US LHC Accelerator Project	Baseline Change Request
BCR Number	59
WBS	1.1.1 IR Quads, 1.1.3 DFBX, 1.5.1 US PM, 1.5.3 FNAL PM
Title	FNAL-LHC Rebaseline
Change Control Level	2
Originator	Jim Kerby
Date	18 May 2004

Description of change

This BCR rebaselines the Fermilab-LHC program, using 31 October 2003 as the cut date. The BCR includes effects due to: schedule delays in delivery of correctors, actual variances through the cut date; the failure of MQXB04 to reach its test gradient and the therefore required rebuild; the change in the cost of shipping to CERN based on the actual contract; schedule delays and reworks required in the Fermilab-DFBX support area; changes in test support in both the magnet test and in the HTS leads test based on actuals; technical simplification of the Q1-Q2 interconnect based on iteration with CERN; and acceptance of a management challenge by Fermilab over the whole program.

The BCR was in process due to the schedule shifts when the MQXB04 test results were finalized, the cumulative effect was to drive the need to completely re-baseline the program.

An itemized breakout of the costs is given below.

Reason for change

The previous overall baseline (set in June 2001, BCR30) was becoming unreasonable with respect to schedule and actual effort, and was becoming less and less practical as a control tool.

There have been several smaller BCRs on specific topics since June 2001 (numbers 41, 42, 43, 44, 47, 48, and 53) having to do with DFBX engineering support, an additional SSW system for CERN, production HTS lead testing, and the move of the magnetic elements in Q3, but no overall rebaseline of the schedule. Comparisons are made to the full program up to and including the implementation of BCR53

Impact on other sub-systems

None.

Impact on cost

<u>Baseline Budget Change</u> Table 1 summarizes the total cost for this BCR compared to the current Fermilab baseline, as shown in BCR53, and the difference between the two, expressed in direct, FY2001 dollars. The BCR59 costs come from the file "rev10k FNAL.mpp." Table 2 shows the old and new baseline budgets in as-spent dollars, and includes the G&A and overhead. This BCR increases the FNAL baseline budget by $1020.2k, from $42,000.5k to $43,020.7k, a 2.4% increase. The individual effect of each of the aforementioned changes are discussed below and summarized Table 3.

Table 1. BCR59 Cost Variance Summary (direct, FY2001 dollars from MSP files)

		BCR59	BCR53	Difference
1	Fermilab- LHC	$33,515,729	$32,627,698	($888,031)
1.1	Interaction Region	$28,019,545	$26,904,584	($1,114,961)
1.1.1	Quadrupoles	$26,386,130	$25,447,621	($938,509)
1.1.1.1	Tooling	$2,328,448	$2,180,725	($147,723)
1.1.1.2	Cold Mass	$5,401,839	$5,205,891	($195,947)
1.1.1.3	Cryostat	$3,227,103	$3,380,726	$153,623
1.1.1.4	Magnet Testing	$1,982,363	$2,023,397	$41,034
1.1.1.5	Cable & Wedges	$0	$0	$0
1.1.1.6	Quadrupole Assembly & Test	$3,604,286	$3,049,139	($555,147)
1.1.1.7	EDIA	$9,842,092	$9,607,741	($234,350)
1.1.3	Cryogenic Feedboxes	$715,775	$565,972	($149,803)
1.1.3.1	Fabrication at FNAL	$56,631	$56,631	$0
1.1.3.3	DFBX EDIA at Fermilab	$264,334	$216,257	($48,077)
1.1.3.4	HTS Lead Testing	$394,811	$293,085	($101,726)
1.1.5	System Design	$917,640	$890,991	($26,649)
1.1.5.1	EDIA	$917,640	$890,991	($26,649)
1.4	Accelerator Physics	$922,056	$922,056	$0
1.4.2	FNAL Accelerator Physics	$922,056	$922,056	$0
1.5	Project Management	$4,574,129	$4,801,058	$226,930
1.5.1	US LHC Proj Man	$2,804,523	$2,833,662	$29,139
1.5.3	FNAL Proj Man	$1,769,606	$1,967,396	$197,791

Table 2. Old and new Cost Baselines (as spent k$ from Microfusion baseline)

WBS	Description	BCR 59	BCR 53	Difference
1	FNAL LHC Accelerator Project	$34,134.3	$33,360.6	($773.7)
1.1	Interaction Regions	$28,556.9	$27,538.1	($1,018.8)
1.1.1	Quadrupoles	$26,871.2	$26,052.8	($818.4)
1.1.1.1	Tooling	$2,345.6	$2,185.1	($160.5)
1.1.1.2	Cold Mass	$5,422.8	$5,209.0	($213.8)
1.1.1.3	Cryostat	$3,269.5	$3,764.6	$495.1
1.1.1.4	Testing	$1,986.7	$2,008.5	$21.8
1.1.1.6	Quad Assy/Test	$3,838.3	$3,180.1	($658.2)
1.1.1.7	EDIA	$10,008.3	$9,705.5	($302.8)
1.1.3	Cryo Feedboxes	$756.1	$598.7	($157.4)
1.1.3.1	Fabrication at FNAL	$60.5	$60.5	($0.0)
1.1.3.3	FNAL EDIA	$278.1	$224.8	($53.3)
1.1.3.4	HTS Leads at FNAL	$417.4	$313.3	($104.1)
1.1.5	System Design	$929.6	$886.6	($43.0)
1.1.5.1	EDIA	$929.6	$886.6	($43.0)
1.4	Accelerator Physics	$925.7	$925.7	$0.0
1.4.2	FNAL AP	$925.7	$925.7	$0.0
1.5	Project Mgt	$4,651.7	$4,896.9	$245.2
1.5.1	US LHC PM	$2,856.2	$2,884.7	$28.5
1.5.1.1	EDIA	$2,325.3	$2,246.1	($79.2)
1.5.1.2	Travel	$403.5	$446.9	$43.4
1.5.1.3	Miscellaneous	$109.0	$163.4	$54.4
1.5.1.4	DFBX Fab Study	$18.5	$28.3	$9.8
1.5.3	FNAL PM	$1,795.5	$2,012.3	$216.8
1.5.3.1	EDIA	$1,364.3	$1,449.8	$85.5
1.5.3.2	Travel	$327.0	$402.0	$75.0
1.5.3.3	Miscellaneous	$83.9	$132.8	$48.9
1.5.3.4	DFBX Travel	$20.3	$27.6	$7.3
	G&A	$3,464.2	$3,385.8	($78.4)
	Overhead	$5,422.2	$5,254.1	($168.1)
	Total	$43,020.7	$42,000.5	($1,020.2)

The entries in Table 1 are taken from the Microsoft Project (MSP) files for BCRs 53 and 59 respectively, while the entries in Table 2 are the baseline as entered in Microfusion and displayed in Winsight. There is a direct relation between these two, except for WBS 1.1.1.3 Cryostat parts. Starting in August 2002 entries in the Baseline Cost column in the MSP files was reduced, while the baseline budget stored in Microfusion was not. The August 2002 date is coincident with the implementation of BCRs 42 and 44, neither of which had any connection to this WBS. The MSP Baseline Cost was lowered to be consistent with the EAC as known at that time. This means that the cost reduction shown in Table 2 (Microfusion) is larger than that shown in Table 1 (Project), since part of the cost reduction was (erroneously) entered in Project already. This BCR brings those baseline values back into line and corrects this error.

<u>Cost Change Details</u> Table 3 summarizes the cost changes associated with each of the causes, compared to the total difference that was previously shown in Table 1. As in Table 1, the values given here are in direct, FY2001 dollars, and are derived from the MSP files for BCRs 53 and 59. The sign convention used here is the same as that used in the cost performance reports, that is, that a cost increase is negative, and a cost decrease is positive: variance = BCR53 – BCR59.

Oct 2003 Actuals Adjustment: The “Oct 2003 Actuals Adjustment” are the changes required to set the cost variance as of 31 October 2003 to zero, in terms of the MSP files. As noted above, this corresponds directly to the CV as reported in the Cost Performance Report (with corrections for as-spent vs. FY2001 dollars), except for WBS 1.1.1.3, where the variance in Table 3 is considerably smaller than the CV reported in the CPR. The total variance is -615.7k$, while during the period June 2001 through October 2003 the earned value of the Fermilab program was 6,717.4k$, or a 9% overrun. A detailed explanation by WBS follows.

The tooling (1.1.1.1, -117.6k$) overrun has been driven by higher than expected costs for setup and maintenance of the production (-53.2k$) and cryostat tooling (-64.4k$) in the ICB production area.

The cold mass (1.1.1.2, -195.9k$) parts variance is due to higher than expected piece part costs, as well as rework of parts as required by rebuilds of the magnets seen through MQXB06 before the coil to ground short problem located at in the lead end splice region was found and rectified.

Table 3. BCR59 Cost Variance Detail by Cause (direct, FY2001 dollars, from MSP files)

		Difference	Oct 2003 Actuals Adjustment	MQXB04 Rebuild	Shipping Contract	Corrector Delay	DFBX Delay & Repair	HTS Leads Test	Quad Test EDIA	Q1-Q2 Redesign	Mgmt Challenge
1	**Fermilab- LHC**	**($888,031)**	**($615,723)**	**($251,893)**	**($159,881)**	**($324,056)**	**($83,569)**	**($16,599)**	**$176,042**	**$22,500**	**$365,245**
1.1	**Interaction Region**	**($1,114,961)**	**($719,735)**	**($251,893)**	**($159,881)**	**($226,688)**	**($83,569)**	**($16,599)**	**$176,042**	**$22,500**	**$144,960**
1.1.1	Quadrupoles	($938,509)	($643,451)	($251,893)	($159,881)	($226,688)	$0	$0	$176,042	$22,500	$144,960
1.1.1.1	Tooling	($147,723)	($117,623)	$0	$0	($30,000)	$0	$0	$0	$0	$0
1.1.1.2	Cold Mass	($195,947)	($195,948)	$0	$0	$0	$0	$0	$0	$0	$0
1.1.1.3	Cryostat	$153,623	$146,749	$0	($15,626)	$0	$0	$0	$0	$22,500	$0
1.1.1.4	Magnet Testing	$41,034	$41,034	$0	$0	$0	$0	$0	$0	$0	$0
1.1.1.5	Cable & Wedges	$0									
1.1.1.6	Quadrupole Assembly & Test	($555,147)	($208,189)	($202,704)	($144,255)	$0	$0	$0	$0	$0	$0
1.1.1.7	EDIA	($234,350)	($309,474)	($49,189)	$0	($196,688)	$0	$0	$176,042	$0	$144,960
1.1.3	Cryogenic Feedboxes	($149,803)	($76,284)	$0	$0	$0	($56,921)	($16,599)	$0	$0	$0
1.1.3.1	Fabrication at FNAL	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
1.1.3.3	DFBX EDIA at Fermilab	($48,077)	$0	$0	$0	$0	($48,079)	$0	$0	$0	$0
1.1.3.4	HTS Lead Testing	($101,726)	($76,284)	$0	$0	$0	($8,842)	($16,599)	$0	$0	$0
1.1.5	System Design	($26,649)	$0	$0	$0	$0	($26,648)	$0	$0	$0	$0
1.1.5.1	EDIA	($26,649)					($26,648)				
1.4	**Accelerator Physics**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
1.4.2	FNAL Accelerator Physics	$0									
1.5	**Project Management**	**$226,930**	**$104,012**	**$0**	**$0**	**($97,368)**	**$0**	**$0**	**$0**	**$0**	**$220,285**
1.5.1	US LHC Proj Man	$29,139	$59,012	$0	$0	($70,873)	$0	$0	$0	$0	$41,000
1.5.3	FNAL Proj Man	$197,791	$45,000	$0	$0	($26,495)	$0	$0	$0	$0	$179,285

The cryostat (1.1.1.3, +146.7k$) parts variance is driven by lower than expected costs in cryostat parts as purchased. While the majority of the other corrections in this column are directly related to the CV reported in the October Winsight CPR, the cryostat parts correction from Table 3 is less than the CV reported for the reasons given above.

The test cost change (1.1.1.4, +41.0k$) is due to small positive variances across the various infrastructure tasks, but mostly due to a large underrun in the test stand commissioning effort.

The quadrupole assembly and test (1.1.1.6, -208.2k$) variance is in actuals accrued in closing out the prototype program (-51.4k$) and in initial fabrication of the Fermilab production quadrupoles (-166.6k$). After the initial learning curve and the solution to the ground short issues, our touch labor costs have been tracking the baseline very well.

The EDIA (1.1.1.7, -309.5k$) variance has 3 major contributors, tooling EDIA (-31.6k$); cryostat EDIA (-166.6k$), and Magnet Test EDIA (-98.5k$). The tooling EDIA charges are tied to the tooling M&S overrun, that the initial setup of the ICB area for production was under estimated. The cryostat EDIA charges are related to the difficulty in closing out the cryostat design, including iterations with CERN on design details. The Test EDIA overrun is mostly in the transitional time frame between the prototype and production test programs, where physicist effort was required, but the baseline had a discontinuity where the scientist effort dropped to near zero.

The Cryogenic Feedbox (1.1.3) variance (-76.3k$) to date has been due to higher than expected labor and cryogen costs associated with acceptance of the DFBX power leads. Not only have the leads required greater acceptance procedures than expected, but many have required minor reworks before testing, that were completed with the vendor in attendance in fall of 2003. Two pair of leads were sent back to the vendor for more serious rework, and negotiations with the vendor on the total cost of the rework effort are not finalized as yet.

The Project Management (1.5) variance to date (+104.0k$) is due to underruns in the actual support of the management effort, including computer software licenses, travel, and actual charged management effort.

MQXB04 Rebuild: Due to the failure of MQXB04 to reach quench current a rebuild is required, the total cost of which is -251.9k$. The “MQXB04 Rebuild” includes 2 parts. The first part is the labor and materials required to disassemble LQXB02, decryostat the prototype magnet Q2P1, reassemble MQXP01 and MQXB03 in a cryostat LQXB10, retest the assembly, and ship it to CERN. Disassembly costs are based on new estimates related to the cryostat effort, and a list of new parts required (such as end plates, etc). Forward progress, such as recryostating the assembly and cold test work, are estimated consistent with the current baseline that we are tracking well to. The second part is the EDIA effort associated with the rebuild and test. Again, this is estimated consistent with the new baseline as set by the Test EDIA reduction described further on.

Shipping Contract: The “Shipping Contract” produces a variance of -159.9k$. The overwhelming portion of this is in the actual shipping costs for the Q1/Q3 magnets, including the return of the shipping frames to Fermilab. The contract was competitively bid, and in the end has been signed as a contract for a single shipment with an option on the remaining 26 shipments. We are tracking the shipment closely, for a variety or reasons, including ways to reduce the return costs.

Corrector Delay: The “Corrector Delay” (-324.1k$) codifies the penalty associated with delay in arrival of correctors from CERN. CERN has had considerable difficulty with the receipt and testing of corrector elements throughout the LHC project, and the MCBX, MCSOX and MQSX correctors required in the triplet are no exception. Relative to the original baseline, the bulk of the production correctors from CERN started arriving 2 years late. Initial workarounds were made using prototype correctors made by CERN, but in the end it was required that we delay our cryostat assembly work. With correctors now arriving, we need an additional cryostat assembly line, and a longer duration program, to complete the assembly task with the September 2005 completion date. This portion of the BCR includes 30k$ of new tooling, EDIA charges of 10k$ for the new tooling, and EDIA charges of 186.7k$ for production oversight over the 11 month program extension. An increase of 97.4k$ for the Project Office in FY05 is included.

DFBX Delay and Repair: “DFBX delays and repairs” results in a variance of -83.6k$. The major portions of this are in EDIA charges associated with Fermilab production oversight at Meyer Tool, which is not dropping off nearly as quickly as previously expected, and minor repairs of the HTS leads at Fermilab that were completed during initial inspection of the leads. Delays in completion of the production result in a program extension until the end of FY05.

HTS Leads Test: In addition to the cost increase for HTS lead testing due to the need to repair many of them, experience has shown that a modest increase of 16.6k$ is required to balance the effort over the remaining leads to be tested. This includes an increase in cryogen costs on a per test basis, and an increase in the touch labor associated with the minor repairs and test of each pair of leads. This cost is shown under “HTS Lead Test.”

Quad Test EDIA: Study of the “Quad Test EDIA” showed that the original baseline estimate was too high. Starting with LQXB03, and continuing through the LQXB10 rebuild, the EDIA cost associated with each test was reduced 18k$. A similar reduction was applied to the two cold tests of the KEK magnets. The total change is +176.0k$.

Q1-Q2 Redesign: The "Q1-Q2 redesign" reduces the project estimated cost by +22.5k$. The TAS located between Q1 and Q2 has been shown by studies to not be required, and has been deleted from the design after consultation with CERN.

Mgmt Challenge: *Finally*, a "management challenge" has been accepted by Fermilab, which results in a savings of +365.2k$. Included in this are a reduction of scientist and project management support in FY05, and a reduction in travel expenses in both FY04 and FY05.

Impact on schedule

The Fermilab program continues to meet the September 2005 end of project date, with several months of float. The schedule is consistent with BCR64, and the revised Level 2 Milestones included therein. Table 3 shows the updated Level 3 milestones for the project.

Table 3. Level 3 Milestone Updates

Milestone No.				Previous	New Baseline
			WBS 1.1.1 Interaction Region Quadrupoles		
3	-1.1.1-	26	IR8 left MQX ready to deliver	1 Mar 2003	18 Aug 2004
3	-1.1.1-	27	IR8 right MQX ready to deliver	1 Jul 2003	18 Dec 2004
3	-1.1.1-	28	IR1 left MQX ready to deliver	1 Nov 2003	10 Mar 2005
3	-1.1.1-	29	IR1 right MQX ready to deliver	1 Dec 2003	30 Mar 2005
3	-1.1.1-	30	IR5 left and right MQX ready to deliver	1 Apr 2004	19 Jun 2005
3	-1.1.1-	31	IR2 left and right MQX ready to deliver	1 Aug 2004	8 Sep 2005
3	-1.1.1-	32	All spare MQX ready to deliver	1 Sep 2004	29 Sep 2005
3	-1.1.1-	33	Interaction Region Quadrupoles task complete	30 Sep 2005	

Other impacts (ES&H, etc.)

None.

Change Control Board recommendation (if required)

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Title	FNAL-LHC Rebaseline
Change Control Level	2
Originator	Jim Kerby
Date	18 May 2004

Approvals

WBS Level 3 Manager	19-Jul-04 Date
Laboratory Project Manager	19-Jul-04 Date
Change Control Board Chair	19 Jul 04 Date
US LHC Accelerator Project Manager	19 Jul 04 Date
DOE LHC Project Manager	19 July 04 Date
Director, DOE Division of High Energy Physics	Date