.15	Assembly fixtures CD-1 design completed				
1.8.6.2.16	Document FD tooling designs				
1.8.6.3	Review far detector mechnical systems and tooling designs				
1.8.6.4	FD mechanical system and tooling CD-2 designs completed				
1.8.7	**Far Detector Installation Procedures**	**The goal of this task is to develop far detector installation procedures, schedules and labor requirements. This task is performed in close coordination with other WBS 1.8 far detector R&D tasks and with the Level 2 tasks that provide extrusion modules (WBS 2.5), readout hardware (WBS 2.6 and 2.7) and liquid scintillator (WBS 2.2). It must be very closely coordinated with the design of the far detector building and infrastructure by WBS 2.1. The far detector assembly must be accomplished as rapidly as possible in a cost effective, safe and environmentally responsible manner. This task will develop and evaluate the mechanical assembly quality assurance and safety protocols that will be used at the far detector site. The far detector prototype task, WBS 1.8.8, will provide valuable tests of the procedures, schedules and labor estimates developed under this task.**	**Inkind effort from UMINN also involved (~2 person-months)**		**physicists estimates**
1.8.7.1	Develop requirements document				
1.8.7.2	Develop block assembly procedures - 1				
1.8.7.3	Develop block assembly procedures - 2				
1.8.7.4	Develop block assembly QA procedures - 1				
1.8.7.5	Develop block assembly QA procedures - 2				
1.8.7.6	Develop alignment and QA procedures - 1				
1.8.7.7	Develop alignment and QA procedures - 2				
1.8.7.8	Review design of installation procedures				
1.8.7.9	Far detector installation procedures completed				
1.8.7.10	FD installation procedure value engineering completed				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.8	**Far Detector Prototypes**	**The goal of this task is to test and optimize the procedures and equipment designs developed under other WBS 1.8 far detector tasks, by constructing full-size mechanical prototype structures of extrusion modules. The full-scale block-assembly prototype will test the installation procedures developed under WBS 1.8.7 and will perform time-and-motion studies of these procedures to allow the optimization of the installation schedule and its labor requirements. The full-height structural engineering prototype will provide a final check of structural engineering analyses relating to the mechanical stability of the detector in all stages of construction, before and after it is raised and filled with liquid scintillator. This task will lead to the final optimization of the designs of assembly tooling and materials handling equipment. It will culminate in the assembly, erection and testing of a full-size 31-plane block of the far detector under WBS 2.9.2.4, using the block raiser and other assembly equipment constructed for use at the far detector site.**			
1.8.8.1	**Full-scale Block Assembly Prototype (FSAP)**			**engineering estimates**	**engineering estimates**
1.8.8.1.1	Develop specifications documents				
1.8.8.1.2	Select site for prototype assembly				
1.8.8.1.3	Design assembly table, fixtures, and tooling for prototype				
1.8.8.1.4	Design glue machine for prototype				
1.8.8.1.5	Review full-scale block assembly prototype design				
1.8.8.1.6	Prepare site infrastructure				
1.8.8.1.7	Fabricate assembly table, fixtures, and tooling for prototype				
1.8.8.1.8	Install assembly table for prototype				
1.8.8.1.9	Fabricate glue machine for prototype				
1.8.8.1.10	Install adhesive dispensing system for prototype				
1.8.8.1.11	Perform assembly prototype studies			15k for adhesives and other consumables	
1.8.8.1.13	Full-scale block assembly prototype testing completed				
1.8.8.2	**Full-height Engineering Prototype (FHEP)**			**engineering estimates**	**engineering estimates**
1.8.8.2.1	Develop specifications document				
1.8.8.2.2	Select site for prototype assembly				
1.8.8.2.3	Design FHEP block raiser, fixtures, and tooling				
1.8.8.2.4	Review full-height engineering prototype design				
1.8.8.2.5	Prepare site infrastructure				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.8.2.6	Fabricate FHEP block raiser, fixtures, and tooling				
1.8.8.2.7	Install FHEP block raiser				
1.8.8.2.8	Move glue machine system from FSAP				
1.8.8.2.9	Assemble and fill FHEP				
1.8.8.2.10	Test FHEP				
1.8.8.2.11	Full-height engineering prototype testing completed				
1.8.9	**Management - R&D Phase**	**Subproject management activities for the Detector Assembly R&D phase**			
1.8.9.1	**FY06**				
1.8.9.1.1	Labor				
1.8.9.1.2	Travel		ANL travel booked and paid thru FNAL		
1.8.9.1.3	Equipment				
1.8.9.1.4	Materials and supplies				
1.8.9.2	**FY07**				
1.8.9.2.1	**H1FY07**				
1.8.9.2.1.1	Labor				
1.8.9.2.1.2	Travel		ANL travel booked and paid thru FNAL	UMINN travel ---------- travel to and from far detector sites and also to and from FNAL FNAL 6 trips x 1.1K per trip = 6.6K Site vists 20 trips @ 90 ea= 1.8k meeting 1 trip @2k = 2k +MINN overhead 26% Total 13.104K / 2= 6552 (half year) FNAL travel - 2 trips @ 1K per trip = 2k / 2 = 1000 (half-yr)	
1.8.9.2.1.3	Equipment				
1.8.9.2.1.4	Materials and supplies				
1.8.9.2.2	**H2FY07**				
1.8.9.2.2.1	Labor				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.8.9.2.2.2	Travel		ANL travel booked and paid thru FNAL	UMINN travel ---------- travel to and from far detector sites and also to and from FNAL FNAL 6 trips x 1.1K per trip = 6.6K Site vists 20 trips @ 90 ea= 1.8k meeting 1 trip @2k = 2k +MINN overhead 26% Total 13.104K /2=6552 (half year) FNAL travel - 2 trips @ 1K per trip = 2k /2 = 1000 (half yr)	
1.8.9.2.2.3	Equipment				
1.8.9.2.2.4	Materials and supplies				
1.8.9.3	**FY08**				
1.8.9.3.1	Labor				
1.8.9.3.2	Travel			UMINN travel ---------- to and from far detector sites and also to and from FNAL FNAL 6 trips x 1.1k per trip = 6.6k Site vists 50 trips @ 90 ea = 4.5k meeting 1 trip @2k = 2k +MINN overhead 26% Total 16.506k FNAL travel - 2 trips @ 1k per trip = 2k	
1.8.9.3.3	Equipment				
1.8.9.3.4	Materials and supplies				
1.8.9.4	FY06 Detector Assembly R&D				
1.8.9.5	FY07 Detector Assembly R&D				
1.9	**Project Management - R&D**				
1.9.1	**FY06**				
1.9.1.1	**FNAL Management 06**				
1.9.1.1.1	Labor				ADMIN SUPPORT = .5 FTE; BUDGET =1 FTE; PM = 1 FTE; DPM = 1 FTE; ESH = .5 FTE; PROJ CHEMIST = .5 FTE; PROJ MECH ENG = .75 FTE; SCHEDULERS = 1.5 FTES
1.9.1.1.2	Travel			6 domestic trips @ 1.5k per trip = 9k; 2 foreign trips @ 5k per trip = 10k; Total = 19k	
1.9.1.1.3	Equipment			Computer = 5k; Prnter = 2k; Welcom licenses = 10k; Total= 17k	

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.9.1.1.4	Materials and supplies			Traning = 10k; Supplies/software/misc = 12k; Total = 22k;	
1.9.2	**FY07**				
1.9.2.1	**Management - 1HFY07**				
1.9.2.1.1	Labor				ADMIN SUPPORT = 1 FTE; BUDGET =1 FTE; PM = 1 FTE; DPM = 1 FTE; ESH =0.33 FTE; PROJ CHEMIST = .5 FTE; PROJ MECH ENG = 0.33 FTE; SCHEDULERS = 1.5 FTES
1.9.2.1.2	Travel			6 domestic trips @ 1.5k per trip = 9k; 2 foreign trips @ 5k per trip = 10k; total = 19k / 2 = 9500 (halfyr)	
1.9.2.1.3	Equipment			Computer = 5k; Prnter = 2k; Welcom licenses = 10k; Total = 17k / 2 = 8500 (halfyr)	
1.9.2.1.4	Materials and supplies			Traning = 10k; Supplies/softare/misc = 12k; Total = 22k/ 2 = 11k (halfyr)	
1.9.2.2	**Management - 2HFY07**				
1.9.2.2.1	Labor				ADMIN SUPPORT = 0.68 FTE; BUDGET =1 FTE; PM = 1 FTE; DPM = 1 FTE; ESH =0 .33 FTE; PROJ CHEMIST = 0.5 FTE; PROJ MECH ENG = 0.33 FTE; SCHEDULERS = 1.9(PPD) + 0.75 (AD)FTES; Assoc Proj Mngr + doc spec/AD.SCI.PHY = 0.25 +0.5 FTE
1.9.2.2.2	Travel			6 domestic trips @ 1.5k per trip = 9k; 2 foreign trips @ 5k per trip = 10k; total = 19k/ 2 = 9500 (halfyr)	
1.9.2.2.3	Equipment			Computer = 5k; Prnter = 2k; Welcom licenses = 10k; Total = 17k / 2 = 8500 (halfyr)	
1.9.2.2.4	Materials and supplies			Traning = 10k; Supplies/softare/misc = 12k; Total = 22k / 2 = 11k (halfyr)	
1.9.3	**FY08**				
1.9.3.1	**Management FY08**				
1.9.3.1.1	Labor				
1.9.3.1.2	Travel				
1.9.3.1.3	Equipment				
1.9.3.1.4	Materials and supplies				
1.9.4	**Critical Decision Milestones**				
1.9.4.1	CD-0				
1.9.4.2	CD-1				
1.9.4.3	CD-2				
1.9.5	**Other Management R&D Milestones**				
1.9.5.5	Cooperative-agreement institution determined				

WBS	Activity Description	WBS Definition	BoE: Ground Rules & Assumptions	BoE: M&S (Materials)	BoE: Labor
1.9.5.6	Aquisition strategy approved by DOE				
1.9.5.10	Cooperative-agreement in place				
1.9.5.15	Cooperative-agreement funds available				
1.9.5.20	Far detector site selected				
1.9.5.25	Building conceptual design frozen (FESS)				