WBS 121.5 – Conventional Facilities

Cost and Schedule

Steve Dixon

PIP-II DOE Independent Project Review

12-14 December 2017

In partnership with:
- India/DAE
- Italy/INFN
- UK/STFC
- France/CEA/Irfu, CNRS/IN2P3

Charge Questions

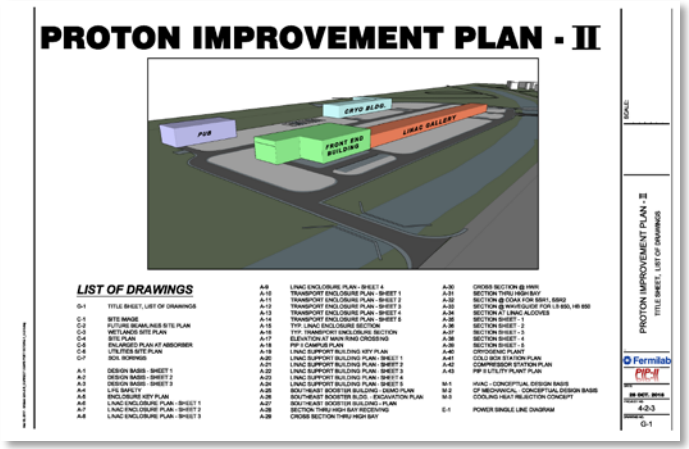
Charge Question	Presentation
1. Has the project team documented a carefully considered analysis of alternates that supports the preferred alternate?	Plenary and Design and Scope Breakout
2. Does the conceptual design satisfy the perfromance requirements?	Design and Scope Breakout
3. Does the conceptual design report and supporting documentaton adequately justify the stated cost range and project duration?	Cost and Schedule Breakout
4. Does the project team have adequate management experience, design skills, and laboratory support to manage all aspects of this project and produce a credible technical, cost, and schedule baseline?	Management Breakout
5. Are the ES&H aspects of the project being properly addressed and is the ES&H planning currently sufficient for this stage of the project?	Plenary
6. Is the documentation required by DOE O413.b for CD-1 approval complete and in good order?	CD-1 Documentation Breakout
7. Is the allocation of the technical scope that will be contributed by international partners sufficiently understood and documented such that the conceptual design and cost range can be relied on?	Plenary
8. Has the project satisfactorily responded to the recommendations from previous reviews?	Plenary

Outline

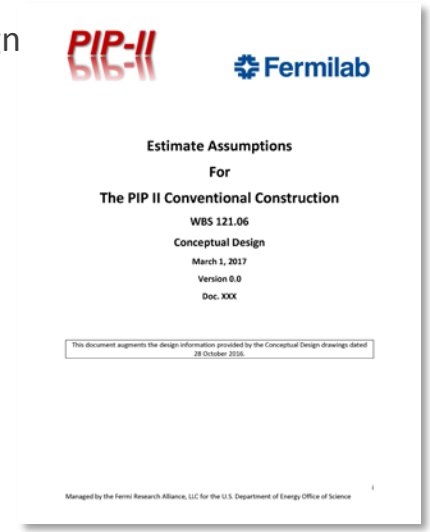
- **Cost Estimate Process**
  - Construction Base Cost;
  - Engineering Design and Inspection;
  - Project Management and Coordination;
- **Schedule Estimate Process**
  - Construction Durations;
  - Procurement Durations;
- **Contingency**
- **Basis of Estimate Form**
- **Risk Uncertainty**

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		$12,444,034	$97.57	$0	$0.00	$1,093,866	$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		$4,718,939	$37.00	$0	$0.00	$124,017	$5.35	$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	$676,912	$109.93	$115,968	$5.82	$2,753,006	$83.67	$1,499,874	$70.40	$135,706	$9.40	$121,026	$15.62
B30-Roofing		$1,994,370	$15.64	$0	$0.00	$472,786	$20.34	$135,923	$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	$216,640	$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	$29,700	$0.63	$169,657	$7.92	$82,800	$5.74	$41,400	$5.34
C30-Interior Finishes		$1,459,128	$13.66	$0	$0.00	$281,673	$12.12	$131,756	$16.35	$123,229	$6.18	$288,656	$8.77	$381,453	$17.93	$90,724	$6.29	$62,637	$8.08
D-Services		$21,219,202	$166.37	$0	$0.00	$4,312,865	$185.54	$2,961,201	$370.38	$1,325,379	$66.49	$7,621,172	$231.61	$2,508,185	$117.89	$1,599,741	$110.82	$890,661	$114.92
D10-Conveying		$260,000	$1.06	$0	$0.00	$0	$0.00	$0	$0.00	$0	$0.00	$126,000	$3.83	$126,000	$5.92	$0	$0.00	$0	$0.00
D20-Plumbing		$968,130	$7.59	$0	$0.00	$149,259	$6.42	$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	$848,537	$42.57	$6,295,159	$191.31	$1,185,558	$55.73	$1,346,214	$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	$366,644	$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	$43.61	$5,466,309	$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.

		#1	#2	#3	#4	#5	#6	#7	#8a	#9
		Remove CW Cooling from Base Scope	Remove Wetland Credits from Base Scope	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	Eliminate Tunnel Space for 2 cryomodules
121.5.2	Site Preparation	-$2,119,156	-$863,056							
121.5.3	Cryo Plant Building									
121.5.4	Utility Plant Building	-$2,183,968		-$158,396						
121.5.5	High Bay Building				-$991,308					
121.5.6	Linac Tunnel	-$78,560								-$660,718
121.5.7	Linac Gallery	-$1,222,590				-$3,505,740		-$1,402,296		
121.5.8	Beam Transfer Line									
121.5.9	Booster Connection						-$3,437,000		-$921,116	
	Totals	**-$5,604,274**	**-$863,056**	**-$158,396**	**-$991,308**	**-$3,505,740**	**-$3,437,000**	**-$1,402,296**	**-$921,116**	**-$660,718**

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

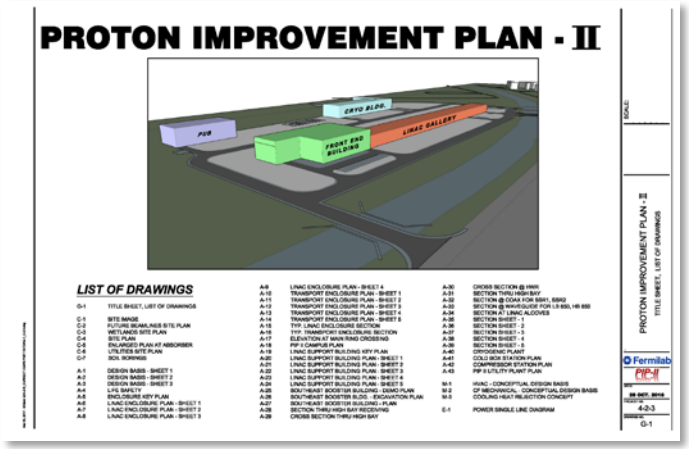
Project Management and Coordination Costs (PM&C)

- "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

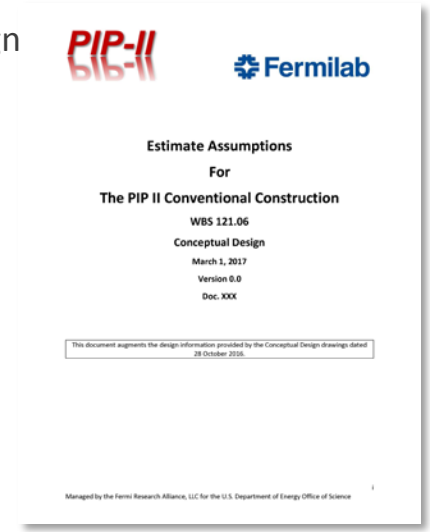
Documentation can be found at PIP-II-doc-327
Project Office Support basis of estimate can be found at PIP-II-doc-229
Conventional Facilities Management and Coordination basis of estimate can be found at PIP-II-217

Schedule Estimate Process

Drawings from PIP-II-doc-1155



Conceptual Design drawings and Estimate Assumptions developed with input from stakeholders

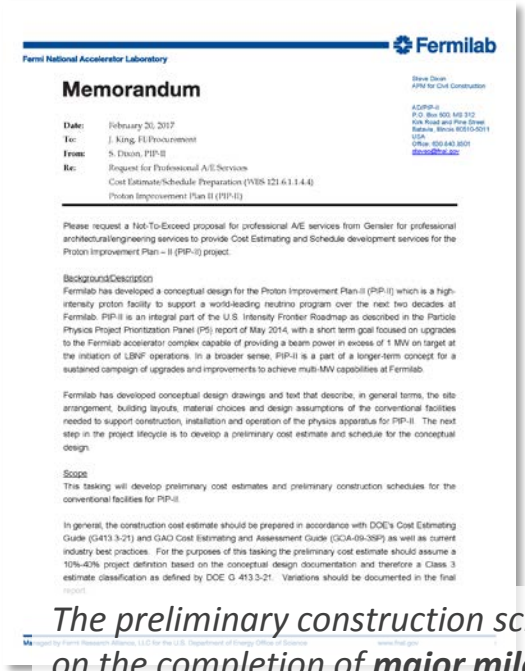

PIP-II
Fermilab

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.

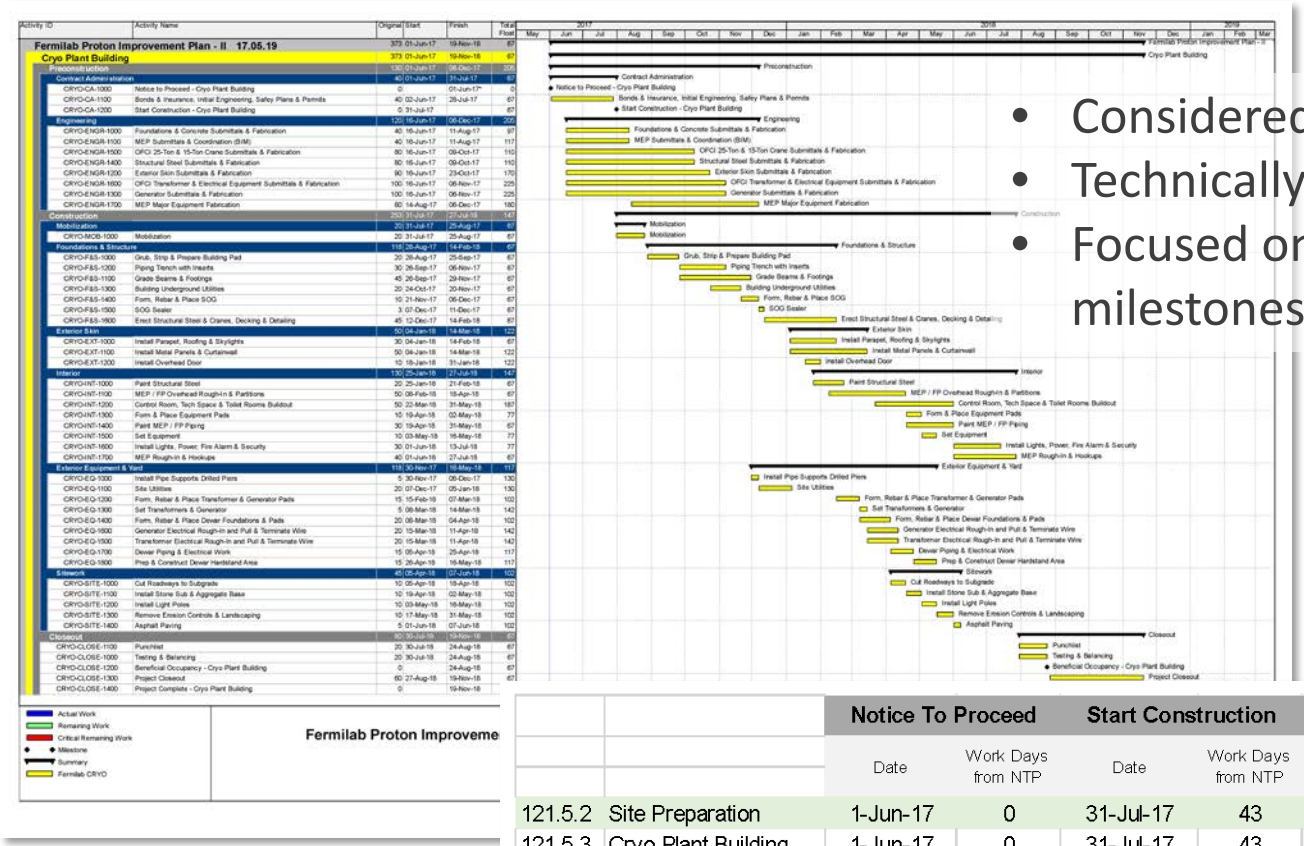
In general, the construction cost estimate should be prepared in accordance with DOE's Cost Estimating Guide (G413.3-21) and GAO Cost Estimating and Assessment Guide (GCA-09-3SP) as well as current industry best practices. For the purposes of this tasking the preliminary cost estimate should assume a 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

*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 subproject 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;
- **22%** cost contingency for High Bay, Linac Tunnel and Linac Gallery work packages;
- **20%** cost contingency applied to design work;

Schedule Uncertainty:

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

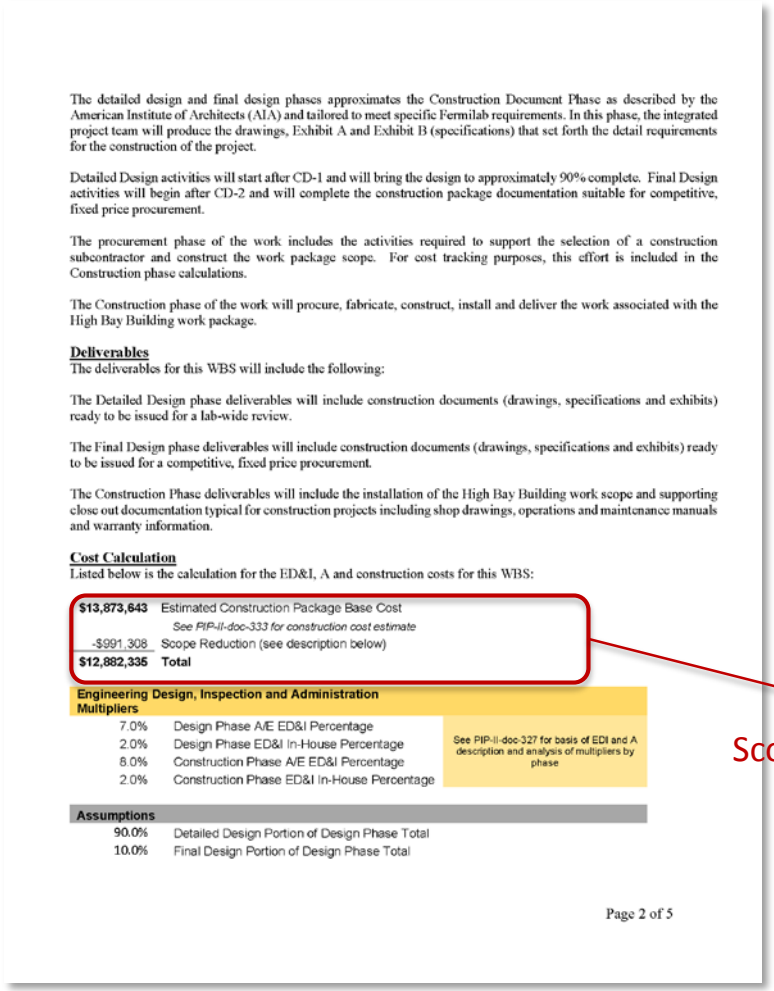
Basis Of Estimate

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



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 High Bay 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 High Bay Building work scope and supporting close out documentation typical for construction projects including shop drawings, operations and maintenance manuals and warranty information.

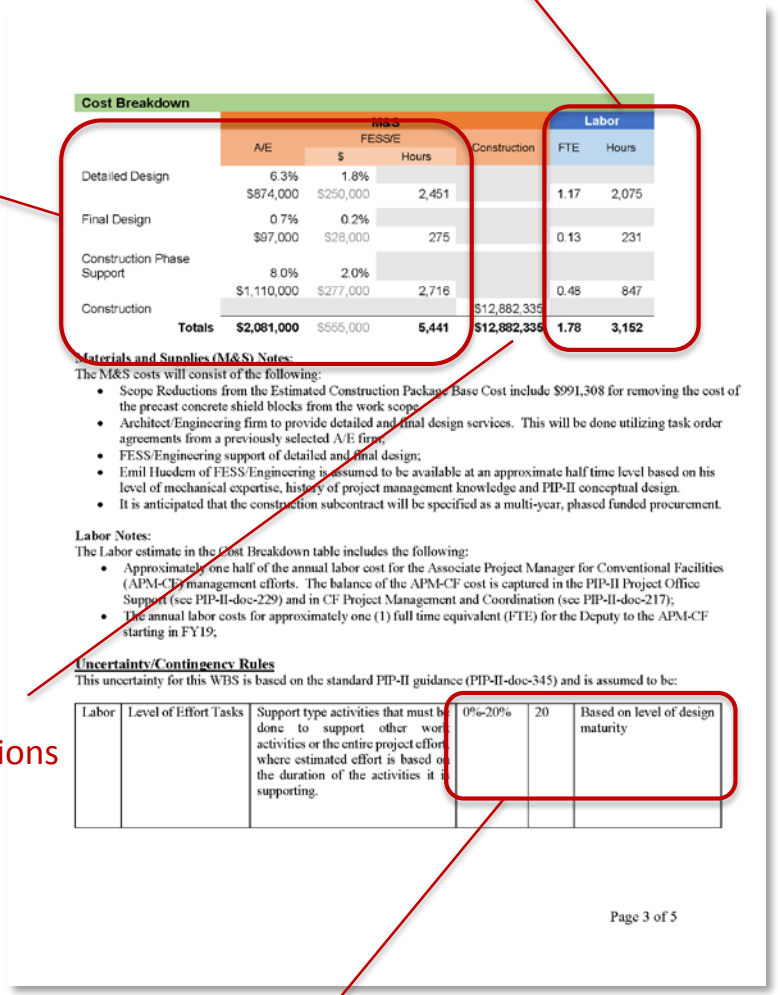
Cost Calculation
Listed below is the calculation for the ED&I, A and construction costs for this WBS:

$13,873,643	Estimated Construction Package Base Cost	
	See PIP-II-doc-333 for construction cost estimate	
-$991,308	Scope Reduction (see description below)	
$12,882,335	Total	

Engineering Design, Inspection and Administration Multipliers		
7.0%	Design Phase A/E ED&I Percentage	See PIP-II-doc-327 for basis of EDI and A description and analysis of multipliers by phase
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	

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

Page 2 of 5



Cost Breakdown

	A/E	M&S FESS/E $	M&S FESS/E Hours	Construction	Labor FTE	Labor Hours
Detailed Design	6.3%	1.8%				
	$874,000	$250,000	2,451		1.17	2,075
Final Design	0.7%	0.2%				
	$97,000	$28,000	275		0.13	231
Construction Phase Support	8.0%	2.0%				
	$1,110,000	$277,000	2,716		0.48	847
Construction				$12,882,335		
Totals	$2,081,000	$555,000	5,441	$12,882,335	1.78	3,152

Materials and Supplies (M&S) Notes:
The M&S costs will consist of the following:
- Scope Reductions from the Estimated Construction Package Base Cost include $991,308 for removing the cost of the precast concrete shield blocks from the work scope;
- Architect/Engineering firm to provide detailed and final design services. This will be done utilizing task order agreements from a previously selected A/E firm;
- FESS/Engineering support of detailed and final design;
- Emil Huedem of FESS/Engineering is assumed to be available at an approximate half 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) and in CF Project Management and Coordination (see PIP-II-doc-217);
- The annual labor costs for approximately one (1) full time equivalent (FTE) for the Deputy to the APM-CF starting in FY19;

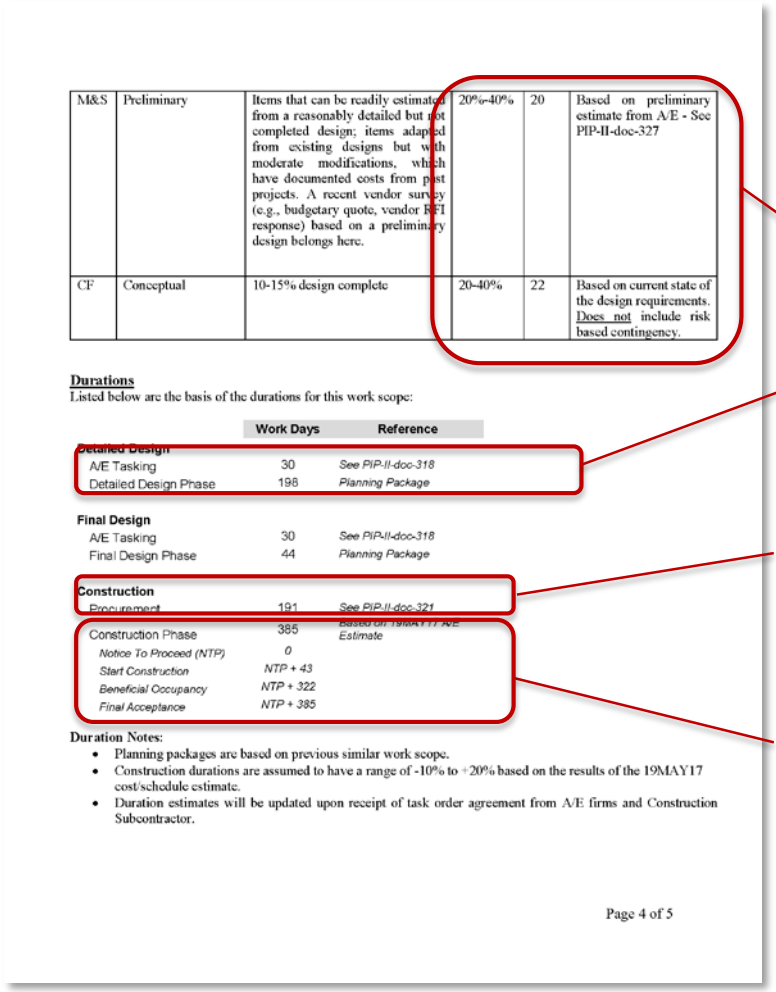
Uncertainty/Contingency Rules
This uncertainty for this WBS is based on the standard PIP-II guidance (PIP-II-doc-345) and is assumed to be:

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

Page 3 of 5

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%	22	Based on current state of the design requirements. 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	198	*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	385	*Based on 19MAY17 A/E Estimate*
Notice To Proceed (NTP)	*0*	
Start Construction	*NTP + 43*	
Beneficial Occupancy	*NTP + 322*	
Final Acceptance	*NTP + 385*	

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.

Page 4 of 5

Contingency

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

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

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

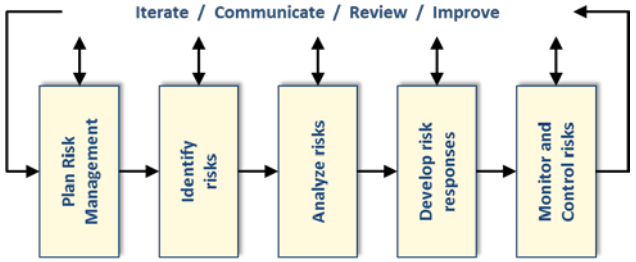
Typical Basis of Estimate form

Basis Of Estimate List

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

Risk Uncertainty

- Follow the **PIP-II Risk Management Plan**
  (see Management Breakout)



- 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

42 Threats and **9** Opportunities

Top 6 Risks:

Title	Technical Impact	P * Impact (k$)	P * Impact (months)	Probability
Subproject Changes Impact Conventional Facilities	1 (L) - somewhat substandard	285	2.0	30.00%
Construction Bids Exceed Estimates	1 (L) - somewhat substandard	68	0.2	15.00%
RF LCW Temperature Delta Too Low	1 (L) - somewhat substandard	63	0.9	20.00%
Unclear/Incomplete Delineation Between Construction Packages	1 (L) - somewhat substandard	58	0.3	25.00%
Design Complexity	1 (L) - somewhat substandard	43	0.0	15.00%
Poor Interface Definition	1 (L) - somewhat substandard	40	1.3	25.00%

5 Closed

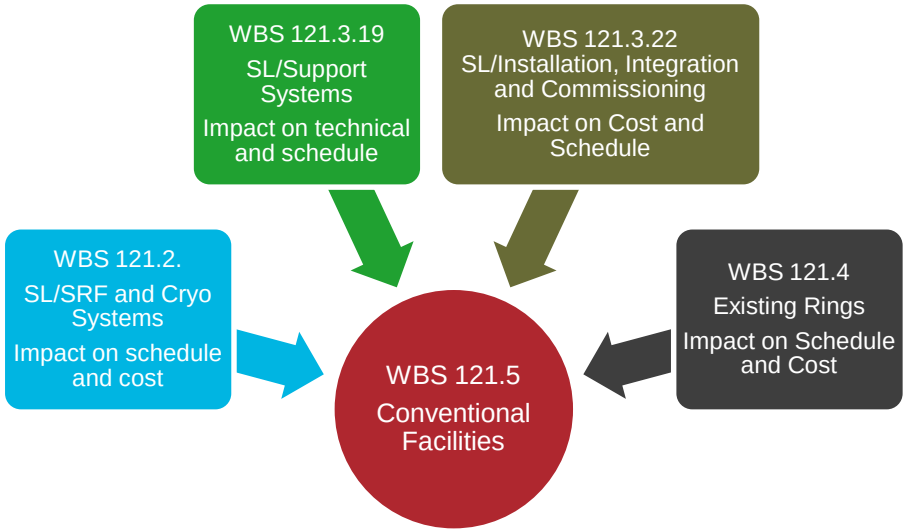
- Light Fixtures Fail in Radiation Environment (Managed);
- Wetland Mitigation Less than Anticipated (Retired);
- One-For-One Replacement/Space Bank Uncertainty (Retired);
- East Booster Tower Shielding Inadequate (Retired);
- Asbestos/Lead in East Booster Tower (Retired)

Risk Opportunities

- RO-121-05-02-001: Value Management Opportunities
- RO-121-05-002: Renewable Energy Opportunities
- RO-121-05-003: Radiation Shielding Opportunities
- RO-121-05-004: Construction Bids Below Estimate
- RO-121-05-005: Full Funding for Conventional Facilities
- RO-121-05-06-001: Increased Linac Enclosure Width
- RO-121-05-07-001: Increased Support Space in Linac Gallery
- RO-121-05-08-001: Main Ring Enclosure Not Needed

Risk Uncertainty – Interfaces

Top 4 systems this WBS interfaces to:



Top 4 interface within this WBS:

Top Risks

RT-121-05-01-002 *– Subproject Changes Impact Conventional Facilities*

RT-121-05-09-005 *– Poor Delineation*

Interfacing within this WBS including sequencing of work and existing Fermilab infrastructure.

Risk Uncertainty – RT-121-05-01-002

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;

Risk Uncertainty – RT-121-05-013

Construction Bids Exceed Estimates

- Summary

  If the construction bid proposals exceed the budgeted estimate then the cost and schedule will be impacted which jeopardizes project goals

- Cause/Trigger

  Construction package proposals receive exceed the budget estimate

- Mitigation
  - Include a reasonable contingency in budget;
  - Design to a target estimate;
  - Revisit the estimate periodically throughout the design process;
  - Include in the design add/deduct alternates to provide flexibility at bid day.

Risk Uncertainty – RT-121-05-07-001

RF LCW Temperature Delta Too Low

- Summary

  If the temperature delta for the LCW cooling water is less than 10 degrees F then the piping size will need to be increased which jeopardizes the cost budget

- Cause/Trigger

  Early discussions with the RF team indicated that temperature differential across the RF equipment was 1 degree F. Upon further discussion, this increased to 10 degrees F since a small temperature differential is inefficient and presents controls difficulties. The conventional facilities was updated with the assumption of a 10 degree temperature differential. Reduction of this value would require increased piping sizes and changes to the equipment selections

- Mitigation
  - Verify that the 10 degree F value is adequate to meet the RF requirements
  - Include RF subprojects on design meetings and formal reviews

Risk Uncertainty – RT-121-05-01-004

Unclear/Incomplete Delineation Between Construction Packages

- Summary

  If the coordination and delineation between construction packages is unclear/incomplete then cost/schedule could be impacted.

- Cause/Trigger

  Unclear delineation between construction packages

- Mitigation
  - Include coordination/delineation requirements during design reviews
  - Include coordination/delineation requirements during constructability reviews

Risk Uncertainty – RT-121-05-01-001

Design Complexity

- Summary

  If the final design is overly complex then the cost/schedule could be impacted which jeopardizes the overall project goals.

- Cause/Trigger

  Designs that are overly complex and/or utilize untested construction methods have the potential to reduce the pool of potential subcontractors and increase the cost of the work and delay the schedule

- Mitigation
  - The project team will conduct periodic constructability reviews focused on key components with the goal of developing a design that can be executed in an efficient and cost effective manner.
  - The PIP-II conventional facilities team will include architect/engineers and construction contractors that will participate in constructability review.
  - If overly complex methods are identified, the project team may consider breaking that work out as a separate construction package and/or pre-qualifying the potential subcontractors.

Risk Uncertainty – RT-121-05-09-005

Poor Interface Definition

- Summary

  If the interface between subprojects and conventional construction in inadequate then needed infrastructure could be missing or double counted which jeopardizes the cost and schedule objectives

- Cause/Trigger

  Poor interface between subprojects and conventional construction

- Mitigation
  - Include subproject managers on design meetings and sign-offs on formal reviews;
  - Document, track and receive concurrence on the interface between the subprojects and conventional facilities

Summary

- **Scope**
  - Conceptual Design is 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**
  - Identified risks based on past project team experience, managed following the project's Risk Management Plan.

Questions?