WBS 121.5 – Conventional Facilities

Cost and Schedule

Steve Dixon

PIP-II Director's Review

10-12 October 2017

In partnership with:
India Institutes Fermilab Collaboration
Istituto Nazionale di Fisica Nucleare
Science and Technology Facilities Council

Outline

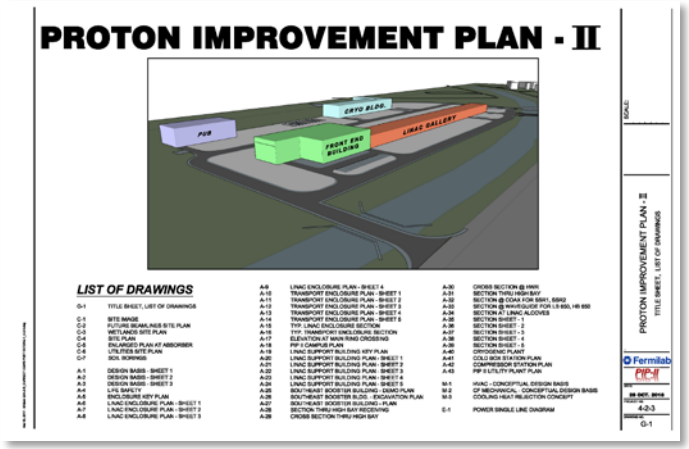
- **Cost Estimate Process**
  - Construction Base Cost;
  - Engineering Design and Inspection;
  - Project Management and Coordination;
- **Schedule Estimate Process**
  - Construction Durations;
  - Procurement Durations;
- **Contingency**
- **Basis of Estimate Form**
- **Risk Uncertainty**

Charge 2:

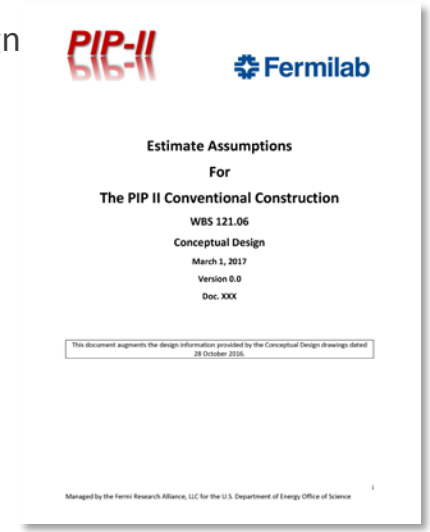
In establishing the cost range for the DOE scope, has the project clearly identified all scope for which the DOE will be responsible? Are the estimated cost and schedule ranges credible and realistic for this stage of the project? Is adequate scope, cost, and schedule contingency included?

Cost Estimate Process – Construction Base Cost

Drawings from PIP-II-doc-1155



Conceptual Design drawings and Estimate Assumptions developed with input from stakeholders



Initial Tasking for A/E Team

the construction cost estimate should be prepared in accordance with DOE's Cost Estimating Guide (G413.3-21) and GAO Cost Estimating and Assessment Guide (GOA-09-3SP) as well as current industry best practices. For the purposes of this tasking the preliminary cost estimate should assume a 10%-40% project definition based on the conceptual design documentation and therefore a Class 3 estimate classification as defined by DOE G 413.3-21

Documentation can be found at PIP-II-doc-333

Cost Estimate Process – Base Cost

Fermilab PIP II
Estimate Level (Concept - Priced at 2nd QTR 2017 - TCCO Index: 1.29)
May 19, 2017

SYSTEM SUMMARY		TOTAL 127,640 GSF Total	TOTAL 127,640 GSF Cost/SF	121.6.2 – Site Preparation 1,390,560 Site - SF Total	121.6.2 Cost/SF	121.6.3 – Cryo Plant Building 23,245 GSF Total	121.6.3 Cost/SF	121.6.4 – Utility Plant Building (PUB) 7,905 GSF Total	121.6.4 Cost/SF	121.6.6 – Linac Tunnel 19,935 GSF Total	121.6.6 Cost/SF	121.6.7 – Linac Gallery 32,905 GSF Total	121.6.7 Cost/SF	121.6.5 – High Bay Building 21,275 GSF Total	121.6.5 Cost/SF	121.6.8 – Beam Transfer Line 14,435 GSF Total	121.6.8 Cost/SF	121.6.9 – Booster Connection 7,760 GSF Total	121.6.9 Cost/SF
A-Substructure		$17,162,973	$134.57	$0	$0.00	$1,217,882	$52.39	$362,921	$45.39	$4,429,565	$222.20	$1,716,070	$52.15	$3,757,250	$176.60	$3,495,734	$241.48	$2,193,551	$283.04
A10-Foundations		$12,464,034	$97.67	$0	$0.00	$1,080,966	$47.04	$343,684	$42.99	$2,959,392	$148.45	$1,590,801	$48.39	$2,157,298	$148.40	$1,345,310	$120.91	$1,554,124	$200.53
A20-Basement Construction		$4,716,939	$37.00	$0	$0.00	$134,417	$5.85	$19,238	$2.41	$1,470,213	$73.75	$125,269	$3.81	$599,952	$28.20	$1,340,424	$120.57	$639,427	$82.51
B-Shell		$20,721,228	$162.47	$0	$0.00	$4,726,330	$203.33	$1,693,408	$211.62	$2,362,024	$119.48	$5,747,556	$174.67	$4,554,997	$214.10	$947,569	$65.64	$669,293	$86.36
B10-Superstructure		$11,120,859	$87.20	$0	$0.00	$2,151,036	$92.54	$629,095	$78.68	$2,108,699	$105.78	$2,229,962	$67.77	$2,676,349	$125.80	$789,995	$54.73	$599,791	$69.13
B20-Exterior Enclosure		$7,605,999	$59.64	$0	$0.00	$2,102,507	$90.45	$879,912	$109.93	$115,968	$5.82	$2,753,006	$83.67	$1,499,874	$70.48	$130,706	$9.40	$121,026	$15.62
B30-Roofing		$1,994,370	$15.64	$0	$0.00	$472,786	$20.34	$185,923	$23.20	$157,358	$7.89	$764,588	$23.24	$379,773	$17.85	$21,868	$1.51	$12,475	$1.61
C-Interiors		$2,950,961	$22.36	$0	$0.00	$408,730	$17.58	$256,526	$31.96	$279,946	$13.96	$379,190	$11.52	$1,114,011	$52.36	$198,029	$13.72	$216,540	$27.94
C10-Interior Construction		$1,054,176	$8.27	$0	$0.00	$127,057	$5.47	$124,769	$15.61	$31,517	$1.58	$69,824	$2.12	$564,001	$26.51	$24,505	$1.70	$112,533	$14.52
C20-Stairs		$437,657	$3.43	$0	$0.00	$0	$0.00	$0	$0.00	$124,200	$6.23	$20,700	$0.63	$169,657	$7.92	$82,800	$5.74	$41,400	$5.34
C30-Interior Finishes		$1,459,128	$11.44	$0	$0.00	$281,673	$12.12	$131,756	$16.35	$123,229	$6.18	$288,666	$8.77	$381,453	$17.93	$90,724	$6.29	$62,607	$8.08
D-Services		$21,219,202	$166.27	$0	$0.00	$4,312,865	$185.54	$2,961,201	$370.38	$1,325,379	$66.48	$7,621,172	$231.61	$2,508,185	$117.89	$1,599,741	$110.82	$890,661	$114.92
D10-Conveying		$260,000	$1.96	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$125,000	$3.80	$125,000	$5.88	$0	$0.00	$0	$0.00
D20-Plumbing		$968,130	$7.59	$0	$0.00	$149,259	$6.43	$41,354	$5.17	$136,359	$6.84	$154,744	$4.70	$314,376	$14.78	$119,171	$8.26	$52,748	$6.81
D30-HVAC		$5,460,134	$42.61	$0	$0.00	$1,022,866	$44.00	$1,833,220	$228.92	$340,883	$17.07	$902,056	$26.69	$803,429	$37.76	$294,056	$18.24	$306,013	$39.49
D40-Fire Protection		$349,398	$2.74	$0	$0.00	$87,169	$3.75	$29,981	$3.76	$0	$0.00	$129,304	$3.75	$79,761	$3.75	$0	$0.00	$29,063	$3.76
D50-Electrical		$14,181,540	$111.27	$0	$0.00	$3,053,466	$131.36	$1,059,646	$132.54	$648,637	$42.57	$6,295,159	$191.31	$1,185,558	$55.73	$1,186,214	$86.33	$502,838	$64.88
E-Equipment & Furnishings		$790,900	$6.20	$0	$0.00	$502,400	$21.61	$0	$0.00	$0	$0.00	$40,000	$1.22	$248,500	$11.68	$0	$0.00	$0	$0.00
E10-Equipment		$790,900	$6.20	$0	$0.00	$502,400	$21.61	$0	$0.00	$0	$0.00	$40,000	$1.22	$248,500	$11.68	$0	$0.00	$0	$0.00
E20-Furnishings		$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
F-Special Construction & Demolition		$172,095	$1.35	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$64,800	$4.49	$107,295	$13.84
F10-Special Construction		$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
F20-Selective Building Demolition		$172,095	$1.35	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$64,800	$4.49	$107,295	$13.84
G-Building Sitework		$23,760,100	$186.20	$17,060,057	$12.27	$311,425	$13.40	$220,055	$27.62	$104,331	$5.23	$912,643	$27.74	$157,016	$7.38	$1,505,868	$104.32	$3,487,914	$450.05
G10-Site Preparation		$3,066,902	$24.05	$1,902,454	$1.39	$201,168	$8.65	$172,073	$21.62	$104,331	$5.23	$362,863	$10.72	$101,956	$4.79	$92,299	$6.39	$109,756	$14.16
G20-Site Improvement		$6,366,821	$50.08	$368,644	$0.71	$71,612	$3.08	$22,249	$2.76	$0	$0.00	$464,870	$14.12	$47,919	$2.25	$1,413,568	$97.93	$3,378,158	$435.69
G30-Site Mechanical Utilities		$5,646,936	$44.51	$5,466,399	$3.95	$12,405	$0.53	$25,932	$3.22	$0	$0.00	$16,449	$0.50	$7,141	$0.34	$0	$0.00	$0	$0.00
G40-Site Electrical Utilities		$8,757,450	$68.66	$8,652,570	$6.22	$26,220	$1.13	$0	$0.00	$0	$0.00	$78,880	$2.39	$0	$0.00	$0	$0.00	$0	$0.00
G90-Other Site Construction		$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
DESIGN CONTINGENCY	0.00%	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
ESCALATION		$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
BONDING / SDI	1.15%	$996,791	$7.82	$196,191	$0.14	$132,015	$5.68	$63,191	$7.90	$97,983	$4.92	$188,791	$5.74	$141,909	$6.67	$89,720	$6.22	$87,000	$11.23
SUBTOTAL DIRECT COST		$87,674,257	$687.43	$17,256,248	$12.41	$11,611,648	$499.53	$5,557,151	$695.09	$8,618,228	$432.32	$16,605,411	$504.65	$12,491,857	$585.69	$7,891,461	$546.89	$7,652,253	$987.39
GC's / INS. / STAFF / FEE	9.45%	$8,684,118	$68.06	$1,709,228	$1.23	$1,150,132	$49.48	$550,435	$68.85	$853,634	$42.82	$1,644,763	$49.99	$1,236,326	$58.11	$781,648	$54.15	$757,954	$97.80
GC / STAFFING PREMIUM	2.40%	$2,104,182	$16.50	$414,150	$0.30	$278,680	$11.99	$133,372	$16.68	$206,837	$10.38	$398,530	$12.11	$299,595	$14.08	$189,395	$13.12	$183,654	$23.70
PAYMENT & PERF. BOND	0.78%	$774,046	$6.07	$152,349	$0.11	$102,515	$4.41	$49,062	$6.14	$76,087	$3.82	$146,603	$4.46	$110,198	$5.18	$69,671	$4.83	$67,559	$8.72
BUILDERS RISK INSURANCE	0.00%	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
CONSTRUCTION CONTINGENCY	0.00%	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00
TOTAL CONSTRUCTION COST		$99,236,603	$776.06	$19,531,975	$14.05	$13,142,975	$566.41	$6,290,020	$786.74	$9,754,786	$489.33	$18,796,307	$571.20	$14,127,946	$664.06	$8,932,174	$616.79	$8,661,421	$1,117.60

Alternates																			
1. Furnish and install CW mode Mechanical System	ADD:	$5,707,000		$2,158,000		$0		$2,224,000		$80,000		$1,245,000		$0		$0		$0	
2. Demolish SE Booster Building in lieu of Base Design	DEDUCT:	-$330,000		$0		$0		$0		$0		$0		$0		$0		-$338,000	
3. Widen Linac Tunnel by 2 - 2"	ADD:	$640,000		$0		$0		$0		$640,000		$0		$0		$0		$0	
Start Year				2017		2017		2017		2017		2017		2017		2017		2017	
Escalation % by Area				0%		0%		0%		0%		0%		0%		0%		0%	

- Estimate completed in May 2017;
- Broken down by work package;
- Costs in **FY17** dollars, de-escalated to **FY16** dollars for overall project consistency;
- Included several initial scope alternates.

Documentation can be found at PIP-II-doc-333

Cost Estimate Process – Early Scope Reductions

- Prioritized List of Scope Reduction (high level);
- Reductions to Base Cost, broken down by work package;
- Costs in **FY17** dollars, de-escalated to FY16 dollars;
- Discussed and reviewed by PIP-II project;
- Documented in Basis of Estimate forms.

		Priority							
		#1	#2	#3	#4	#5	#6	#7	#8a
		Remove CW Cooling from Base Scope	Eliminate Wetland Credits	Eliminate HX for Cryo Compressor	Elminate Precast Shield Blocks	Eliminate Gallery Space for 4 Cyromodules	Eliminate Sheilding Steel at Booster Connection	Reduce Width of Linac Gallery by 5'	Demolish Booster Tower Southeast
121.5.2	Site Preparation	-$2,158,000	-$878,875						
121.5.3	Cryo Plant Building								
121.5.4	Utility Plant Building	-$2,224,000		-$161,299					
121.5.5	High Bay Building				-$1,009,478				
121.5.6	Linac Tunnel	-$80,000							
121.5.7	Linac Gallery	-$1,245,000				-$3,570,000		-$1,428,000	
121.5.8	Beam Transfer Line								
121.5.9	Booster Connection						-$3,500,000		-$938,000
	Totals	-$5,707,000	-$878,875	-$161,299	-$1,009,478	-$3,570,000	-$3,500,000	-$1,428,000	-$938,000

Documentation can be found at PIP-II-doc-1025

Cost Estimate Process – ED&I

- Engineering Design and Inspection (EDI)
  - Based on Construction Cost;
  - Review of Historic Data from Fermilab projects;
  - Initial Range from architect/engineer;

			Engineering, Design and Inspection					
Project Name	Project Stage	Construction Base Cost	Total EDI		Design Phase		Construction Phase	
			%	$	A/E	In-House	A/E	In-House
NOVA Site Prep Package	CD-1 Review	$8,868,437	15%	$1,344,832	3%	1%	10%	2%
NOvA Far Detector Building	CD-1 Review	$26,978,612	26%	$7,018,202	10%	1%	12%	2%
SBN Far Detector Building	CDR	$5,746,000	18%	$1,025,661	9%	3%	1%	5%
SBN Near Detector Buildng	CDR	$4,317,000	18%	$770,585	9%	3%	1%	5%
Mu2e Service Buildng and Hall	CDR	$14,046,094	23%	$3,230,602	8%	4%	1%	10%
MC-1 Building	CD-1 Review	$5,720,000	15%	$846,903	7%	1%	1%	6%
Utilties Upgrade Project	CD-1 Review	$22,500,000	22%	$4,952,000	8%	8%	2%	4%
IERC	CD-1 Review	$58,000,000	16%	$11,600,000	7%	2%	2%	4%
		Average	19%		7.6%	2.8%	3.8%	4.8%
		Average Over $10m	22%		8.4%	3.8%	4.3%	5.1%

Historic data from previous projects

Range: 10.4% to 14.6%

Company	Responsibility	Design through DD (60% CDs) assume to be completed for all buildings/phases at one time		Final CDs assume to be completed for each building/phase separately		Construcion Administration assume to be completed for each building/phase separately		Subtotal	
		low range	high range	low range	high range	low range	high range	low range	high range
Gensler	Project Management	$ 170,000	$ 190,000	$ 175,000	$ 240,000	$ 250,000	$ 400,000	$ 595,000	$ 830,000
Gensler	Architecture	$ 650,000	$ 850,000	$ 400,000	$ 700,000	$ 600,000	$ 850,000	$ 1,650,000	$ 2,400,000
TGRWA	Structural Engineering	$ 200,000	$ 300,000	$ 200,000	$ 300,000	$ 100,000	$ 150,000	$ 500,000	$ 750,000
CMT	Civil Engineering	$ 1,000,000	$ 1,250,000	$ 800,000	$ 1,000,000	$ 650,000	$ 1,000,000	$ 2,450,000	$ 3,250,000
Hoerr Schaudt	Landscape Design	$ 250,000	$ 300,000	$ 330,000	$ 380,000	$ 230,000	$ 270,000	$ 810,000	$ 950,000
KJWW	MEPFP Engineering	$ 780,000	$ 860,000	$ 210,000	$ 235,999	$ 330,000	$ 365,000	$ 1,320,000	$ 1,460,999
Jensen Hughes	Life Safety	$ 12,000	$ 15,000	$ 6,000	$ 9,000	$ 17,000	$ 25,000	$ 35,000	$ 49,000
Subtotal		$ 3,062,000	$ 3,765,000	$ 2,121,000	$ 2,864,999	$ 2,177,000	$ 3,060,000	$ 7,360,000	$ 9,689,999
Syska Hennessey	Commissioning Agent	$ 45,000	$ 75,000	$ 45,000	$ 75,000	$ 300,000	$ 900,000	$ 390,000	$ 1,050,000
Turner Construction	CM/Estimating/ Scheduling	$ 90,000	$ 130,000	$ 90,000	$ 130,000	$ 3,000,000	$ 4,300,000	$ 3,180,000	$ 4,560,000
TOTAL		$ 3,197,000	$ 3,970,000	$ 2,256,000	$ 3,069,999	$ 5,477,000	$ 8,260,000	$ 10,930,000	$ 15,299,999

Documentation can be found at PIP-II-doc-327

Cost Estimate Process – ED&I

- Engineering Design and Inspection (ED&I) **– 19% Overall**
  - In-house: 2% for Design, 2% for Construction Phase
  - Architect/Engineer: 7% for Design, 8% for Construction Phase

					Engineering, Design and Inspection			
WBS	Construction Package	Base Cost (FY16$)	Total EDI		Design Phase		Construction Phase	
			%	$	A/E	In-House	A/E	In-House
121.5.2	Site Preparation	$21,299,555	19%	$4,047,000	7.0%	2.0%	8.0%	2.0%
					$1,491,000	*$426,000*	*$1,704,000*	*$426,000*
121.5.3	Cryo Plant Building	$12,906,401	19%	$2,452,000	7.0%	2.0%	8.0%	2.0%
					$903,000	*$258,000*	*$1,033,000*	*$258,000*
121.5.4	Utility Plant Building	$8,360,768	19%	$1,589,000	7.0%	2.0%	8.0%	2.0%
					$586,000	*$167,000*	*$669,000*	*$167,000*
121.5.5	High Bay Building	$13,873,643	19%	$2,635,000	7.0%	2.0%	8.0%	2.0%
					$971,000	*$277,000*	*$1,110,000*	*$277,000*
121.5.6	Linac Tunnel	$9,657,760	19%	$1,835,000	7.0%	2.0%	8.0%	2.0%
					$676,000	*$193,000*	*$773,000*	*$193,000*
121.5.7	Linac Gallery	$19,679,581	19%	$3,740,000	7.0%	2.0%	8.0%	2.0%
					$1,378,000	*$394,000*	*$1,574,000*	*$394,000*
121.5.8	Beam Transfer Line	$8,771,395	19%	$1,666,000	7.0%	2.0%	8.0%	2.0%
					$614,000	*$175,000*	*$702,000*	*$175,000*
121.5.9	Booster Connection	$8,505,515	19%	$1,615,000	7.0%	2.0%	8.0%	2.0%
					$595,000	*$170,000*	*$680,000*	*$170,000*
	Total	$103,054,619	19%	$19,579,000	$7,214,000	$2,060,000	$8,245,000	$2,060,000

Documentation can be found at PIP-II-doc-327

Cost Estimate Process - Administration

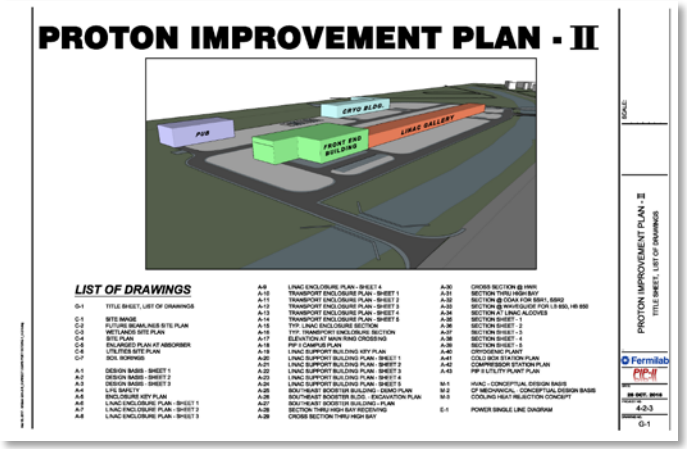
Project Management and Coordination Costs (PM&C)

- "Administration" costs are primarily management and oversite activities during the design and construction phases;
- Consist of one (1) full time equivalent (FTE) for the Associate Project Manager for Conventional Facilities (APM-CF) from FY18 until the end of the project;
- An additional one (1) FTE for a deputy APM-CF position assumed to begin in ~FY19 coinciding with CD-2/3a and extends until the end of the project;
- This PM&C cost is divided between:
  - 40% - Project Office Support
  - 10% - Conventional Facilities Management and Coordination
  - 50% - Individual work packages

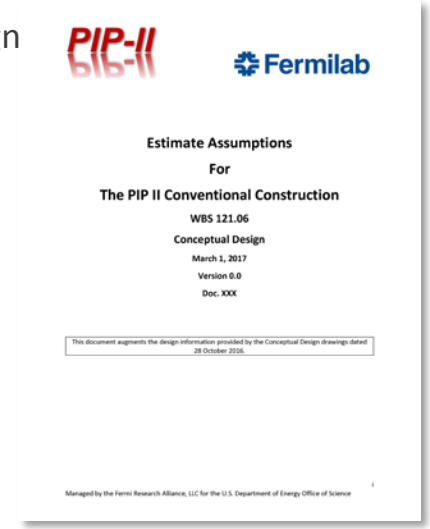
Documentation can be found at PIP-II-doc-327
Project Office Support basis of estimate can be found at PIP-II-doc-229
Conventional Facilities Management and Coordination basis of estimate can be found at PIP-II-217

Schedule Estimate Process

Drawings from PIP-II-doc-1155



Conceptual Design drawings and Estimate Assumptions developed with input from stakeholders


PIP-II

Fermilab

Estimate Assumptions

For

The PIP II Conventional Construction

WBS 121.06

Conceptual Design

March 1, 2017

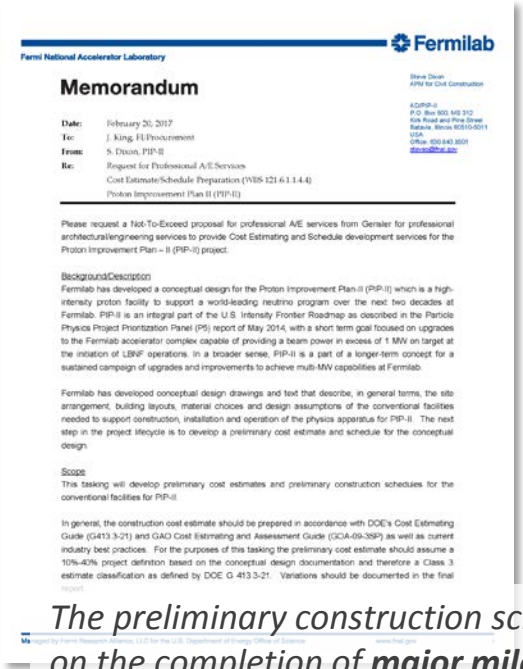
Version 0.0

Doc. XXX

This document augments the design information provided by the Conceptual Design drawings dated 28 October 2016.

Managed by the Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Initial Tasking for A/E Team


Fermilab

Fermi National Accelerator Laboratory

Memorandum

Date: February 20, 2017

To: J. King, FI Procurement

From: S. Dixon, PIP-II

Re: Request for Professional A/E Services

Cost Estimate/Schedule Preparation (WBS 121.6.1.1.4.4)

Proton Improvement Plan II (PIP-II)

Please request a Not-To-Exceed proposal for professional A/E services from Gensler for professional architectural/engineering services to provide Cost Estimating and Schedule development services for the Proton Improvement Plan – II (PIP-II) project.

Background/Description

Fermilab has developed a conceptual design for the Proton Improvement Plan-II (PIP-II) which is a high-intensity proton facility to support a world-leading neutrino program over the next two decades at Fermilab. PIP-II is an integral part of the U.S. Intensity Frontier Roadmap as described in the Particle Physics Project Prioritization Panel (P5) report of May 2014, with a short term goal focused on upgrades to the Fermilab accelerator complex capable of providing a beam power in excess of 1 MW on target at the initiation of LBNF operations. In a broader sense, PIP-II is a part of a longer-term concept for a sustained campaign of upgrades and improvements to achieve multi-MW capabilities at Fermilab.

Fermilab has developed conceptual design drawings and text that describe, in general terms, the site arrangement, building layouts, material choices and design assumptions of the conventional facilities needed to support construction, installation and operation of the physics apparatus for PIP-II. The next step in the project lifecycle is to develop a preliminary cost estimate and schedule for the conceptual design.

Scope

This tasking will develop preliminary cost estimates and preliminary construction schedules for the conventional facilities for PIP-II.

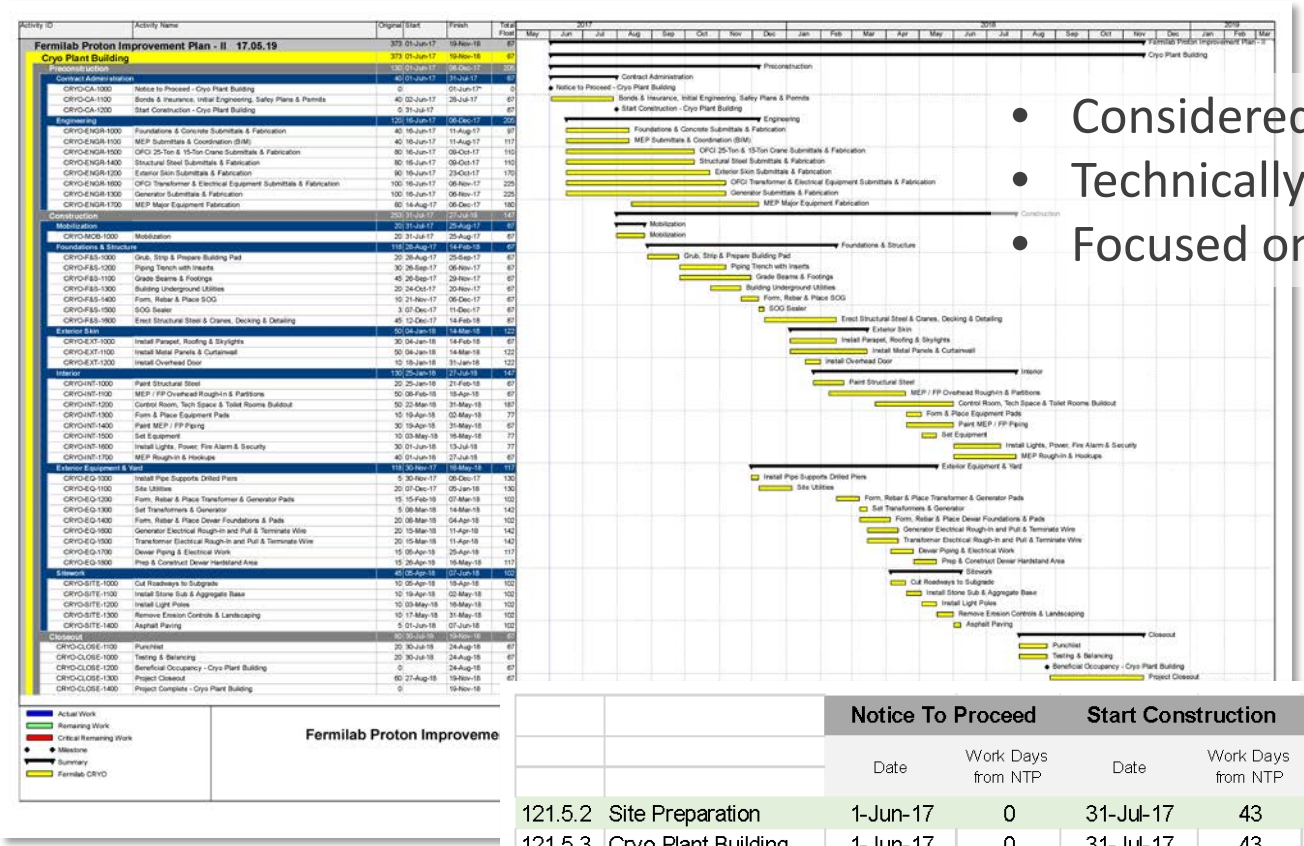
In general, the construction cost estimate should be prepared in accordance with DOE's Cost Estimating Guide (G413.3-21) and GAO Cost Estimating and Assessment Guide (GCA-09-3SP) as well as current industry best practices. For the purposes of this tasking the preliminary cost estimate should assume a 10%-43% project definition based on the conceptual design documentation and therefore a Class 3 estimate classification as defined by DOE G 413.3-21. Variations should be documented in the final report.

*The preliminary construction schedule should instead focus on the completion of **major milestones** (eg: excavation complete, foundation complete, building shell complete, beneficial occupancy, etc.) within the overall schedule to provide a reasonable prediction of one possible construction scenario. This schedule information will be included in the PIP-II resource loaded schedule as a **planning package** that will be updated with further information and details as they become available.*

Documentation can be found at PIP-II-doc-581

PIP-II

Schedule Estimate Process



- Considered Planning Packages;
- Technically driven schedules;
- Focused on **interface milestones.**

		Notice To Proceed		Start Construction		Benefical Occupancy		Project Complete	
		Date	Work Days from NTP	Date	Work Days from NTP	Date	Work Days from NTP	Date	Work Days from NTP
121.5.2	Site Preparation	1-Jun-17	0	31-Jul-17	43	30-Nov-18	392	3-Dec-18	393
121.5.3	Cryo Plant Building	1-Jun-17	0	31-Jul-17	43	24-Aug-18	322	19-Nov-18	383
121.5.4	Utility Plant Building	1-Jun-17	0	30-Jun-17	22	21-Mar-18	210	14-Jun-18	271
121.5.5	High Bay Building	1-Jun-17	0	31-Jul-17	43	24-Aug-18	322	21-Nov-18	385
121.5.6	Linac Tunnel	1-Jun-17	0	31-Jul-17	43	24-Jul-18	299	17-Oct-18	360
121.5.7	Linac Gallery	1-Jun-17	0	31-Jul-17	43	26-Nov-18	388	25-Feb-19	453
121.5.8	Beam Transfer Line	1-Jun-17	0	30-Jun-17	22	25-Jun-18	278	19-Sep-18	340
121.5.9	Booster Connection	1-Jun-17	0	30-Jun-17	22	7-Aug-18	309	31-Oct-18	370

Documentation can be found at PIP-II-doc-581 and in each Basis of Estimate file

Procurement Durations – A/E Firms

- Architect/Engineering Firm;
  - Review of Historic Data from Fermilab projects;
  - Includes turnaround times for Request for Proposal (RFP), Requisition Approval and Issue PO;
  - Average of **30 working days.**

		Durations in Working Days			
	Base Cost	RFP Turnaround	Req Approval	Approved Req to PO *(Procurement Cycle)*	A/E Tasking Period
SBN Far Detector Building - Final Design	$575,844	14	8	11	33
SBN Near Detector Building - Final Design	$193,864	14	9	15	38
UUP ICW Final Design	$300,000	13	8	2	23
UUP Field Support	$236,348	38	3	3	44
MSS AP Design	$426,161	38	3	2	43
IERC Management Support	$158,534	6	4	3	13
IERC Conceptual Design Support	$517,296	10	4	5	19
	Average	19	6	6	30

Historic data from previous projects

30 Working Days

		A/E Base Cost (FY16$)	RFP Turnaround	Req Approval	Approved Req to PO *(Procurement Cycle)*	A/E Tasking Period	Basis
			Durations in Working Days				
121.5.2	**Site Preparation**						
	Design	$1,491,000	19	6	6	30	*Historical Average*
	Construction Support	$1,704,000	19	6	6	30	*Historical Average*
121.5.3	**Cryo Plant Building**						
	Design	$903,000	19	6	6	30	*Historical Average*
	Construction Support	$1,033,000	19	6	6	30	*Historical Average*
121.5.4	**Utility Plant Building**						
	Design	$586,000	19	6	6	30	*Historical Average*
	Construction Support	$669,000	19	6	6	30	*Historical Average*
121.5.5	**High Bay Building**						
	Design	$971,000	19	6	6	30	*Historical Average*
	Construction Support	$1,110,000	19	6	6	30	*Historical Average*
121.5.6	**Linac Tunnel**						
	Design	$676,000	19	6	6	30	*Historical Average*
	Construction Support	$773,000	19	6	6	30	*Historical Average*
121.5.7	**Linac Gallery**						
	Design	$1,378,000	19	6	6	30	*Historical Average*
	Construction Support	$1,574,000	19	6	6	30	*Historical Average*
121.5.8	**Beam Transfer Line**						
	Design	$614,000	19	6	6	30	*Historical Average*
	Construction Support	$702,000	19	6	6	30	*Historical Average*
121.5.9	**Booster Connection**						
	Design	$595,000	19	6	6	30	*Historical Average*
	Construction Support	$680,000	19	6	6	30	*Historical Average*

Documentation can be found at PIP-II-doc-318

Procurement Durations – Construction

- Construction Subcontracts;
  - Review of Historic Data from Fermilab projects;
  - Includes turnaround times for Requisition Approval, Request for Proposal (RFP) and Issue Notice To Proceed (NTP);
  - Average of **107 working days** for under $10m;
  - Average of **191 working days** for over $10m;

		Durations in Working Days		
	Base Cost	Req Approval	Approved Req to NTP (Procurement Cycle)	Req Start to NTP
SBN Far Detector Building	$7,367,422	13	77	89
SBN Near Detector Building	$4,855,000	7	95	101
UUP Backbone Piping	$10,997,151	55	14	68
Master Substation	$24,975,000	90	222	311
Master Substation Site Prep	$4,814,000	90	39	92
	Average	**51**	**89**	**132**
	Average Under $10m	**37**	**70**	**107**
	Average Over $10m	**73**	**118**	**191**

Historic data from previous projects

WBS	Construction Package	A/E Base Cost (FY16$)	Req Approval	Approved Req to NTP *(Procurement Cycle)*	Requsitition Start to NTP	Basis
			Durations in Working Days			
121.5.2	Site Preparation	$18,317,344	73	118	191	*Based on average of recent projects **over** $10m*
121.5.3	Cryo Plant Building	$12,906,401	73	118	191	*Based on average of recent projects **over** $10m*
121.5.4	Utility Plant Building	$6,018,404	37	70	107	*Based on average of recent projects under $10m*
121.5.5	High Bay Building	$12,882,335	73	118	191	*Based on average of recent projects **over** $10m*
121.5.6	Linac Tunnel	$9,579,200	37	70	107	*Based on average of recent projects under $10m*
121.5.7	Linac Gallery	$13,548,955	73	118	191	*Based on average of recent projects **over** $10m*
121.5.8	Beam Transfer Line	$8,771,395	37	70	107	*Based on average of recent projects under $10m*
121.5.9	Booster Connection	$4,147,399	37	70	107	*Based on average of recent projects under $10m*

Documentation can be found at PIP-II-doc-321

Contingency

Cost Estimate Uncertainty:

- Based on level of definition and design maturity;
- A/E team provided input;
- **20%** cost contingency applied to most construction subcontracts;
- **25%** cost contingency applied to Booster Connection construction subcontract;
- **20%** cost contingency applied to design work;

Schedule Uncertainty:

- -10% to +20% schedule contingency provided by A/E team.

Basis Of Estimate

Project Management and Coordination Costs (PIP-II-doc-327)

ED&I Costs (PIP-II-doc-327)

Construction Cost (PIP-II-doc-333) including Scope Reduction Options (PIP-II-doc-1025)

Contingency

Details of the Base Estimate

Description
This work will consist of the detailed design, final design, procurement and construction phases for the Cryo Plant Building construction package. The construction package will include the infrastructure required to install, assemble and operate the cryogenics equipment for PIP-II. This includes the Cold Box Station, Warm Compressor Station, support spaces and related exterior work.

The detailed design and final design phases approximates the Construction Document Phase as described by the American Institute of Architects (AIA)and tailored to meet specific Fermilab requirements. In this phase, the integrated project team will produce the drawings, Exhibit A and Exhibit B (specifications) that set forth the detail requirements for the construction of the project.

Detailed Design activities will start after CD-1 and will bring the design to approximately 90% complete. Final Design activities will begin after CD-2 and will complete the construction package documentation suitable for competitive, fixed price procurement.

The procurement phase of the work includes the activities required to support the selection of a construction subcontractor and construct the work package scope. For cost tracking purposes, this effort is included in the Construction phase calculations.

The Construction phase of the work will procure, fabricate, construct, install and deliver the work associated with the Cyro Plant Building work package.

Deliverables
The deliverables for this WBS will include the following:

The Detailed Design phase deliverables will include construction documents (drawings, specifications and exhibits) ready to be issued for a lab-wide review.

The Final Design phase deliverables will include construction documents (drawings, specifications and exhibits) ready to be issued for a competitive, fixed price procurement.

The Construction Phase deliverables will include the installation of the Cryo Plant Building work scope and supporting close out documentation typical for construction projects including shop drawings, operations and maintenance manuals and warranty information.

Cost Calculation
Listed below is the calculation for the ED&I, A and construction costs for this WBS:

$12,906,401	Estimated Construction Package Base Cost *See PIP-II-doc-333 for construction cost estimate*

Engineering Design and Inspection Multipliers

7.0%	Design Phase A/E ED&I Percentage
2.0%	Design Phase ED&I In-House Percentage
8.0%	Construction Phase A/E ED&I Percentage
2.0%	Construction Phase ED&I In-House Percentage

See PIP-II-doc-327 for basis of EDI and A description and analysis of multipliers by phase

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Assumptions

90.0%	Detailed Design Portion of Design Phase Total
10.0%	Final Design Portion of Design Phase Total

Cost Breakdown

	M&S A/E	M&S FESS/E $	M&S FESS/E Hours	Construction	Labor FTE	Labor Hours
Detailed Design	6.3%	1.8%				
	$813,000	$232,000	2,275		0.23	410
Final Design	0.7%	0.2%				
	$90,000	$26,000	255		0.03	46
Construction Phase Support	8.0%	2.0%				
	$1,033,000	$258,000	2,529		0.68	1,203
Construction				$12,906,401		
Totals	**$1,936,000**	$516,000	**5,059**	**$12,906,401**	**0.94**	**1,659**

Materials and Supplies (M&S) Notes:
The M&S costs will consist of the following:

- Architect/Engineering firm to provide detailed design, final design and construction phase services. This will be done utilizing task order agreements from a previously selected A/E firm;
- FESS/Engineering will provide support during the detailed design, final design and construction phases;
- Emil Huedem of FESS/Engineering is assumed to be available at an approximate full time level based on his level of mechanical expertise, history of project management knowledge and PIP-II conceptual design.
- It is anticipated that the construction subcontract will be specified as a multi-year, phased funded procurement.

Labor Notes:
The Labor estimate in the Cost Breakdown table includes the following:

- Approximately one half of the annual labor cost for the Associate Project Manager for Conventional Facilities (APM-CF) management efforts. The balance of the APM-CF cost is captured in the PIP-II Project Office Support (see PIP-II-doc-229);
- The annual labor costs for approximately one (1) full time equivalent (FTE) for the Deputy to the APM-CF starting in FY19;

Uncertainty/Contingency Rules
This uncertainty for this WBS is based on the standard PIP-II guidance (PIP-II-doc-345) and is assumed to be:

Labor	Level of Effort Tasks	Support type activities that must be done to support other work activities or the entire project effort where estimated effort is based on the duration of the activities it is supporting.	0%-20%	20	Based on level of design maturity

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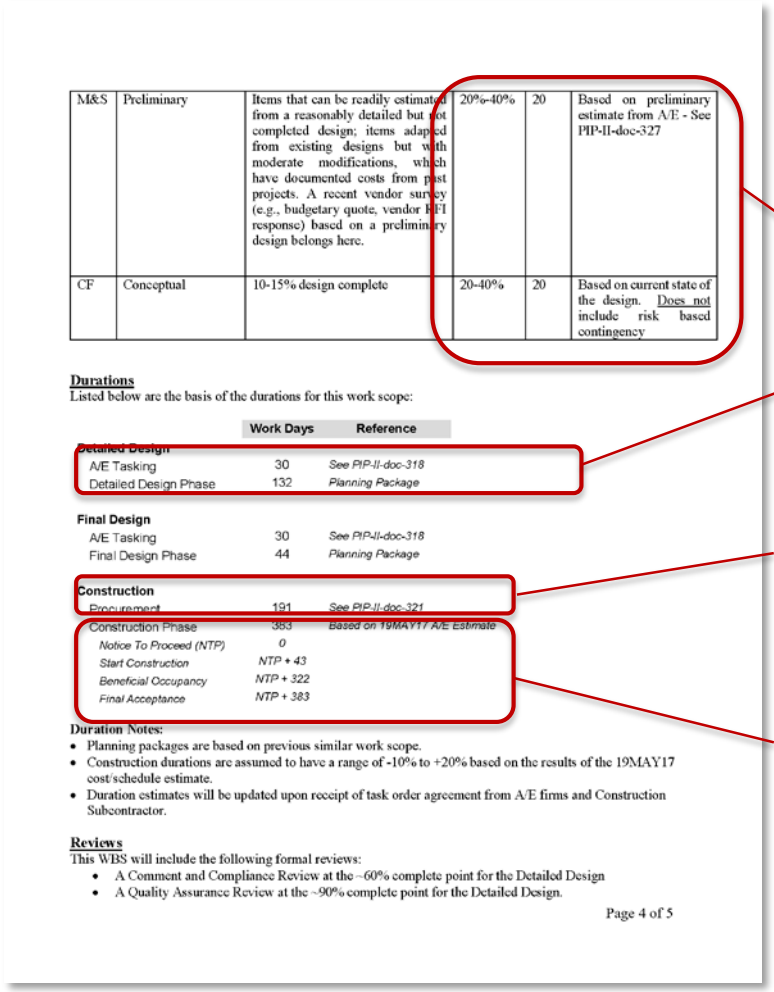
Typical Basis of Estimate form

Basis Of Estimate



M&S	Preliminary	Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design belongs here.	20%-40%	20	Based on preliminary estimate from A/E - See PIP-II-doc-327
CF	Conceptual	10-15% design complete	20-40%	20	Based on current state of the design. Does not include risk based contingency

Durations
Listed below are the basis of the durations for this work scope:

	Work Days	Reference
Detailed Design		
A/E Tasking	30	*See PIP-II-doc-318*
Detailed Design Phase	132	*Planning Package*
Final Design		
A/E Tasking	30	*See PIP-II-doc-318*
Final Design Phase	44	*Planning Package*
Construction		
Procurement	191	*See PIP-II-doc-321*
Construction Phase	383	*Based on 19MAY17 A/E Estimate*
Notice To Proceed (NTP)	*0*	
Start Construction	*NTP + 43*	
Beneficial Occupancy	*NTP + 322*	
Final Acceptance	*NTP + 383*	

Duration Notes:
- Planning packages are based on previous similar work scope.
- Construction durations are assumed to have a range of -10% to +20% based on the results of the 19MAY17 cost/schedule estimate.
- Duration estimates will be updated upon receipt of task order agreement from A/E firms and Construction Subcontractor.

Reviews
This WBS will include the following formal reviews:
- A Comment and Compliance Review at the ~60% complete point for the Detailed Design
- A Quality Assurance Review at the ~90% complete point for the Detailed Design.

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Contingency

A/E Tasking Durations
(PIP-II-doc-318)

Construction Subcontract Procurement Duration
(PIP-II-doc-321)

Construction Subcontract Duration
(PIP-II-doc-581)

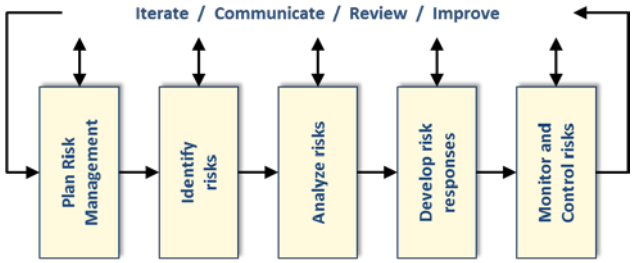
Typical Basis of Estimate form

Basis Of Estimate List

		Basis of Estimate	
WBS	**Identification**	DocDb ID	Date
121.5.1	CF Project Management and Coordination	PIP-II-doc-217	25-Aug-17
121.5.2	Site Preparation	PIP-II-doc-238	23-Aug-17
121.5.3	Cryo Plant Building	PIP-II-doc-244	18-Aug-17
121.5.4	Utility Plant Building	PIP-II-doc-253	23-Aug-17
121.5.5	High Bay Building	PIP-II-doc-516	23-Aug-17
121.5.6	Linac Tunnel	PIP-II-doc-256	23-Aug-17
121.5.7	Linac Gallery	PIP-II-doc-259	23-Aug-17
121.5.8	Beam Transfer Line	PIP-II-doc-262	10-Aug-17
121.5.9	Booster Connection	PIP-II-doc-265	23-Aug-17

Risk Uncertainty

- Follow the **PIP-II Risk Management Plan**
  (see Shekar's Presentation)



- Process:
  - Reviewed past projects at Fermilab;
  - Reviewed lessons learned from other labs;
  - Met with the Conventional Facilities project team including A/E and Procurement (April 2017);
  - Formal Risk Management Workshop with outside reviewers;
  - Input, tracked and updated in the Fermilab Risk Register;

PIP-II Risk Management Plan can be found at PIP-II-doc-163
Fermilab Risk Register can be found at https://fermipoint.fnal.gov/organization/ocoo/ippm/Lists/Risk%20Register/all-risks.aspx

Risk Uncertainty Results

- **44** Threats and **9** Opportunities

Risk Type	WBS / Ops Lab Activity	RI-ID	Title	Probability	Probability Score	Impact Score - Cost	Impact Score - Schedule	Risk Rank	P * Impact (k$)	P * Impact (months)
Threat	121.06 Conventional Facilities	RT-121-06-09-001	Accelerator Shutdown Changes	50.00%	4 (H)	2 (M)	3 (H)	3 (High)	292	3.1
Threat	121.06 Conventional Facilities	RT-121-06-002	Inadequate Fermilab Support	50.00%	4 (H)	2 (M)	2 (M)	3 (High)	150	4.0
Threat	121.06 Conventional Facilities	RT-121-06-03-004	Cryoplant Cooling Water	50.00%	4 (H)	2 (M)	0 (N)	3 (High)	54	0.0
Opportunity	121.06 Conventional Facilities	RO-121-06-001	Value Management Opportunities	50.00%	4 (H)	2 (M)	1 (L)	3 (High)	-67	-0.7
Threat	121.06 Conventional Facilities	RT-121-06-01-002	Subproject Changes Impact Conventional Facilities	30.00%	3 (M)	2 (M)	3 (H)	3 (High)	285	2.0
Threat	121.06 Conventional Facilities	RT-121-06-03-001	Cryoplant Design Requirements	25.00%	3 (M)	2 (M)	2 (M)	2 (Medium)	55	0.9
Threat	121.06 Conventional Facilities	RT-121-06-09-005	Poor Interface Definition	25.00%	3 (M)	2 (M)	2 (M)	2 (Medium)	40	1.3
Threat	121.06 Conventional Facilities	RT-121-06-01-004	Unclear/Incomplete Delineation Between Construction Packages	25.00%	3 (M)	2 (M)	1 (L)	2 (Medium)	58	0.3
Threat	121.06 Conventional Facilities	RT-121-06-011	Improper Maintanance After Beneficial Occupancy	25.00%	3 (M)	2 (M)	0 (N)	2 (Medium)	21	0.0
Threat	121.06 Conventional Facilities	RT-121-06-07-002	Increase in RF Heat Load in Pulsed Mode Requires Additional Cooling	30.00%	3 (M)	2 (M)	1 (L)	2 (Medium)	90	0.6
Threat	121.06 Conventional Facilities	RT-121-06-09-006	Booster Ventilation Inadequate	30.00%	3 (M)	1 (L)	0 (N)	1 (Low)	14	0.0
Threat	121.06 Conventional Facilities	RT-121-06-03-003	Cryogenic plant building BO delayed	10.00%	2 (L)	0 (N)	2 (M)	2 (Medium)	0	0.6
Threat	121.06 Conventional Facilities	RT-121-06-08-003	Damage to Main Ring Beamline Equipment During Construction	15.00%	2 (L)	1 (L)	1 (L)	1 (Low)	5	0.2
Threat	121.06 Conventional Facilities	RT-121-06-06-003	Equipment Induced Vibrations Impact Accelerator Operations	10.00%	2 (L)	1 (L)	1 (L)	1 (Low)	6	0.1
Opportunity	121.06 Conventional Facilities	RO-121-06-005	Full Funding for Conventional Facilities	0.10%	1 (VL)	2 (M)	3 (H)	2 (Medium)	0	0.0
Threat	121.06 Conventional Facilities	RT-121-06-04-001	CUB Chilled Water Inadequate	5.00%	1 (VL)	2 (M)	0 (N)	1 (Low)	15	0.0
Opportunity	121.06 Conventional Facilities	RO-121-06-08-001	Main Ring Enclosure Not Needed	5.00%	1 (VL)	2 (M)	0 (N)	1 (Low)	-4	0.0
Threat	121.06 Conventional Facilities	RT-121-06-06-001	Sump Pump Failure	5.00%	1 (VL)	2 (M)	1 (L)	1 (Low)	4	0.1
Threat	121.06 Conventional Facilities	RT-121-06-006	Substantial Claim by Subcontractor	5.00%	1 (VL)	2 (M)	2 (M)	1 (Low)	8	0.1
Threat	121.06 Conventional Facilities	RT-121-06-007	Unavailability of Construction Workforce	5.00%	1 (VL)	2 (M)	2 (M)	1 (Low)	9	0.1
Threat	121.06 Conventional Facilities	RT-121-06-01-003	Errors/Omissions in Construction Documents	5.00%	1 (VL)	2 (M)	1 (L)	1 (Low)	13	0.0
Threat	121.06 Conventional Facilities	RT-121-06-02-001	Permitting Delay	5.00%	1 (VL)	1 (L)	2 (M)	1 (Low)	1	0.1
Opportunity	121.06 Conventional Facilities	RO-121-06-002	Renewable Energy Opportunities	5.00%	1 (VL)	2 (M)	0 (N)	1 (Low)	14	0.0
Threat	121.06 Conventional Facilities	RT-121-06-014	A/E Proposals Exceed Budget	5.00%	1 (VL)	2 (M)	1 (L)	1 (Low)	5	0.1
Threat	121.06 Conventional Facilities	RT-121-06-015	Quality Deficiencies Result in Decreased Performance	5.00%	1 (VL)	2 (M)	1 (L)	1 (Low)	33	0.1
Threat	121.06 Conventional Facilities	RT-121-06-02-003	Unknown Soil Contaminants	5.00%	1 (VL)	1 (L)	1 (L)	1 (Low)	3	0.1
Threat	121.06 Conventional Facilities	RT-121-06-009	Labor Action Delays Construction	5.00%	1 (VL)	1 (L)	1 (L)	1 (Low)	1	0.0
Threat	121.06 Conventional Facilities	RT-121-06-012	Poor Performance by A/E Team	5.00%	1 (VL)	1 (L)	1 (L)	1 (Low)	3	0.1

Title	Probability	Probability Score	Impact Score - Cost	Impact Score - Schedule	Risk Rank	P * Impact (k$)	P * Impact (months)
Accelerator Shutdown Changes	50.00%	4 (H)	2 (M)	3 (H)	3 (High)	292	3.1
Inadequate Fermilab Support	50.00%	4 (H)	2 (M)	2 (M)	3 (High)	150	4.0
Cryoplant Cooling Water	50.00%	4 (H)	2 (M)	0 (N)	3 (High)	54	0.0
Value Management Opportunities	50.00%	4 (H)	2 (M)	1 (L)	3 (High)	-67	-0.7
Subproject Changes Impact Conventional Facilities	30.00%	3 (M)	2 (M)	3 (H)	3 (High)	285	2.0

Risk Uncertainty – RT-121-09-002

Accelerator Shutdown Changes

- Summary
  - If the planned accelerator shutdown changes then the construction of the booster connection will be impacted and jeopardizes the cost/schedule.
- Cause/Trigger
  - The PIP-II transport line scope includes a connection to the existing booster enclosure. This connection is scheduled to occur concurrently with the LBNF accelerator shutdown. Changes, especially sooner than anticipated, could impact the cost and schedule of the connection work
- Mitigation
  - Coordination with LBNF and accelerator operations should be ongoing to understand the latest schedule. In addition, the design of the booster tower connection should be completed early and packaged as a stand-alone work scope to provide flexibility in executing the work.

Risk Uncertainty – RT-121-06-002

Inadequate Fermilab Support

- Summary
  - If there is inadequate Fermilab support during design and construction then the construction activities will be impacted which jeopardizes the completion of the work.
- Cause/Trigger
  - Construction activities require Fermilab support during the design and construction phases for reviews, shop drawing tracking/review, response to subcontractor questions, Fermilab interfaces and construction coordinator duties. Traditionally, these functions are provided by FESS/E.
- Mitigation
  - The PIP-II conventional facilities will develop a memorandum of understanding between the project and FESS to detail the responsibilities and expectations.
  - As part of the architect/engineer selection, the design team will be able to supplement the support functions during design and construction.

Risk Uncertainty – RT-121-03-002

Cryoplant Cooling Water

- Summary
  - If there is insufficient ICW for cooling the cryogenic equipment then cooling towers/fluid coolers will be required which jeopardizes the cost assumptions
- Cause/Trigger
  - The baseline design for the cooling of the cryogenic compressors assumes a 1,400 gpm flow of industrial cooling water (ICW) from the existing sitewide ICW system. If the existing system is unable to meet this requiement a cooling tower or fluid cooler system is required.
- Mitigation
  - The project team has provided the process load requirements to FESS for input into the sitewide ICW flow model.
  - The project team will continue to discuss the use of ICW with FESS personnel and include this requirements in the assumption document.

Risk Uncertainty – RO-121-06-001

Value Management Opportunities

- Summary
  - If the design of the conventional facilities can be changed/modified to achieve the same performance at a lower cost and schedule duration then the project will realize a cost/scheduling improvement
- Cause/Trigger
  - Convene Value Engineering exercise with project team
- Mitigation
  - Encourage designs that are able to achieve the required performance at reduced life cycle cost.
  - Conduct formal value management/engineering workshops during the design process. (Purchase order in place with A/E team)

Risk Uncertainty – RT-121-06-01-002

Subproject Changes Impact Conventional Facilities

- Summary
  - If the subproject requirements changes then the design of the conventional facilities will need to be modified jeopardizing the cost and schedule objectives
- Cause/Trigger
  - Changes to the subproject requirements
- Mitigation
  - Include subproject managers in design meetings;
  - Include subproject managers in formal design reviews;
  - Management control of changes through a change/configuration control process;

Summary

- Scope
  - Conceptual Design based on stakeholder input which identifies the scope of the conventional facilities required to support the project.
- Cost Estimate
  - Construction Cost estimate was done by professional contractors independent from the team that developed the conceptual design;
  - Engineering, Design and Inspection (ED&I) costs were based on historic Fermilab project data and initial cost ranges provided by the architect/engineer.
- Schedule
  - Work packages schedules were developed based on historic data and input from professional contractors.
- Basis of Estimate
  - Contain the information needed as input for the resource loaded schedule.
- Risk
  - Developed risks based on past project team experience following the project's Risk Management Plan.

Questions?