



Trigger Cost & Schedule

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CMS Trigger Project Manager

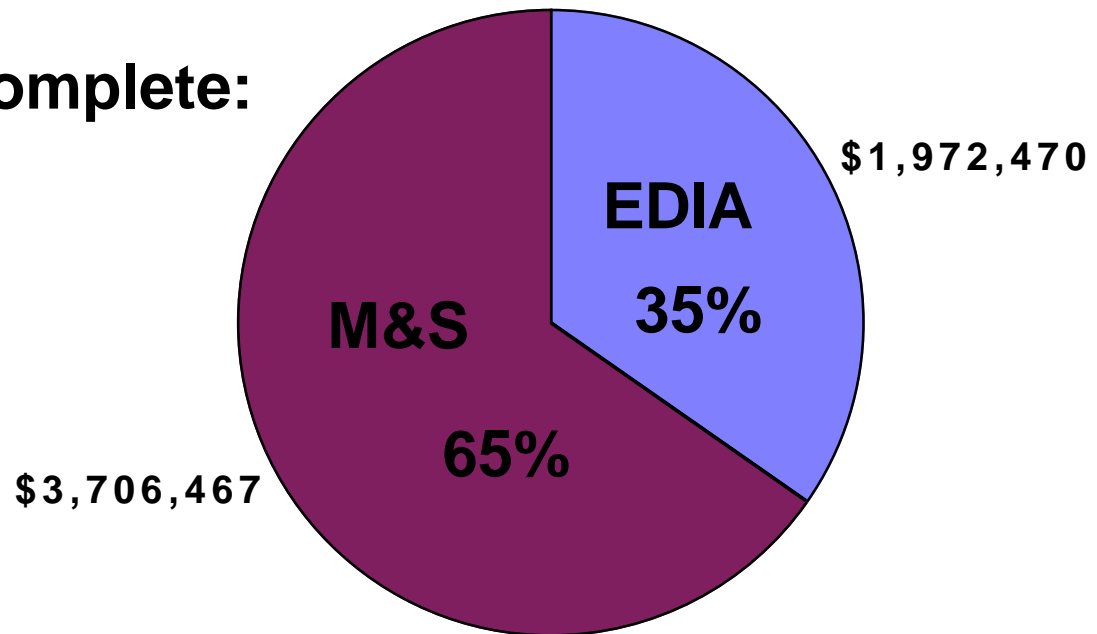
DOE/NSF Review
April 12, 2000



Trig. - Estimate to Complete

WBS Number	Description	EDIA (k\$)	M&S (k\$)	Mfg Labor (k\$)	Base Cost (k\$)	Cont (k\$)	Cont (%)	Total Cost (k\$)
Estimate at Completion (AY\$)					12,983			18,297
FY96-FY99 (AY\$)					2,311			2,311
Estimate to Complete (AY\$)		3,257	7,404	10	10,671	5,314	50	15,985
Escalation (DOE January 2000 indices)		153	440	0	593			
3	Trigger and Data Acquisition	3,105	6,963	10	10,078	5,012	50	15,090
3.1	Trigger	1,972	3,706	10	5,689	2,642	46	8,331
3.1.1	CSC Muon Trigger	856	867	10	1,733	904	52	2,636
3.1.2	Calorimeter Regional Trigger	1,117	2,839		3,956	1,738	44	5,694
3.1.3	Physicist Activity							
3.2	Data Acquisition	1,132	3,257		4,389	2,371	54	6,760

**Trigger Cost to Complete:
\$5.7 M**





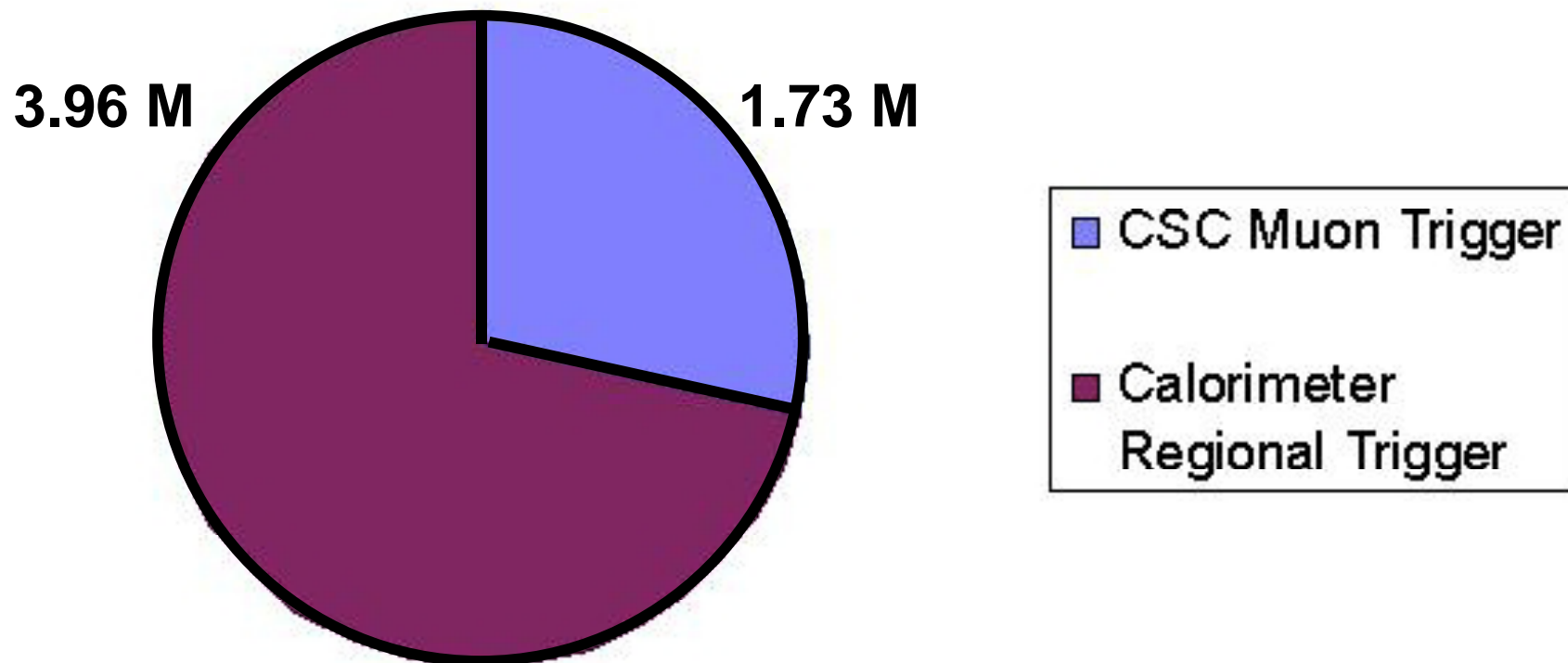
Trig. - Estimate to Complete

WBS Number	Description	EDIA (k\$)	M&S (k\$)	Mfg Labor (k\$)	Base Cost (k\$)	Cont (k\$)	Cont (%)	Total Cost (k\$)	DOE Funding (k\$)	NSF Funding (k\$)			
Estimate at Completion (AY\$)					12,983			18,297	17,199	1,097			
FY96-FY99 (AY\$)					2,311			2,311	2,311				
Estimate to Complete (AY\$)					3,257	7,404	10	10,671	5,314	50	15,985	14,888	1,097
Escalation (DOE January 2000 indices)					153	440	0	593					
3	Trigger and Data Acquisition	3,105	6,963	10	10,078	5,012	50	15,090	14,074	1,017			
3.1	Trigger	1,972	3,706	10	5,689	2,642	46	8,331	8,331				
3.1.1	CSC Muon Trigger	856	867	10	1,733	904	52	2,636	2,636				
3.1.1.1	Muon Port Cards (MPC)	182	282	10	475	232	49	707	707				
3.1.1.2	Sector Receivers (SR)	119	209		328	163	50	491	491				
3.1.1.3	CSC Sector Processors (SP-CSC)	146	86		232	151	65	383	383				
3.1.1.4	Overlap Sector Processors (SP-OVR)	146	56		202	129	64	331	331				
3.1.1.5	Clock&Control Cards (CCC)	83	60		142	57	40	199	199				
3.1.1.6	Crate Monitor Cards		10		10	5	50	15	15				
3.1.1.7	Muon Backplanes	64	30		94	44	47	137	137				
3.1.1.15	Muon Sorter	64	40		104	50	48	154	154				
3.1.1.8	Crate Controllers		35		35	18	50	53	53				
3.1.1.9	Muon Crates		6		6	3	50	9	9				
3.1.1.10	Muon Power Supplies		23		23	12	50	35	35				
3.1.1.11	Additional Cables		30		30	15	50	45	45				
3.1.1.12	Trigger System Tests	52			52	26	50	78	78				
3.1.2	Calorimeter Regional Trigger	1,117	2,839		3,956	1,738	44	5,694	5,694				
3.1.2.1	Prototypes	296	81		377	163	43	540	540				
3.1.2.2	Preproduction ASICs	213	260		473	236	50	709	709				
3.1.2.3	Test Facilities	19	60		79	40	50	119	119				
3.1.2.4	Power Supplies	3	79		82	25	30	107	107				
3.1.2.5	Crates	23	13		36	11	30	47	47				
3.1.2.6	Backplane	35	42		77	42	54	119	119				
3.1.2.7	Clock & Control Card	36	65		101	40	40	141	141				
3.1.2.8	Receiver Card	87	1,457		1,545	717	46	2,262	2,262				
3.1.2.9	Electron Identification Card	58	649		707	226	32	934	934				
3.1.2.10	Jet Summary Card	71	103		174	87	50	261	261				
3.1.2.11	Cables		7		7	2	30	9	9				
3.1.2.13	Crate Monitor Card												
3.1.2.14	Trigger Tests	276	22		298	149	50	447	447				



L4 Trigger Costs Remaining

Trigger, L4 Costs -- 5.69 M





Calorimeter Trig. Costs at L5

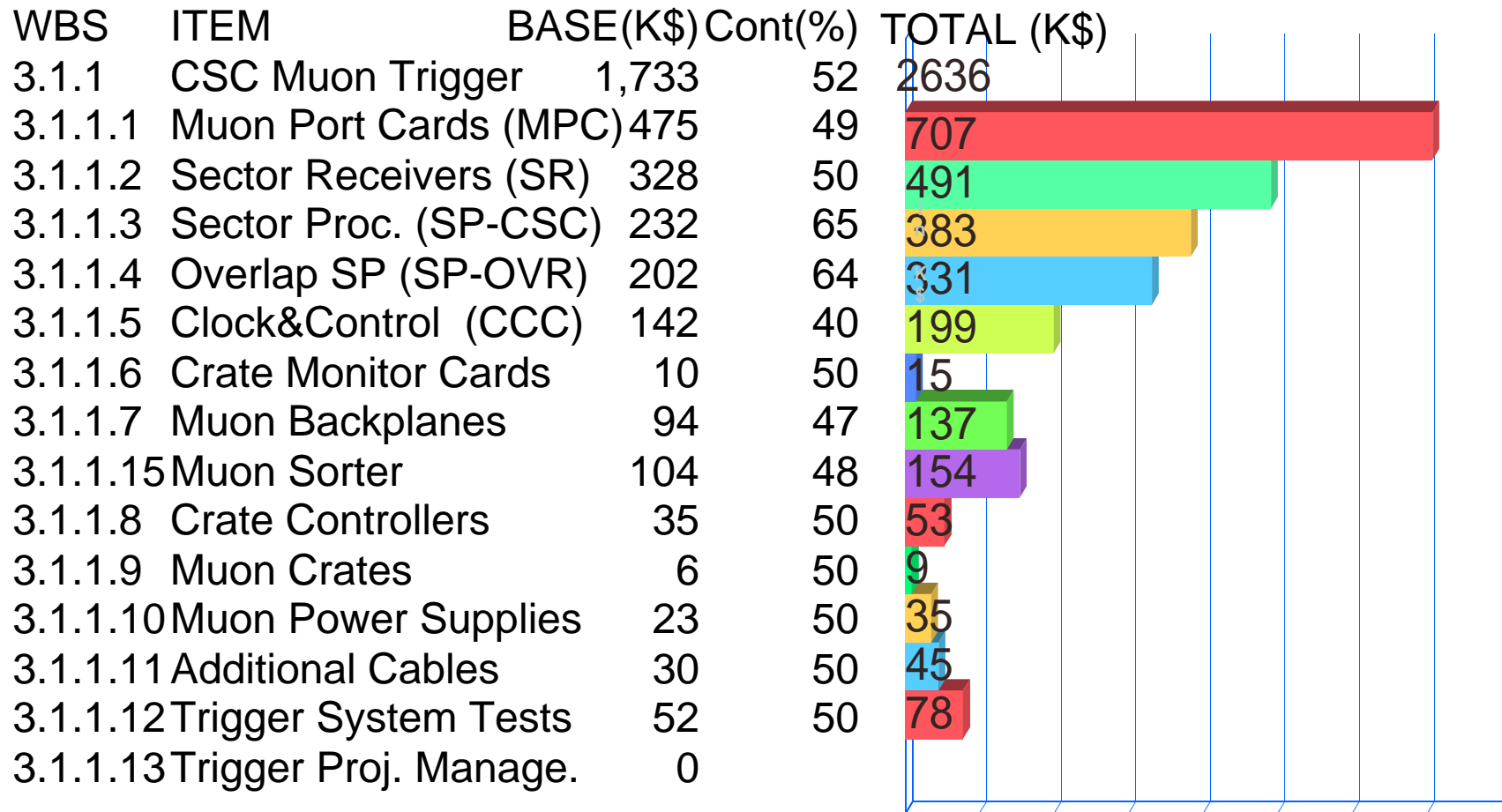
WBS	Item	Base(k\$)	Cont(%)	TOTAL (K\$)
3.1.2	Cal. Regional Trigger	3,956	44	5694
3.1.2.1	Prototypes	377	43	540
3.1.2.2	Preproduction ASICs	473	50	709
3.1.2.3	Test Facilities	79	50	119
3.1.2.4	Power Supplies	82	30	107
3.1.2.5	Crates	36	30	47
3.1.2.6	Backplane	77	54	119
3.1.2.7	Clock & Control Card	101	40	141
3.1.2.8	Receiver Card	1,545	46	2262
3.1.2.9	Electron ID Card	707	32	934
3.1.2.10	Jet Summary Card	174	50	261
3.1.2.11	Cables	7	30	9
3.1.2.12	DAQ Processor			
3.1.2.13	Crate Monitor Card			
3.1.2.14	Trigger Tests	298	50	447
3.1.2.15	Trigger Project Management			

Changes since Feb 1999 Review:

- All ASIC's prototypes & production under contract w/Vitesse
- ASIC Production advanced to immediately follow acceptance tests
- No change in overall costs



Muon Trigger Costs at L5

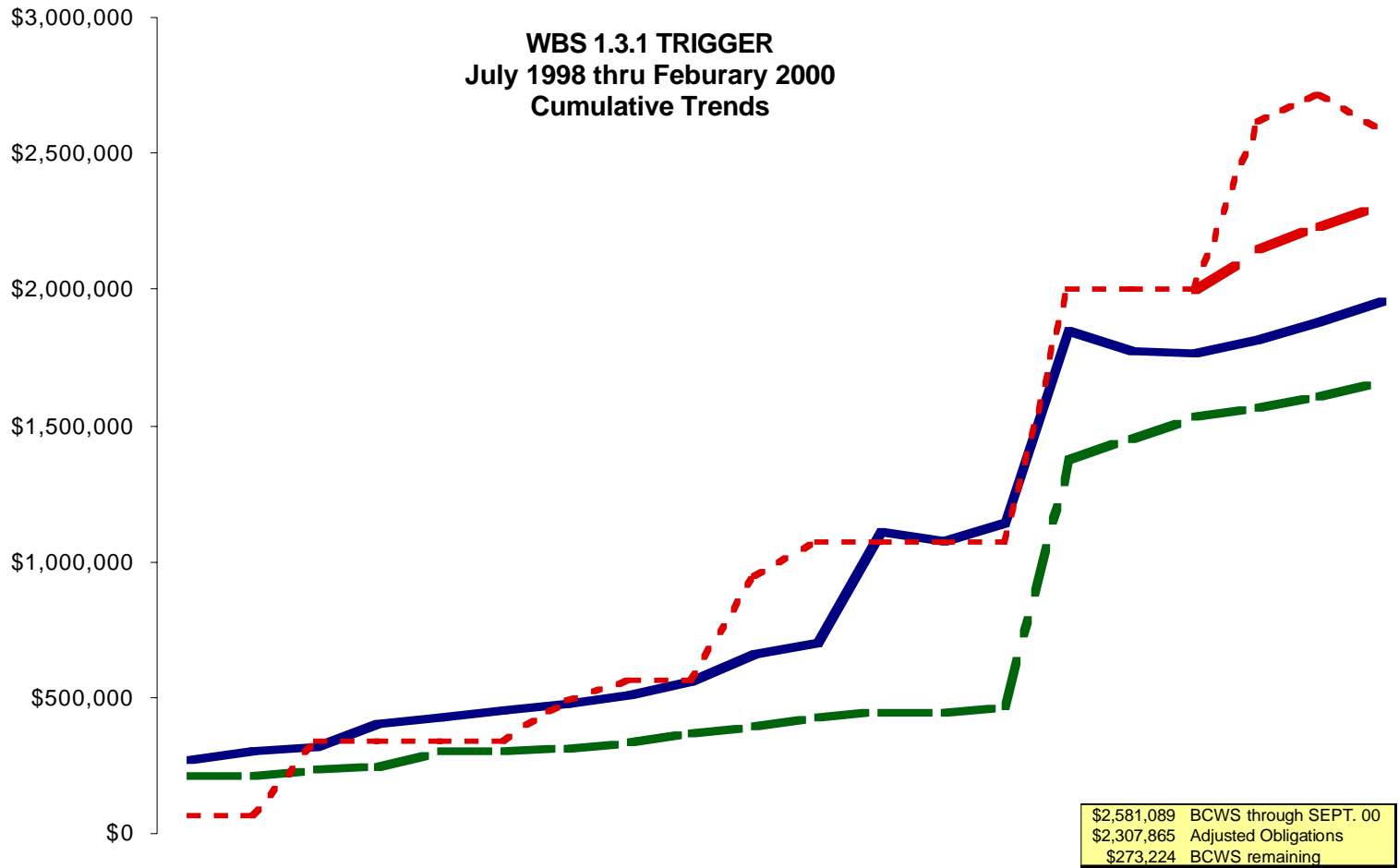


Change since Feb1999 Review -- net cost difference ~ 100K:

- Addition of independent CSC sorter
- Redesign of Counting House Crates for new interface with Drift Tube trigger
- New design of Track-Finding in the overlap region



Trigger - BCWS and BCWP



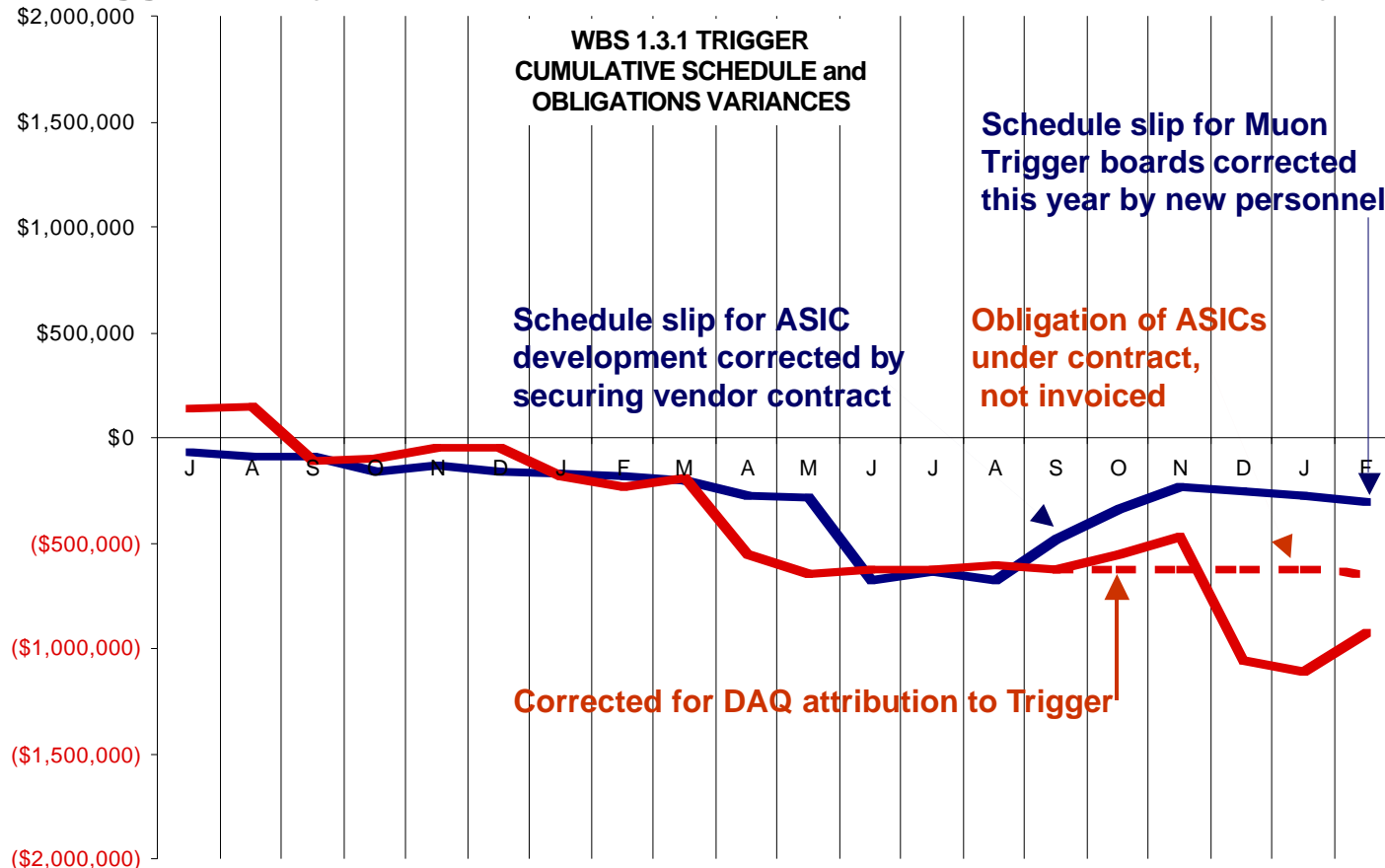
	Jul-98	Aug-98	Sep-98	Oct-98	Nov-98	Dec-98	Jan-99	Feb-99	Mar-99	Apr-99	Jun-99	Jul-99	Aug-99	Sep-99	Oct-99	Nov-99	Dec-99	Jan-00	Feb-00
BCWS (Budget)	\$274,3	\$303,4	\$323,1	\$403,2	\$433,7	\$456,0	\$482,8	\$516,1	\$563,6	\$668,7	\$1,115	\$1,077	\$1,149	\$1,855	\$1,776	\$1,766	\$1,818	\$1,882	\$1,964
BCWP (Performance)	\$214,4	\$217,9	\$240,9	\$252,4	\$306,0	\$306,0	\$315,0	\$337,1	\$371,1	\$397,2	\$448,7	\$450,6	\$475,2	\$1,379	\$1,451	\$1,536	\$1,572	\$1,614	\$1,667
OBLIGATIONS	\$65,62	\$65,62	\$344,7	\$344,7	\$344,7	\$344,8	\$494,1	\$561,6	\$561,7	\$943,6	\$1,071	\$1,071	\$1,071	\$2,002	\$2,002	\$2,002	\$2,621	\$2,714	\$2,583
Adjusted OBLIGATIONS																\$2,002	\$2,155	\$2,231	\$2,307



Trigger - BCWS and BCWP

Cumulative BCWP/BCWS = 85% indicating little schedule slippage.

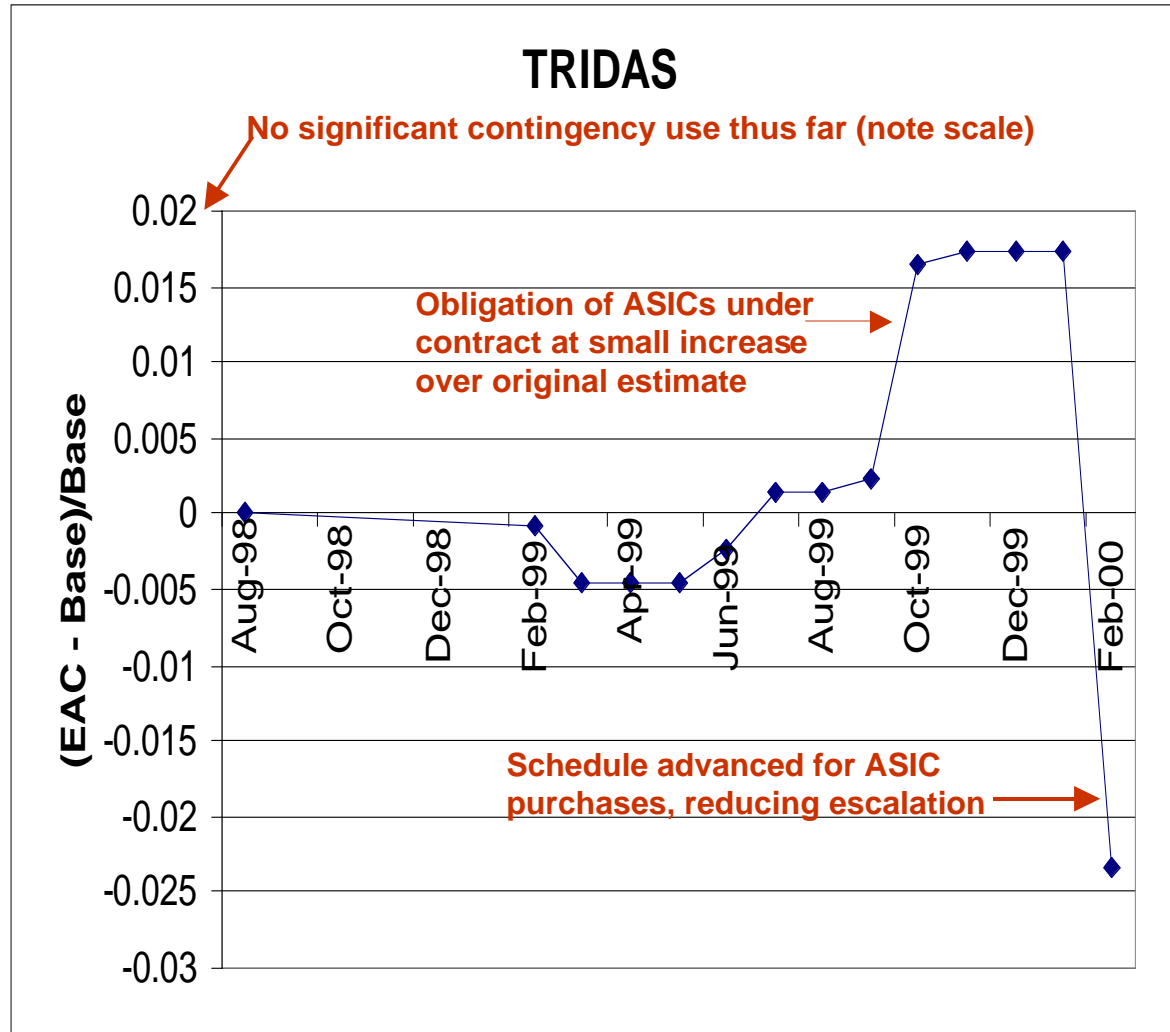
Trigger subsystem has completed BCWP/EAC = 22% of the project.



	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04
Schedule Variance	(\$59,812)	(\$85,467)	(\$82,194)	(\$150,761)	(\$127,728)	(\$150,066)	(\$167,801)	(\$179,004)	(\$192,463)	(\$271,444)	(\$275,501)	(\$666,874)	(\$626,359)	(\$674,541)	(\$476,066)	(\$325,042)	(\$229,827)	(\$246,063)	(\$268,131)	(\$296,892)
Obligation Variance	\$148,865	\$152,313	(\$103,757)	(\$92,267)	(\$38,738)	(\$38,826)	(\$179,056)	(\$224,512)	(\$190,622)	(\$546,367)	(\$641,297)	(\$623,003)	(\$621,036)	(\$596,546)	(\$622,509)	(\$550,431)	(\$465,684)	(\$1,048,92)	(\$1,100,43)	(\$915,947)
Adjusted OV															(\$622,509)	(\$622,509)	(\$622,509)	(\$622,509)	(\$622,509)	(\$639,947)



TRIDAS - Contingency Use

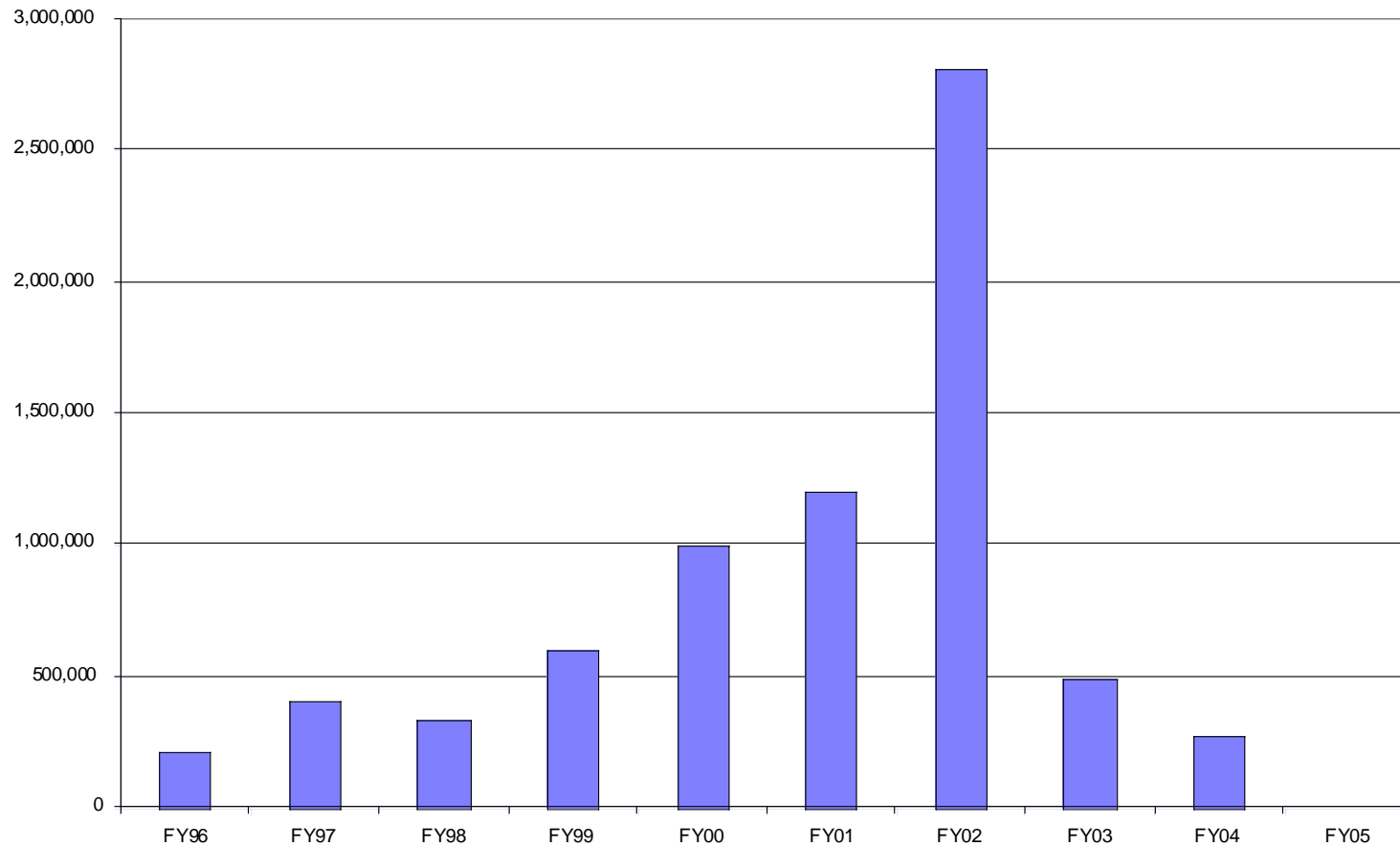




Trigger - Yearly BCWS

Costs ramp up until production, the bulk of which happens in FY02. M&S costs dominate at 65% of the ETC.

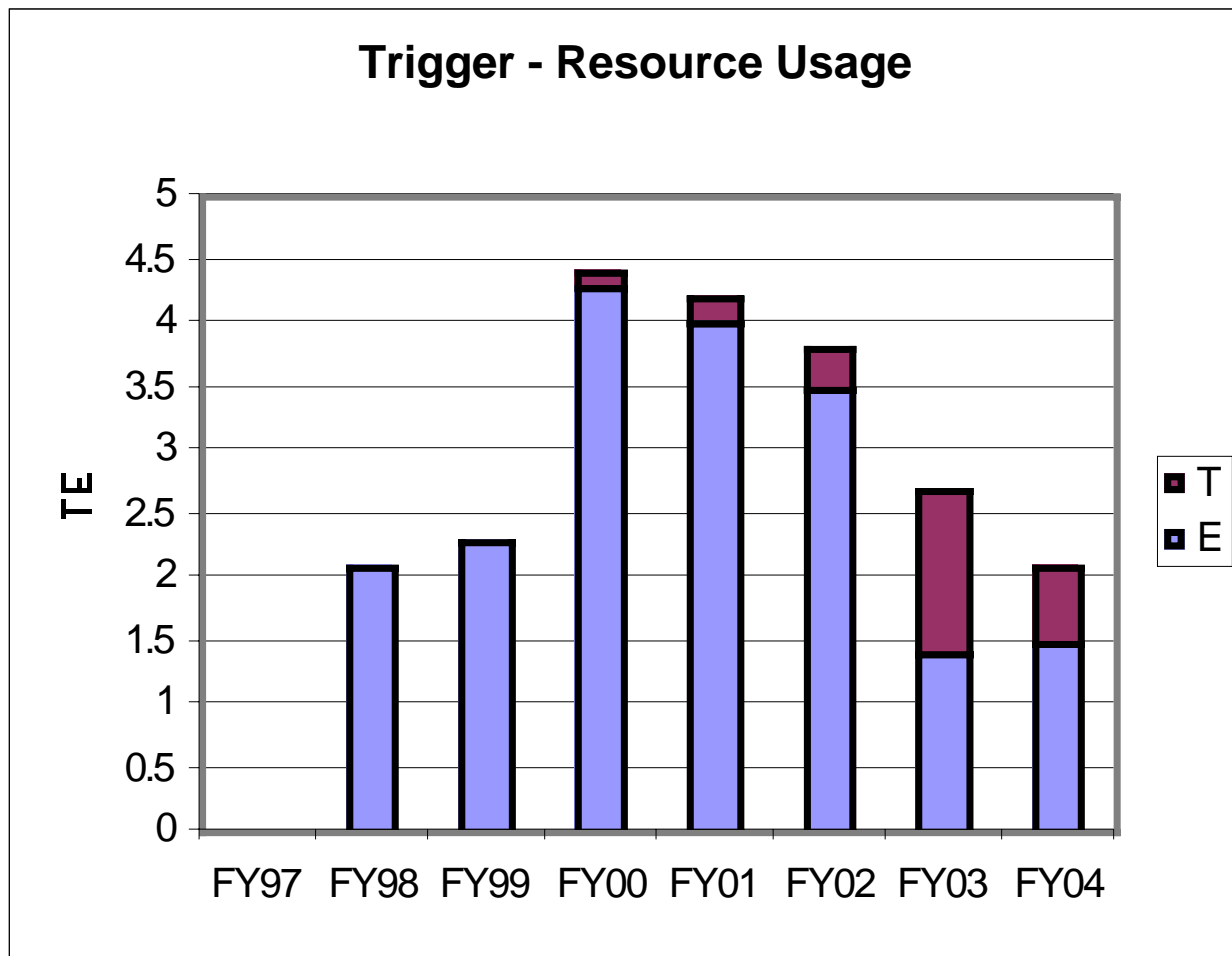
Trigger BCWS by FY





Trigger Resource Usage

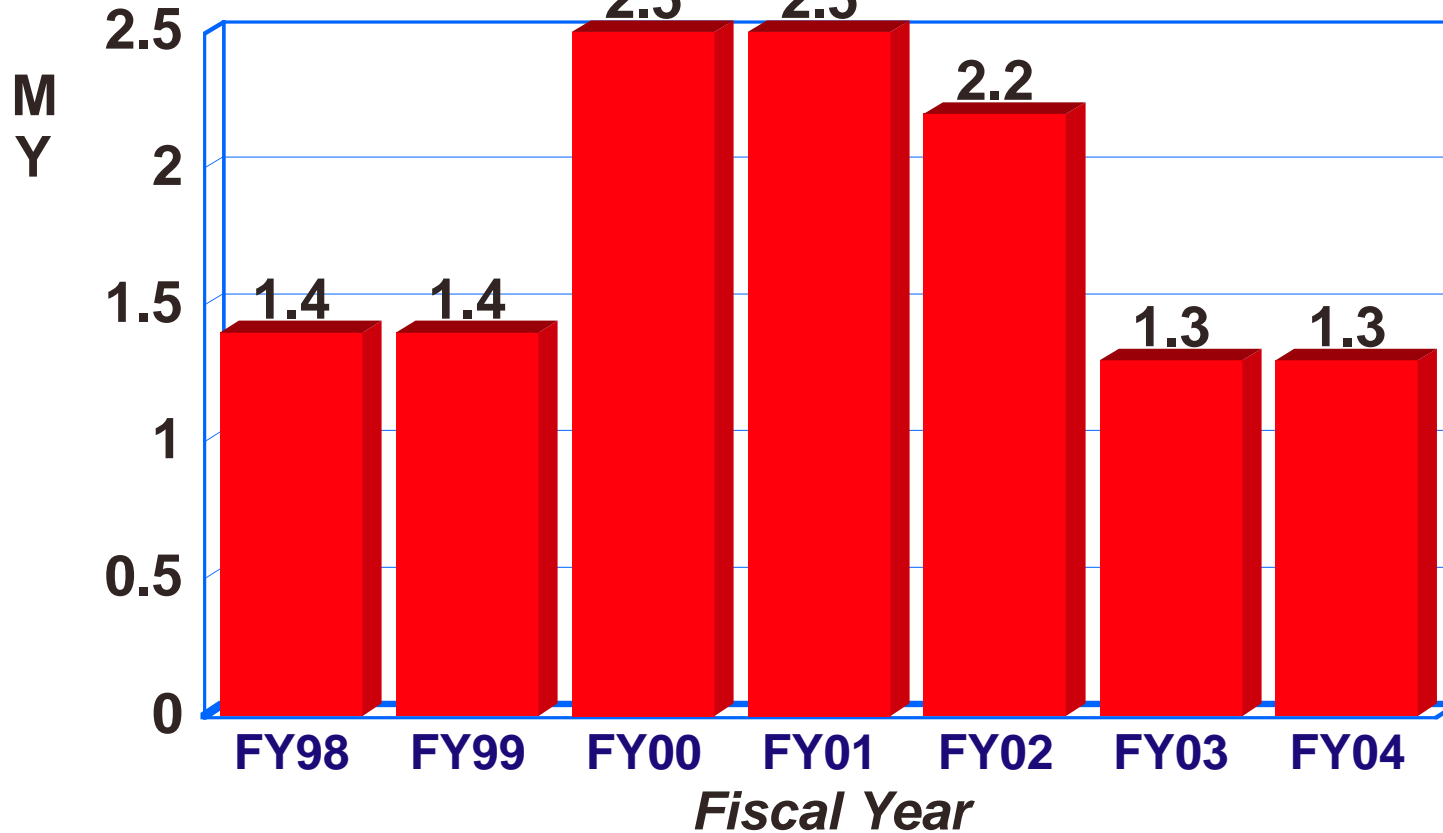
Engineering and Technical resources are compared to the people called out in the annual SOW. This tracking ensures that the needed labor is deployed.





Peak Engineering Level

Calorimeter Trigger *WBS 3.1.2*



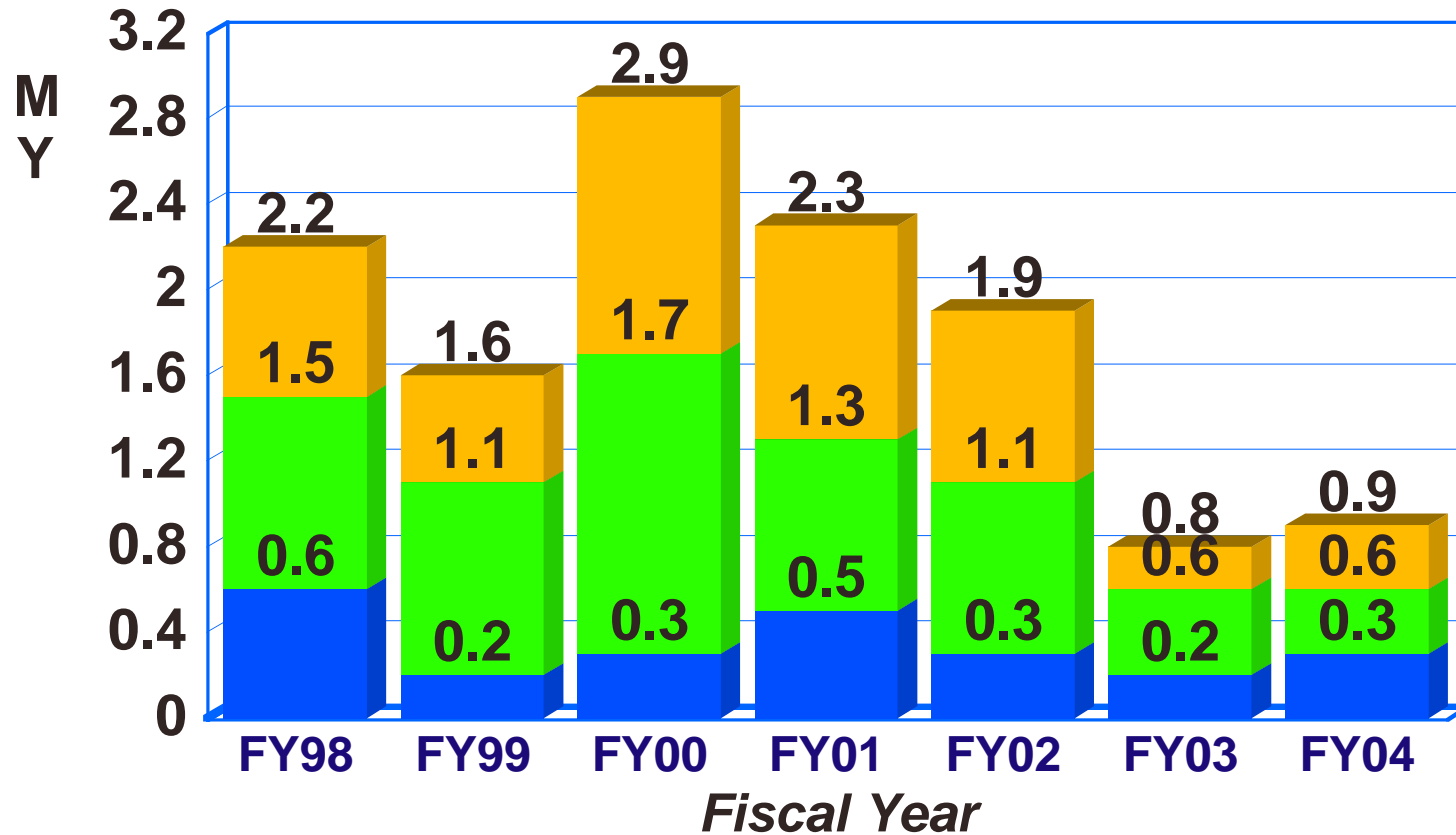
■ Wisconsin



Peak Engineering Level

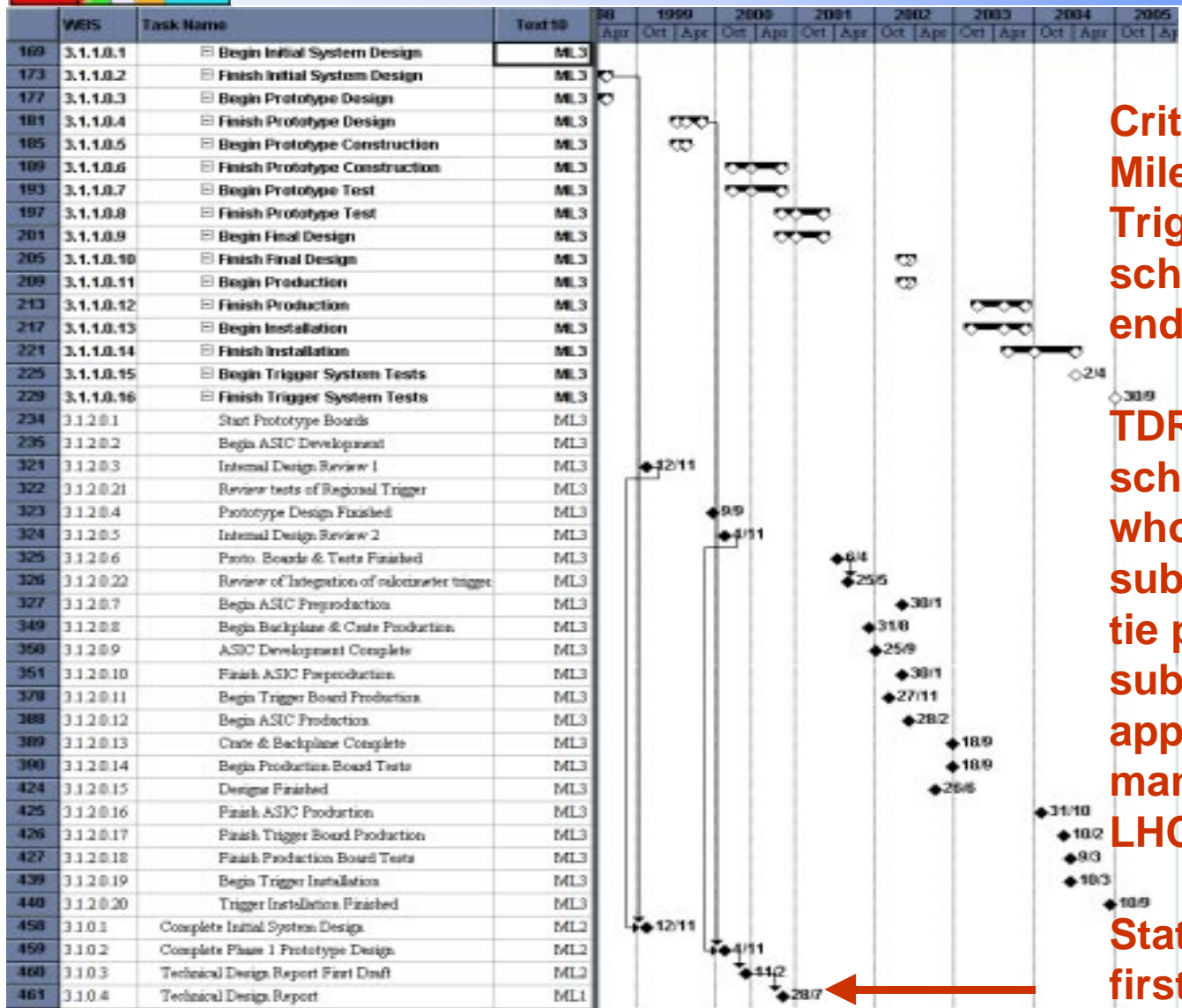
Muon Trigger

WBS 3.1.1





Trigger - ML1-3



Critical Level 1 Milestone is Trigger TDR, scheduled for end of this year.

TDR will contain schedule for the whole trigger subsystem with tie points to CMS subsystems approved by CMS management and LHCC.

Status: first draft exists.



Cal.Trig. - 3.1.2 Milestones

1995		1996		1997		1998		1999		2000		2001		2002		2003		2004			
Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr		
Start Prototype Boards				◆ 10/1/97																	
Begin ASIC Development				◆ 10/1/97																	
Internal Design Review 1						◆ 11/12/98															
Prototype Design Finished								◆ 9/9/99													
Internal Design Review 2								◆ 11/4/99													
Begin ASIC Preproduction								◆ 9/30/99													
Proto. Boards & Tests Finished										◆ 4/6/01											
Review tests of Regional Trigger										◆ 4/6/01											
Review of Integration of calorimeter trigger												◆ 5/25/01									
Begin Backplane & Crate Production												◆ 8/31/01									
ASIC Development Complete												◆ 9/25/01									
Finish ASIC Preproduction												◆ 1/30/02									
Begin Trigger Board Production										◆ 11/27/01											
Begin ASIC Production										◆ 2/28/02											
Crate & Backplane Complete												◆ 9/18/02									
Begin Production Board Tests												◆ 9/18/02									
Designs Finished												◆ 6/26/02									
Finish ASIC Production														◆ 10/31/03							
Finish Trigger Board Production														◆ 2/10/04							
Finish Production Board Tests														◆ 3/9/04							



Muon Trig. - 3.1.1 Milestones

1995		1996		1997		1998		1999		2000		2001		2002		2003		2004	
Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr	Oct	Apr
Begin Initial System Design ◇ 10/1/97																			
Finish Initial System Design ◊ 5/13/98																			
Begin Prototype Design ◊ 5/13/98																			
Finish Prototype Design ◊ 7/22/99																			
Begin Prototype Construction ◊ 5/13/99																			
Finish Prototype Construction ◊ 7/21/00																			
Begin Prototype Test ◊ 7/21/00																			
Finish Prototype Test ◊ 2/2/01																			
Begin Final Design ◊ 2/2/01																			
Finish Final Design ◊ 3/4/02																			
Begin Production ◊ 3/4/02																			
Finish Production ◊ 8/19/03																			
Begin Installation ◊ 8/19/03																			
Finish Installation ◊ 4/1/04 ◊																			
Begin Trigger System Tests ◊ 4/2/04																			
Finish Trigger System Tests ◊																			



Trigger Project Management

CMS TriDAS Reviews

- **April: TriDAS Status**

- Progress, draft R&D plans & expenses for next year
- In 1999, Added introductory Internal CMS Review w/external and CMS referees.

- **November: TriDAS Annual Review**

- R&D Plans/Progress, Cost & Schedule, Milestones
- Finalize R&D plans & expenses for next year
- In 1999, Internal Annual CMS Review w/external and CMS referees:
 - Myron Campbell, U. Michigan
 - Jean-Louis Faure, Zurich
 - Gigi Rolandi, CERN, Chair
 - Lucas Taylor, Northeastern
 - Hans von der Schmitt, DESY



Trigger Project Management

US CMS Management

- **US Reviews**

- Monthly Video Conferences
- Florida, Rice, UCLA, Wisconsin
- Review Progress, milestones, simulation activities

- **US Reporting**

- Monthly progress reports:
 - % complete
 - activities narrative

- **US Integration Meetings:**

- Calorimeter Trigger: FNAL, Maryland, Wisconsin
- Muon Trigger: Ohio, Florida, Rice, UCLA, Wisconsin, others.

- **Annual US Trigger Site Visits: Florida, Rice, UCLA**



Trigger R&D Program

Summary

- Engineering evaluation & prototyping to evaluate design capability, feasibility, and cost.
- Goal is to provide the information required for the subsystem trigger designs and specifications of interfaces to the Front End, Trigger and DAQ systems.
- Phase 1 prototyping program designs were complete November 1999 and tests will be complete and fully reported on by November 2000. Final result of this program is the Level-1 Trigger Technical Design Report in 2000.
- Phase 2 prototyping program will concentrate on final or pre-production prototypes based on the design in the TDR.



Level 1 Milestones: 1998-2000

Nov. 1998 Complete Initial Trigger Design ✓

- Algorithms finalized
- Functional blocks determined
- Numbers of ASICs, boards, cards and crates specified
- Interfaces specified
- Trigger geometry determined

Nov. 1999 Complete Phase 1 Prototype Design ✓

- Designs of boards, cards
- ASICs for prototype tests done

Nov. 2000 Phase 1 Prototype Tests Finished

- All tests necessary to begin design of production electronics are complete

Nov. 2000 Technical Design Report



Trigger Program

Simulation

- Check detector changes effect on trigger performance
- Validate final algorithms as implemented in hardware

Calorimeter Trigger

- Validate 160 MHz dataflow & processing
- Design & test prototype Boards
- Design & test prototype ASICs
- Design & test high speed Cu serial Link system

Muon Trigger

- Design & test prototype Boards
- Design & test prototype FPGA circuits
- Design & test high speed optical serial link system
- Test interface with CSC FE electronics



Trigger TDR Plans

- Jan 14: **(Done)** List of all sections, subsections & subsubsections
- Feb 21: **(Done)** List of figures & tables, text that can be directly copied from existing notes, and section introductions.
- Feb 28: 9:00 - 13:00 (during CMS week) **(Done)** Trigger Editorial Board meets with other section editors to review material submitted and request revisions
- Mar 31: **(Done)** First draft of all text due
- Apr 7: **(Done)** Trigger Editorial Board meets with section editors. Text is reviewed and revisions requested.
- May 2: Revised drafts of all sections due.
- May 8 - 12: TriDAS Review: Trigger TDR text released to TriDAS group (only) and TEB meetings held to go over text. Further revisions requested
- May 29: Revised drafts of all sections due.
- Jun 5: Revised text distributed to CMS members and Referees during CMS week and TEB meetings held to go over text.
- Jul 5: Comments from Referees and CMS management due.
- Jul 12: Full day meeting of Trigger Editorial Board to review comments.
- Sep 18: Deadline for revised draft.
- Sep 25: Revised text distributed to CMS members and Referees during CMS week and TEB meetings held to go over text.



Muon Trigger Status & Plans

Muon Port Card - Rice

- Construct Prototype - Sep '99
- Test with Sector Receiver - Dec '99
- Test with Trigger Motherboard - Mar '00

Sector Receiver - UCLA

- Prototype Design Review - Mar '99
- Construct Prototype - Oct '99
- Test with Muon Port Card - Dec '99

Sector Processor - Florida

- Prototype Design Review - Mar '99
- Construct CSC Prototype - Oct '99
- Construct OVR Prototype - Dec '99

Crate Test - Jul '00

- Sector Receiver Prototype - UCLA
- Sector Processor CSC & Overlap Prototypes - Florida
- Backplane - UCLA
- Clock & Control Card - Rice



Cal.Trigger Status & Plans

Prototype Dataflow Tests - Sep '99

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card

Serial Data Tests - Dec '99

- Serial Link Test Card

ASIC Design & Prototypes - Sep '00

- Electron ID ASIC
- Phase ASIC
- Boundary Scan ASIC
- Sort ASIC

Crate Test - Dec '00

- 160 MHz Backplane
- Proto. Receiver Card
- Proto. Clock Card
- Proto. Electron ID Card



Cost & Schedule Performance

Important revisions result in an improved system

- Muon trigger move to peripheral crates
- Trackfinder integration w/ Drift Tubes & Global Muon Trig.
- Calorimeter trigger serial links to adjacent E/HCAL crates
- Cost in BCWP/BCWS recovered with additional personnel

Actions taken to address schedule

- Additional engineering added
 - To both muon & calorimeter trigger projects
- Contract with Vitesse for all ASICs
 - accelerated purchases of production ASICs
- New Physicist effort on muon trig. Sector Receiver Card

Positive Developments that help schedule

- Muon trigger test beam results - encouraging
- Prototype tests successful (Adder ASIC is final!)



Conclusions - Trigger

Good Progress Since Feb 99 Lehman Review

- **Extensive prototyping & test program**
 - "Proof of principle" of critical items
 - Number of successes already
 - Muon trigger test beam, Optical Links
 - Calorimeter trigger Receiver & Electron Cards, Backplane, ASIC
- **Cost & Schedule Performance**
 - All Milestones made
 - BWCP/BWCS at 85%
 - In good shape
 - Additional resources helping to "catch up"-- will improve
 - Advancing ASIC's reduces risk, saves on escalation
- **Project Management**
 - Extensive system of reviews and monitoring in place
 - TDR by end of year, detailed documentation on WWW:
<http://cmsdoc.cern.ch/ftp/afscms/TRIDAS/html/level1.html>