

**Director's Review of the Project X  
Cost Range Estimate:  
Development Effort**

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Project X Director's Review  
March 16, 2009



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- Purpose (1)
  - Development (4)
  - Integration (11)
  - Schedule (1)
  - Outside Collaborators (2)
  - Boundary Conditions (1)
  - Summary



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- From DOE Order 413.3, as part of the CD-0 process an “order of magnitude” cost range is to be developed in conjunction with the initial designs under consideration
  - The cost range is used to inform the stakeholders and builders of the potential total cost of a project; through the CD process the cost is refined as the technical design is developed
  - Following CD-0, the initial request for PED project funding occurs quickly, requiring year by year funding profiles.
  - The cost range provides an input to the R&D effort.
  - The cost range is NOT a baseline; it is just one of the inputs needed in the process to develop the best final overall design.



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We have developed the cost following our interpretation of the intent of the DOE guidelines. This means we have:

- Taken the ICD as the technical design to be estimated
- Estimated the technical components based on the current state of the technology
- Estimated the technical components based on recent purchases and / or quotes wherever possible
- Estimated infrastructure; other costs based on current understanding of other parallel programs
- Developed an RD&D plan consistent with the remaining needs of the 'project'
- Rolled the inputs together in a common, coarsely time phased manner



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The technical leaders were asked to:

- Develop a technical design consistent with the ICD
- Develop a cost estimate for that design through and including the hardware checkout phase of the machine with
  - FNAL FTE's in 4 broadly defined labor categories
  - FY09\$
  - Time phasing in increments of no less than quarter-years
- These estimates, and the RD&D plan associated with them, will be discussed in the breakout sessions this afternoon.



The labor categories were chosen based grouping FNAL labor categories based on average salaries

DRIVER / WAREHOUSE WORKER	
OTHER - LOW RANGE	
CLERK / STOREKEEPER	
ACCOUNTING CLERICAL	CATEGORY 1:
HR SPECIALIST LOW < 60	"Clerical / Technican / Operator "
ADMIN SUPPORT	
RESEARCH ASSOCIATE	
TECHNICIAN	
ACCELERATOR OPERATOR	
CP LOW RANGE < 60	
BUILDING SERVICES	
MACHINIST / WELDER	
SKILLED TRADES	CATEGORY 2:
DESIGN DRAFTER	"Machinist / Drafter / Lead Tech"
GUEST SCIENTIST	
Grand Total	
OP SPEC / TECH SPEC / FLOOR MGR	
OTHER - MID RANGE	
HR SPECIALIST MID 60-120	
ASSOCIATE SCIENTIST	
APPLICATION PHYSICIST	
ES&H SPECIALIST	CATEGORY 3:
ACCOUNTANT	"Assoc Sci / Engineering / Accountant / Engr Phys / Comp Prof / Budget Analyst "
ENGINEERING PHYSICIST	
CP MID RANGE 60-120	
PROCUREMENT	
BUDGET ANALYST / FINANCIAL MANAGER	
ELECTRICAL ENGINEER	
MECHANICAL ENGINEER	
RF ENGINEER	
CRYO ENGINEER	
APPLIED SCIENTIST	
SCIENTIST	CATEGORY 4:
ENG MANAGER	"Scientist / Engr Mge / IT Mgr "
OTHER - HIGH RANGE	
HR SPECIALIST - HIGH . 120	
IT MANAGER / SR CP / SYS ADMIN >120	
DIRECTOR / MANAGER/ SCI III	



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For the purposes of this exercise we use:

- CD-0 approval July 2009
- CD-1 approval December 2010
- CD-2 approval July 2012
- CD-3 approval August 2013
- CD-4 (hardware checkout, from schedule) Mar 2018
- RD&D phase CD 0-2 (July 2009- July 2012)
- PED funds CD 1-3 (December 2010 – August 2013)
- Construction funds CD 3-4 (September 2013 – March 2018)



The inputs from the technical leaders were then

- Rolled up and input into a MS Project file
- With the technical leaders input, time phased appropriately for a technically driven schedule subject to
  - Specified the CD approval dates
  - High level milestones of other tasks
    - Civil construction occupancy dates
    - Cryo plant availability
- With the conversion of FTEs to SWF in MS Project, this gives a coarsely time phased, technically limited construction project.
- The RD&D plan was then developed, and input in the same MS Project structure, using the same methodology



A note on structure: while MS Project labels the categories in the roll up “WBS”, and it looks something like a “WBS”, in fact this is NOT a proposed “WBS”. This is a convenient way to sensibly collect and organize the estimates from the people doing the estimates.

Microsoft Project - Project\_X\_Estimate\_12Mar09oldvers

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No Group

Integration

Uniq	ID	WBS	Task Name	Base Labor	Base M&S	Cost	Dur	Start	Finish	Predecessors	St
9	1	1	Project X	\$188,942,289	\$554,603,484	\$743,545,773	2369 d	Wed 10/1/08	Tue 3/13/18		
119	2	1.1	Project Management	\$19,889,856	\$3,597,000	\$23,486,856	2182 d	Wed 7/1/09	Tue 3/13/18		
84	12	1.2	LE Linac	\$22,495,803	\$80,213,390	\$102,709,193	2274 d	Wed 10/1/08	Fri 10/20/17		
115	92	1.3	HE Linac	\$27,096,446	\$195,471,724	\$222,568,170	2344 d	Wed 10/1/08	Tue 2/6/18		
32	170	1.4	MI/RR	\$12,071,807	\$49,608,550	\$61,680,357	1968 d	Wed 10/1/08	Wed 8/3/16		
10	212	1.5	PX Instrumentation	\$15,645,066	\$7,354,706	\$22,999,772	1942 d	Wed 10/1/08	Mon 6/27/16		
1	236	1.6	Controls	\$20,818,858	\$5,607,820	\$26,426,678	2245 d	Wed 10/1/08	Mon 9/11/17		
116	321	1.7	Cryogenics	\$6,679,600	\$40,962,000	\$47,641,600	2254 d	Wed 10/1/08	Fri 9/22/17		
380	370	1.8	Utilities & Interlocks	\$1,962,620	\$5,663,294	\$7,625,914	250 d	Fri 8/2/13	Thu 7/31/14		
117	374	1.9	Conventional Facilities	\$46,750,000	\$148,609,000	\$195,359,000	2174 d	Wed 10/1/08	Wed 5/31/17		
130	416	1.10	8 GeV	\$8,791,919	\$16,706,000	\$25,497,919	2174 d	Wed 10/1/08	Wed 5/31/17		
483	428	1.11	Integration	\$6,740,314	\$810,000	\$7,550,314	1004 d	Wed 10/1/08	Fri 9/28/12		
428	434	1.12	General	\$0	\$0	\$0	60 d	Wed 12/13/17	Tue 3/13/18		



Microsoft Excel - Item 1.2.1 - 1.2.7.325 LE Linac

1 << Number of units											
45	RT section										
47	RT CH cavities	ea	\$86,000	16	\$1,376,000					HINS purchase	
48	RT CH solenoid cold masses	ea	\$17,500	16	\$280,000					HINS purchase	
49	RT CH solenoid cryostats	ea	\$45,000	16	\$720,000					HINS purchase	
50	Assembly	lot	\$10,000	1	\$10,000	1.00		1.00	\$287,500	\$287,500	2 engrs, 2 techs, 1 phys for
51	Parts, assy, install, non-recurring labor	ea	\$2,386,000	1.00		1.00	0.50		\$287,500	\$2,673,500	
52	Parts, assy, install, non-recurring labor	lot			\$2,386,000	1.00		1.00	\$287,500	\$2,673,500	
53	EDIA	lot				4.00	4.00	1.00	\$1,015,000	\$1,015,000	2 drafters, 2 engrs, 1 phys for
54	Grand total RT section									\$3,688,600	

  

2 << Number of units											
57	Vacuum vessel	ea	\$105,000	1/CM	\$105,000					\$105,000	ILC cost estimate
58	Internal piping	ea	\$55,000	1/CM	\$55,000					\$55,000	ILC cost estimate
59	Raw niobium	ea	\$25,000	9/CM	\$225,000					\$225,000	HINS SSR1 fab and r
60	Cavity fabrication	ea	\$100,000	9/CM	\$900,000					\$900,000	HINS SSR1 fab and r
61	Helium vessel	ea	\$10,000	9/CM	\$90,000					\$90,000	Engr estimate, 50%
62	Processing	ea	\$5,000	9/CM	\$45,000	0.08		0.08	\$266,250	\$311,250	1 tech, 1 engr, 1 phys for
63	Testing	ea	\$5,000	9/CM	\$45,000	0.08		0.08	\$266,250	\$311,250	1 tech, 1 engr, 1 phys for
64	Solenoids	ea	\$17,500	9/CM	\$157,500					\$157,500	HINS purchase
65	Supports	ea	\$4,500	18/CM	\$81,000					\$81,000	HINS purchase
66	Magnetic shield	ea	\$120,000	1/CM	\$120,000					\$120,000	
67	Thermal shield	ea	\$18,000	1/CM	\$18,000					\$18,000	
68	MLI	ea	\$11,000	1/CM	\$11,000					\$11,000	
69	Couplers	ea	\$20,000	9/CM	\$180,000					\$180,000	
70	Turners	ea	\$15,000	9/CM	\$135,000					\$135,000	
71	Current leads	pr	\$2,900	13/CM	\$36,400					\$36,400	

During the breakout sessions, the speakers will discuss estimates in FY09 M&S\$ and FTE.

Microsoft Excel - WBS 1.2.5 Hours\_Matl by Qtr

WBS 1.2.5 SSR1 Cryomodules																
	Quarters	Jul-12	Oct-12	Jan-13	Apr-13	Jul-13	Oct-13	Jan-14	Apr-14	Jul-14	Oct-14	Jan-15	Apr-15	Jul-15	Oct-15	Total
1	WBS 1.2.5 SSR1 Cryomodules															
3	Cat 1: Clerical/Tech/Operator	Work	0	0	0	1344	1952	1934	2724	1655	937	952	983	983	2934	16448
5	Cat 2: Mach/Draft/Lead Tech	Work	2016	1952	1984	2048	0	0	0	0	0	0	0	0	0	8000
7	Cat 3: Assoc Sci/Eng/Comp Prof/Proj Cntrlrs	Work	2016	1952	1984	2048	672	976	992	1700	1319	937	952	983	1590	19104
9	Cat 4: Sci/Engr Mgr/IT Mgr	Work	504	488	496	512	336	488	496	1188	1151	937	952	983	918	10432
11	Total	Work	4536	4392	4464	4608	2352	3416	3472	5612	4125	2811	2857	2949	2949	53984
12		M&S	\$0	\$0	\$0	\$0	\$294,986	\$428,431	\$483,455	\$670,622	\$3,833,710	\$556,287	\$522,789	\$517,120	\$305,920	\$7,685,800

	\$0	\$2,702,500	\$3,751,500	1104 d	Wed 12/1/10	Mon 4/27/15
	\$0	\$3,286,000	\$4,601,000	1104 d	Wed 12/1/10	Mon 4/27/15
	\$0	\$7,685,800	\$10,675,336	874 d	Mon 7/2/12	Wed 12/23/15
	\$450,000	\$450,000	\$450,000	125 d	Thu 8/1/13	Mon 2/3/14 9
	\$1,800,000	\$1,800,000	\$1,800,000	375 d	Tue 2/4/14	Wed 7/29/15 33
	\$1,230,000	\$1,230,000	\$2,261,040	375 d	Tue 4/29/14	Thu 10/22/15 34SS+60 d
	\$389,800	\$389,800	\$389,800	375 d	Thu 8/1/13	Mon 2/2/15 9
	\$596,000	\$596,000	\$1,282,000	250 d	Thu 8/1/13	Wed 7/30/14 9
	\$20,000	\$20,000	\$250,496	42 d	Fri 10/23/15	Wed 12/23/15 30,16,20,25,36SS+185 d
	\$2,200,000	\$3,200,000	\$3,200,000	1 d	Fri 9/12/14	Fri 9/12/14 95SS
					Mon 7/2/12	Fri 6/28/13 7
					Mon 7/2/12	Mon 1/30/17



- Summary cost → FY09\$, SWF, M&S

	Total	SWF	M&S
<u>Project X</u>	<u>\$743,545,773</u>	<u>\$188,942,289</u>	<u>\$554,603,484</u>
Project Management	\$23,486,856	\$19,889,856	\$3,597,000
LE Linac	\$102,709,193	\$22,495,803	\$80,213,390
HE Linac	\$222,568,170	\$27,096,446	\$195,471,724
MI/RR	\$61,680,357	\$12,071,807	\$49,608,550
PX Instrumentation	\$22,999,772	\$15,645,066	\$7,354,706
Controls	\$26,426,678	\$20,818,858	\$5,607,820
Cryogenics	\$47,641,600	\$6,679,600	\$40,962,000
Utilities & Interlocks	\$7,625,914	\$1,962,620	\$5,663,294
Conventional Facilities	\$195,359,000	\$46,750,000	\$148,609,000
8 GeV	\$25,497,919	\$8,791,919	\$16,706,000
Integration	\$7,550,314	\$6,740,314	\$810,000



- Summary Costs by breakout session

<b>S/C 1</b>		FY09\$	Total	SWF	M&S
1.1	Project Management		\$23,486,856	\$19,889,856	\$3,597,000
1.11	Integration (RD&D)		\$7,550,314	\$6,740,314	\$810,000
1.8	Utilities & Interlocks		\$7,625,914	\$1,962,620	\$5,663,294
<b>S/C 2</b>		FY09\$	Total	SWF	M&S
1.10	8 GeV		\$25,497,919	\$8,791,919	\$16,706,000
1.3.3	Debuncher Beta = 1.0 (copper) Cavity		\$1,759,430	\$585,360	\$1,174,070
<b>S/C 3</b>		FY09\$	Total	SWF	M&S
1.4	MI/RR		\$61,680,357	\$12,071,807	\$49,608,550
<b>S/C 4</b>		FY09\$	Total	SWF	M&S
1.5	PX Instrumentation		\$22,999,772	\$15,645,066	\$7,354,706
1.6	Controls		\$26,426,678	\$20,818,858	\$5,607,820



- Summary Costs by breakout session

<b>S/C 5</b>		FY09\$	Total	SWF	M&S
1.2.1	Ion Source & LEBT		\$8,846,656	\$1,846,656	\$7,000,000
1.2.2	RF Quad		\$1,779,000	\$179,000	\$1,600,000
1.2.3	MEBT		\$3,751,500	\$1,049,000	\$2,702,500
1.2.4	Room Temperature Section		\$4,601,000	\$1,315,000	\$3,286,000
1.2.5	SSR1 Cryomodules		\$10,675,336	\$2,989,536	\$7,685,800
1.2.6	SSR2 Cryomodules		\$17,043,877	\$4,183,977	\$12,859,900
1.2.7	TSR Cryomodules		\$24,055,095	\$6,061,895	\$17,993,200
1.2.10	LE Linac RD&D (1.2.1 - 1.2.7)		\$2,633,525	\$1,478,525	\$1,155,000
<b>S/C 6</b>		FY09\$	Total	SWF	M&S
1.3.1	Beta = 0.81 Cryomodules		\$22,694,400	\$2,430,140	\$20,264,260
1.3.2	Beta = 1.0 Cryomodules		\$109,071,680	\$10,334,280	\$98,737,400
1.3.6	HE Linac RD&D Plan (1.3.1 - 1.3.2)		\$6,941,340	\$2,816,340	\$4,125,000



- Summary Costs by breakout session

<b>S/C 7</b>		FY09\$	Total	SWF	M&S
1.2.8	325 MHz RF and Distribution		\$26,273,990	\$1,712,000	\$24,561,990
1.2.9	325MHz LLRF		\$1,819,900	\$820,900	\$999,000
1.2.10	LE LinacRD&D (1.2.8 - 1.2.9)		\$1,229,314	\$859,314	\$370,000
<b>S/C 8</b>		FY09\$	Total	SWF	M&S
1.3.4	1.3 GHz RF and Distribution		\$74,981,784	\$8,074,580	\$66,907,204
1.3.5	1.3GHz LLRF and Global LLRF Systems		\$4,767,490	\$1,753,700	\$3,013,790
1.3.6	HE Linac RD&D Plan (1.3.4 - 1.3.5)		\$2,352,046	\$1,102,046	\$1,250,000
<b>S/C 9</b>		FY09\$	Total	SWF	M&S
1.7	Cryogenics		\$47,641,600	\$6,679,600	\$40,962,000
<b>S/C 10</b>		FY09\$	Total	SWF	M&S
1.9	Conventional Facilities		\$195,359,000	\$46,750,000	\$148,609,000



- To be consistent with a Cost Range in current DOE parlance, the range must be presented including:
  - Escalation to Then Year \$
  - Fully Burdened
  - Contingency
- This has been done at a high level using the time phased output from the MS Project file.
  - Escalation was done using standard DOE escalation rates
  - Burdens were applied using standard FNAL burdens
  - Contingency was applied top down at 40%
- These can be discussed in the Project Management break out session



Escalation uses DOE Scientific Laboratory Index

- It is recognized this would be redone for a cost baseline; however, for a means to compare ranges, it provides a common ground and avoids trying to find a one handed economist



Office of Cost Analysis

## Market Baskets with Industry Specific Escalation

DOE Market Baskets using Industry Specific Inflation Indexes (CCI and BCI projections from Global Insight and CEPCI projections from CF-70)

FY	Nuclear		Scientific Laboratory		Admin/ Warehouse		Remediation/ D&D	
	Rate	Index	Rate	Index	Rate	Index	Rate	Index
2008	72	1.000	56	1.000	43	1.000	50	1.000
2009	51	1.051	40	1.040	32	1.032	20	1.020
2010	40	1.093	36	1.077	32	1.065	38	1.059
2011	28	1.124	27	1.107	27	1.093	28	1.088
2012	25	1.152	23	1.132	22	1.117	24	1.115
2013	26	1.182	26	1.162	26	1.146	28	1.146
2014	26	1.213	26	1.192	26	1.176	23	1.172
2015	25	1.243	23	1.220	22	1.201	24	1.200
2016	24	1.273	21	1.245	19	1.224	22	1.227
2017	29	1.309	33	1.286	36	1.268	35	1.270
2018	26	1.343	25	1.319	25	1.299	28	1.305
2019	26	1.377	25	1.352	25	1.332	28	1.342



Short version of FNAL burdens:

- Average Program Support burden on SWF estimated at 75% (currently varies by Division)
- M&S at 16% except capped at 80k\$ for reqs above 0.5M\$

Consult your Division/Section/Project Field Financial Manager for the proper application of these rates to costs.		
<b>Labor Burdens</b>		
<u>Labor Burden Rate is applied to:</u>		
Vacation	<u>Monthly</u> Time Worked	11.0%
Vacation	<u>Weekly</u> Time Worked	12.0%
OPTO (Other Paid Time Off)	<u>Monthly</u> Time Worked	6.25%
OPTO (Other Paid Time Off)	<u>Weekly</u> Time Worked	9.25%
Fringe	Time Worked + Vacation + OPTO	33.5%
Effective Labor (Vacation, OPTO, Fringe)	<u>Monthly</u> Time Worked	56.33% (1)
Effective Labor (Vacation, OPTO, Fringe)	<u>Weekly</u> Time Worked	61.87% (1)
Summer/Temp Fringe		8.00%
<b>Indirect Rates</b>		
MSA (Material/Services Acquisition)		5.0%
MSA (Material/Services Acquisition)	Effective Rate (MSA & G&A)	16.03% (2)
CSS (Common Site Support)		23.5%
CSS (Common Site Support)	Effective Rate - Non-Divisional (CSS & G&A)	36.47% (3)
CSS (Common Site Support)	Fully Loaded <u>Monthly</u> Time Worked - Non-Divisional	113.6% (4)
CSS (Common Site Support)	Fully Loaded <u>Weekly</u> Time Worked - Non-Divisional	120.9% (4)
PS (Program Support)	Accelerator Division	30.5%
PS (Program Support)	Accelerator Division - Effective Rate (CSS, PS, G&A)	78.09% (5)
PS (Program Support)	Computing Division	19.5%
PS (Program Support)	Computing Division - Effective Rate (CSS, PS, G&A)	63.08% (5)
PS (Program Support)	Particle Physics Division	16.0%
PS (Program Support)	Particle Physics Division - Effective Rate (CSS, PS, G&A)	58.30% (5)
PS (Program Support)	Technical Division	35.5%
PS (Program Support)	Technical Division - Effective Rate (CSS, PS, G&A)	84.91% (5)
PS (Program Support)	Fully Loaded <u>Monthly</u> Time Worked - Accelerator Division	178.76% (6)
PS (Program Support)	Fully Loaded <u>Weekly</u> Time Worked - Accelerator Division	188.27% (6)
PS (Program Support)	Fully Loaded <u>Monthly</u> Time Worked - Computing Division	155.26% (6)
PS (Program Support)	Fully Loaded <u>Weekly</u> Time Worked - Computing Division	163.97% (6)
PS (Program Support)	Fully Loaded <u>Monthly</u> Time Worked - Particle Physics Division	147.79% (6)
PS (Program Support)	Fully Loaded <u>Weekly</u> Time Worked - Particle Physics Division	156.24% (6)
PS (Program Support)	Fully Loaded <u>Monthly</u> Time Worked - Technical Division	189.44% (6)
PS (Program Support)	Fully Loaded <u>Weekly</u> Time Worked - Technical Division	199.32% (6)
G&A (General and Administrative)		10.5%
Pass-Through		1.5%
The above rates have been submitted to the U. S. Department of Energy (DOE) and have been neither approved nor disapproved. The Laboratory's current Cost Accounting Standards Disclosure Statement has been approved by DOE. All the above rates are subject to adjustment to actual at least once per year in September.		



Using this methodology, the Fully Burdened value is

<u>ICD FY09 SWF/MS Base Roll Up</u>	<u>\$743,545,773</u>	
Labor Programmatic Burden	\$141,706,717	75%
<u>M&amp;S Burden</u>	<u>\$44,210,773</u>	std FNAL procedure
Base + Burden	\$929,463,263	
<u>Escalation</u>	<u>\$135,701,636</u>	14.60%
	\$1,065,164,900	
<u>Contingency</u>	<u>\$426,065,960</u>	40%
<b>Total</b>	<b>\$1,491,230,859</b>	



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MS Project (or my use of it...) is not fantastic at easily showing the critical path through a file w/ hundreds of lines and summary tasks. I'll describe it, and be happy to walk through the file in a breakout session as needed

- Initially we are limited by the CD process and completing the baseline design
- After CD-3, the civil construction and main cryogenic plant purchase are the limits
- When occupancy of the Linac and Beam Gallery is permissible, installation of the Beta = 1 cryomodules drives the schedule to CD-4.
- By design at this time, everything else is in the shadow of these efforts

# Project X Outside Collaborators (1)



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This estimate has been developed using four FNAL labor categories, and then burdened with FNAL burdens.

It could appear rather FNAL centric.

This is not the intent. In fact, we welcome collaborations (and it's part of the reason you are here!).

BUT...at this point of the process...

- We do not have a final technical design
- We do not have collaboration agreements (for deliverables we can not yet specify)
- We are not trying to finalize a baseline.

# Project X Outside Collaborators (2)

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We ARE trying to develop an estimate than can be used as a tool to compare one design, at the highest or lowest level, to another.

For the sake of consistency, we chose to use the FNAL rates and burdens.

We have had discussions with many of you already on various collaborations; we look forward to continuing those discussions in the future and your input in the next few days can help lead us to the best final design.

We will discuss the status of our collaborators in the RD&D plan and the setup of collaborations for the project in the management session.

# Project X Boundary Conditions(1)

Project X



There are several related parallel efforts within FNAL/the US/the World that provide inputs to Project X. These include, among others:

- HINS
- SRF Infrastructure
- ILC
- XFEL

Some of the inputs are equipment, some are technical, and some are knowledge. In developing the Project X ICD estimate and RD&D plan, we have taken account of these inputs to the best of our knowledge and they can be discussed in the various breakout sessions.



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- From the Project X ICD, a pre-conceptual design has been developed and an estimate of labor and materials created, integrated, and time phased.
  - This estimate is a tool for incrementally improving the technical design, developing the RD&D plan, and providing a means to compare this design with alternative designs that could be estimated similarly.
  - This estimate has been created using our most current cost experience, typically in small R&D quantities.
  - We believe the estimate is conservative and with the effort typical of projects during the CD-0 to CD-2 phase a technically superior, more cost efficient design can be achieved.