GLAST Large Area Telescope:

LAT System Engineering

Pat Hascall
SLAC
System Engineering

Topics

- Action Item Status
- Technical Baseline Management
- Issues
- Interface Control Documentation
- RFA Closure
- Key Metrics
- Risk Management

Monthly Action Item Status

Action Item ID	Actionee	Description	Status

Technical Baseline: Flight Drawing Release

- **Status details**
  - **Tracker**
    - **141 of 141 released**
  - **ACD**
    - **Completed**
  - **Calorimeter**
    - **Completed**
  - **Mech**
    - **Completed 66 of 73**
      - **3 MLI drawings in work**
      - **Remaining 4 drawings (shims and spacers) are needed in for radiator fit check (August earliest)**
  - **Design Integration**
    - **Major drawings: 4 of 7 signed off**
      - **Added External Cable Installation Kit**
  - **DAQ**
    - **300 of 300 released**

Issues

No.	Description	Status	Due Date	Actionee
3	Technical baseline: Flight Drawing release	-All drawings to be under CM prior to flight build -Flight drawing release plan generated and statused weekly	Weekly Review	P. Hascall
22	ASIC radiation testing status	Radiation testing scheduled for completion. **Request to eliminate TID for 3rd and 4th GTFE run**	30 April ->June->Jan 05 >March 05	Sadrozinksi
31	Tracker flex cable coupon failures	Process change implemented. Coupons from flight panels failed. Steve Kahn assigned to work with Parlex on quality and schedule. **Pioneer first article source inspection**	10/15/04->11/5> 1/31	Rich
35	Reliability assessments not completed	FMEAs done, reviews with Subsystems started. Held TKR and Mech reviews with SLAC, TPS, GASU and PDU held on 5/13. Updates to FMEA provided on 5/21**. Tony distributed complete set, forwarded to local subsystem managers for review**	12/31/04	DiVenti
37	SIB EEPROM DPA Failure	PCB approved enough parts for flight build, still working parts for spares and qual. **Have enough parts for 5 boxes, all 5 will fly.**		Haller

Issues (continued)

No.	Description	Status	Due Date	Actionee
40	LAT-DAQ FPGA development and qualification	SLAC to respond to AIs' from FPGA reviews – AI's in review		Haller
41	Qualification of ERNI connectors	**Still in work**		Haller
43	TEM/TPS voltage ripple	Combination of hardware test and modeling in process to determine cause and potential fixes. Cause and corrective action determined, retrofit in process. **Replacement of 2 installed TPS to be determined**		Haller

Interface Management

Interface Document Status

- **SC-LAT ICD ICN Status**
  - **LAT signed this month**
    - **None**
  - **Currently under signature review**
    - **None**
  - **Currently in draft or revision**
    - **ICN-087 LAT Deliveries Table**
    - **ICN-0XX LAT Survey Feature Locations and Access Requirements***
    - **ICN-0XX Location and Access Requirements for LAT test connectors, auxiliary cooling inlet/outlet and purge ports***
    - **ICN-0XX MLI Interface**

    ***** **Will be contained in a single ICN adding an I&T appendix to the SC-LAT ICD.**
- **Internal LAT ICD's**
  - **Signed off this month**
    - **None**
  - **Currently in signature review**
    - **None**
  - **Currently in update**
    - **Electronics-LAT ICD (Comments being incorporated as they are received)**

Deliverables/Receivables

- **LAT Deliverables**
  - **July: None Scheduled**
  - **Aug: None Scheduled**
  - **Sept: None Scheduled**
  - **Oct: None Scheduled**
- **LAT Receivables**
  - **July: SC Interface Tool, SC-LAT Flexure Pins, Bolts and Washers**
  - **Aug: None Scheduled**
  - **Sept: None Scheduled**
  - **Oct: None Scheduled**

LAT Level Verification Status

Category	Verification Method					Requirements		
	Test	Demonstration	Analysis	Inspection	Children			
	# Complete	# Complete	# Complete	# Complete	# Complete	# Comp	Total	% Comp
Requirement Identified	-	-	-	-	-	484	484	100.0%
Flow Down Complete	-	-	-	-	-	469	484	96.9%
Draft Verification Plan	192	106	103	48	10	459	484	94.8%
Final Verification Plan	0	0	19	0	10	29	484	6.0%
Verification Plan Executed	0	0	0	0	10	10	484	2.1%
Requirement Sold	0	0	0	0	10	10	484	2.1%

- Remainder of requirements from Spectrum Astro's 1196 EI-Y46311-000C LAT-SC Interface Control Document have been incorporated into LAT's version of DOORS.
  - This has resulted in additional Level 2b requirements.
- Flow down of the level 2b requirements is complete.
- All verification methods have been incorporated into the Verification Compliance Requirements Matrix (VCRM).
- Verification Plans are in the process of being generated.
- Progress since last month
  - Requirements Identified : Additional 54 Requirements
  - Flow Down Complete : Additional 116 Requirements
  - Draft Verification : Additional 133 Requirements
  - Final Verification: Additional 5 Requirements
  - Verification Plan Executed : Additional 6 Requirements
  - Requirement Sold: Additional 6 Requirements

Key Design Metrics

Mass and Power Status Summary

- Mass
  - No change
- Power
  - No change
- FSW estimates updated
  - No change

LAT Mass Status

LAT Mass Status Report LAT-TD-00564-11

LAT Mass Status
Martin Nordby

Effective Date: 2-Jun-05
Print Date: 29-Jun-05

Jun-05

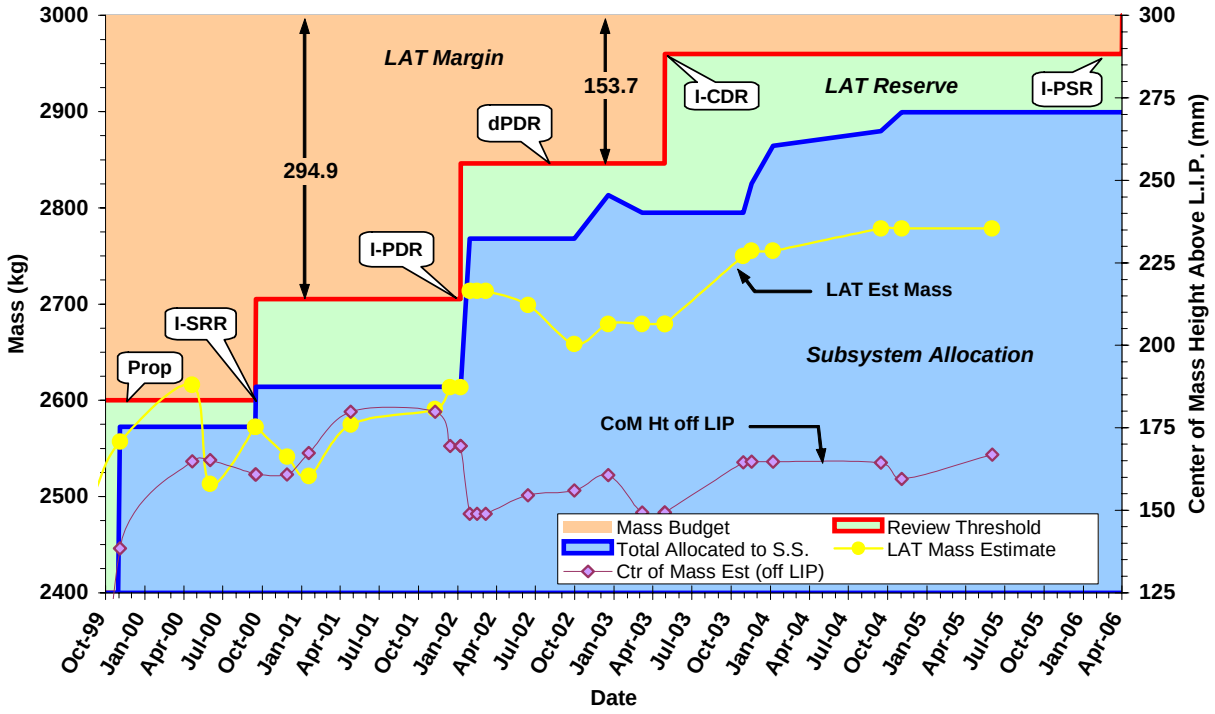
Mass (kg)	Estimate	Alloc.
TKR	523.6	530.0
CAL	1382.3	1440.0
ACD	277.6	295.0
Mech	355.7	386.6
Elec	232.0	240.0
Systems	7.5	8.0
LAT Total	**2778.7**	**2899.6**
Rsrv/Margin	221.3	
Rsrv/Margin*	8.0%	
Allocation		3000.0

* AIAA G-020 recommended min reserve = 4.7%
Allocations per latest mass CCB on 3 Nov 2004

Mass Estimate Breakdown		
	(kg)	%
Parametric	56.3	2.0%
Calculated	121.8	4.4%
Measured	2600.5	93.6%
Total	**2778.7**	**100%**

Center of Mass (mm)		
CMx	-1.06	-20 < CMx < 20
CMy	-0.87	-20 < CMx < 20
CMz	-69.32	CMz < -51.2
Ht off LIP	166.88	Ht < 185

Second Moment of Inertia (kg-m^2)		
Ixx	1061.3	1400.0
Iyy	1013.6	1350.0
Izz	1398.4	1580.0



LAT Power Status

LAT Power Consumption Estimate has increased by 21.7 W.

8-Jun-05 Item	Estimate (Watts)	PARA (Watts)	CALC (Watts)	MEAS (Watts)	SPEC (Watts)
ACD	11.5	2.4	3.9	5.2	11.5
Tracker	157.9	0.0	0.0	157.9	160.0
Calorimeter	67.7	0.0	0.0	67.7	71.0
Trigger & Data Flow	331.6	43.2	72.3	216.1	327.5
Grid/thermal	20.4	20.4	0.0	0.0	35.0
Instrument Total	589.1	66.0	76.2	446.9	605.0
Instrument Allocation	650.0				
% Reserve	10.3%				

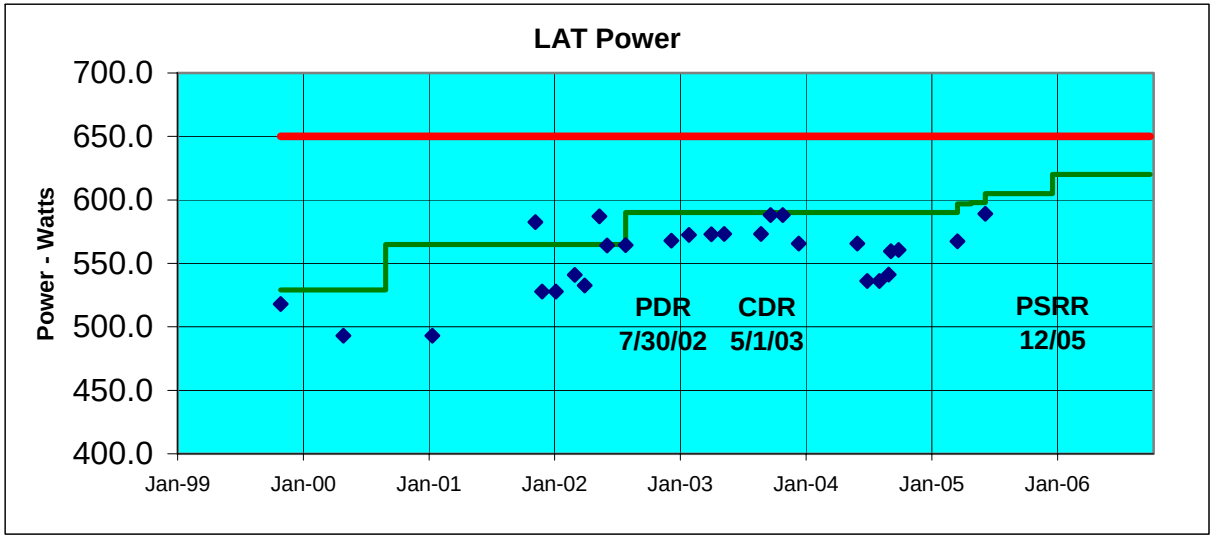
PARA - Best Estimate based on conceptual design parameters
CALC - Estimate based on Calculated power from detailed design documentation
MEAS - Actual power measurements of components

Goals estimated using guidelines given in ANSI/AIAA G-020-1992 "Estimating and Budgeting Weight and Power Contingencies for Space Craft Systems"

- TKR Estimate increase by 11.0 W based on average of measured modules. TKR Spec increased by 7 W.
- CAL Estimate increase by 0.3 W based on average of measured modules.
- T&DF Estimate increase by 10.4 W; 6.9 W due to TPS inefficiencies, 3.5 W due to flight PDU measurement.

PDR Reserve Was 15.2%
CDR Reserve Was 13.4%

Goal for PSRR Reserve > 5%



Measured LAT Power

LAT Tower Power	Unit Current (A)	Unit Power (W)
TWR 0	0.954	26.72
TWR 1	0.954	26.72
TWR 4	0.967	27.08
TWR 5	0.966	27.05
TWR 8	0.967	27.08
TWR 9	0.966	27.05
TWR Total	5.775	161.70
TWR Avg	0.963	26.95
Tower Variance	0.013	0.36

16 Tower Estimate		431.20
Orig 16 Tower Estimate		414.88
Estimated 16 Tower Increase		16.32

- **1. Tower measurements for bays 0,1,4,5,8,9 are consistent and above predicts**
- **2. Measured Tower data indicates a 16.3 W increase in LAT power consumption which is supported by TKR, CAL, TPS unit level data (10.1W + 0.3W + 6.4W = 16.8W).**

TEM/TPS Assembly Power Consumption

Estimate		12.94	Watts
Serial #	Cold	Ambient	Hot
GLAT1754[1]			
GLAT1752	8.97	10.73	10.36
GLAT1753	11.25	11.16	13.35
GLAT1832			
GLAT1833			
GLAT1834			
GLAT1835		9.98	
?			
?			
?			
?			
?			
?			
?			
?			
?			
Average	10.11	10.63	11.86
LAT Estimate	161.69	170.00	189.71

[1] Qualification Unit

Calorimeter Power Consumption

Estimate		4.21	Watts
Serial #	-30	25	50
FM101 [1]	4.48	4.12	3.96
FM102	4.59	4.22	4.06
FM103	4.60	4.24	4.07
FM104	4.59	4.25	4.07
FM105	4.55	4.22	4.02
FM106	4.61	4.21	4.05
FM107	4.53	4.25	3.99
FM108	4.56	4.23	4.05
FM109	4.58	4.23	4.05
FM110	4.61	4.26	4.08
FM111	4.61	4.26	4.08
FM112	4.60	4.25	4.07
FM113	4.62	4.25	4.10
FM114	4.59	4.22	4.06
FM115			
FM116			
FM117			
FM118			
Average	4.58	4.23	4.05
LAT Estimate	73.26	67.69	64.80

[1] Proto Flight Unit

Tracker Module Power Consumption

Estimate	9.18
Serial #	Ambient
A [1]	9.70
B	9.80
1	9.87
2	9.80
3	9.90
4	9.86
5	10.15
6	
7	
8	
9	
10	
11	
12	
13	
14	
Average	9.87
LAT Estimate	157.90

[1] Proto Flight Unit

LAT Power Status (Continued)

- **Survival Power**

Component	Current Alloc.	Subsystem Power Estimates (W)				
		PARA	CALC	MEAS	Total	Margin
On-Orbit Average Power Total[1]	**278.00**	**0.00**	**203.00**	**0.00**	**203.00**	36.90%
Regulated VCHP Power Total	58.00	0.00	43.00	0.00	43.00	34.90%
Unregulated Passive Survival Power	220.00	0.00	160.00	0.00	160.00	37.50%

[1]Power estimates reflect the LAT steady state orbit average. Numbers do not reflect transition into or out of survival mode, i.e. early orbit operations.

FSW Resource Usage Current Estimates

Resource	Total Available	Current Usage	Margin Factor
EPU Boot EEPROM (SUROM)	256 kB	<64 kB*	4*
SIU Boot EEPROM (SUROM)	256 kB	<64 kB*	4*
EPU EEPROM	6 MB	1.5 MB	4
SIU EEPROM	6 MB	1.5-2.5 MB	3
EPU CPU cycles	200% in 2 EPUs	40%	> 5
SIU CPU cycles	100% in 1 SIU	25%	4
EPU memory	128 MB	16-32 MB	4-8
SIU memory	128 MB	< 16 MB	8

* Storing multiple copies (4 currently to use available memory) for risk mitigation

Instrument Bandwidth Resources

• LAT communication, bandwidth (BW) in Mbyte/sec

Resource	Max Total BW limited by Hardware	Max limited by SC-ground transmission	Ave current BW at 10 KHz max trigger rate*	Ave current BW at 2 KHz nominal trigger rate*	Margin Factor (for 10 KHz rate)
Detector to GASU-EBM	45	N/A	10	2	4.5
GASU-EBM to EPU-CPU	20	N/A	5	1	4
EPU-CPU to GASU-EBM	2.5	0.075	0.04*	0.02*	2
GASU-EBM to SIU-CPU	5	0.15	0.08*	0.015*	2
SIU-CPU to Spacecraft	5	0.15	0.08*	0.015*	2

* Present performance of event filter for EPU-CPU, still being optimized. Eventually the physics filter will be adjusted/loosened to take advantage of the max average bandwidh

EBM: Event-Builder Module

EPU: Event-Processing Unit

SIU: Spacecraft Interface Unit

Key Science Performance Metrics

Parameter	SRD Value	Present Design Value
Peak Effective Area (in range 1-10 GeV)	>8000 cm^2	10,000 cm^2 at 10 GeV
Energy Resolution 100 MeV on-axis	<10%	9%
Energy Resolution 10 GeV on-axis	<10%	8%
Energy Resolution 10-300 GeV on-axis	<20%	<15%
Energy Resolution 10-300 GeV off-axis (>60°)	<6%	<4.5%
PSF 68% 100 MeV on-axis	<3.5°	3.37° (front), 4.64° (total)
PSF 68% 10 GeV on-axis	<0.15°	0.086° (front), 0.115° (total)
PSF 95/68 ratio	<3	2.1 front, 2.6 back (100 MeV)
PSF 55°/normal ratio	<1.7	1.6
Field of View	>2sr	2.4 sr
Background rejection (E>100 MeV)	<10% diffuse	6% diffuse (adjustable)
Point Source Sensitivity(>100MeV)	$<6\times10^{-9}$ $cm^{-2}s^{-1}$	3×10^{-9} $cm^{-2}s^{-1}$
Source Location Determination	<0.5 arcmin	<0.4 arcmin (ignoring BACK info)
GRB localization	<10 arcmin	5 arcmin (ignoring BACK info)

Risk Management

Risk Management Activity

- **Added risk of late deliveries delaying location of system integration or performance issues.**

Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 002	Moderate	If ASICs fail to meet qualification requirements; then schedule impact will occur	•Focused review & test. Margin for re-runs protected where possible •Individual risks Identified by subsystem •Extensive use of DAQ test bed to drive out system issues	•Cal/ACD ASIC's continued testing •Test Bed operating •No new issues
Proj Mgt - 004	Moderate	If TEM Power supply fails qualification; then final implementation may exceed schedule impacting delivery to I&T	•Key focus item identified for DAQ • TEM/PS extensive EM use as EGSE	• Implementation plan in place and proceeding •Fuse audit completed **•Data package complete, review in process**

Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE-007	Moderate	If a critical component fails post LAT integration; then de-integration will result in cost & schedule impact	•Extensive use of EM test bed to support flight H/W & S/W development •Thorough qualification and acceptance tests •Pre planned I&T actions for de-integration	•Qual & acceptance planning in-place •I&T developing re-work contingency plans. •Integration plan baselined
Elec-004	Moderate	If target hardware, requirement development or manpower is delayed; Then Flight-Software development schedule will be impacted	•Detailed incremental development program •Ensure sufficient software test on target hardware during development to drive out any requirement disconnects. • Bring packages under CCB control •Define incremental release plan to FQT	•Adapting monthly demos •Tracking EGSE resource utilization •Updated detailed test plan released •All packages in CCB 8 Aug •Completed release 4. Release 6 targeted for FQT

Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
Proj Mgt - 005	Moderate	If parts and vendor orders are delayed or bids exceed expectations; then flight production costs & delivery schedule will be impacted	•Manufacturing engineer added to expedite minimum cost closure •Clarification and purchase package review to ensure accurate bids •Increase production management staff •I&T tracks parts needs	•Purchase order tracking/monitoring system in place to highlight roadblocks •Design documentation release plan prioritized by vendor selection and component fabrication need dates •Parts needs (including long term needs) are addressed weekly during I&T 2 week lookahead meeting. •MCM delivery complete
IT - 006	Moderate	If logistic or facility integration issues are found during LAT environmental test program; then re-work will delay schedule	•LAT I&T to plan a roadmap of activities from LAT building 33 to completion of environmental testing •LAT I&T to consider and develop opportunities to path find key activities required prior to LAT shipment to NRL	•Follow up Environmental Planning TIM held on 1 October at SLAC, I&T driving AIs to conclusion •Continuing periodic TIMS, next is scheduled for 8 Sept.

Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE - 011	Low	If individual tracker towers do not meet performance requirements due to manufacturing issues (e.g. wire bond breaks) then the LAT may not meet science requirements	Understand stability of performance to determine mitigation strategies Limit LAT temperature excursions to minimize possible propagation of some types of tracker issues Optimize placement of towers based on individual tower performance to minimize science effects and to minimize removal and replacement efforts should they become necessary	Temperature range reduced at the LAT level to allow a narrower range during Tracker and LAT tests Alternate plan for placement of Tracker A and B being implemented

Top risks

ID #	Risk Rank	Risk Description	Risk Mitigation	Status
SE - 012	Moderate	If hardware deliveries are delayed (TRK, DAQ) then there will be a delay in finding system integration or performance issues	1-Improve test bed utilization 2-Early integration of ACD, 8 (TBD) towers, EM DAQ hardware, and FSW.	1-Test bed updated to accommodate calibration requirements 2-Plan in place to support early integration checkout starting in October

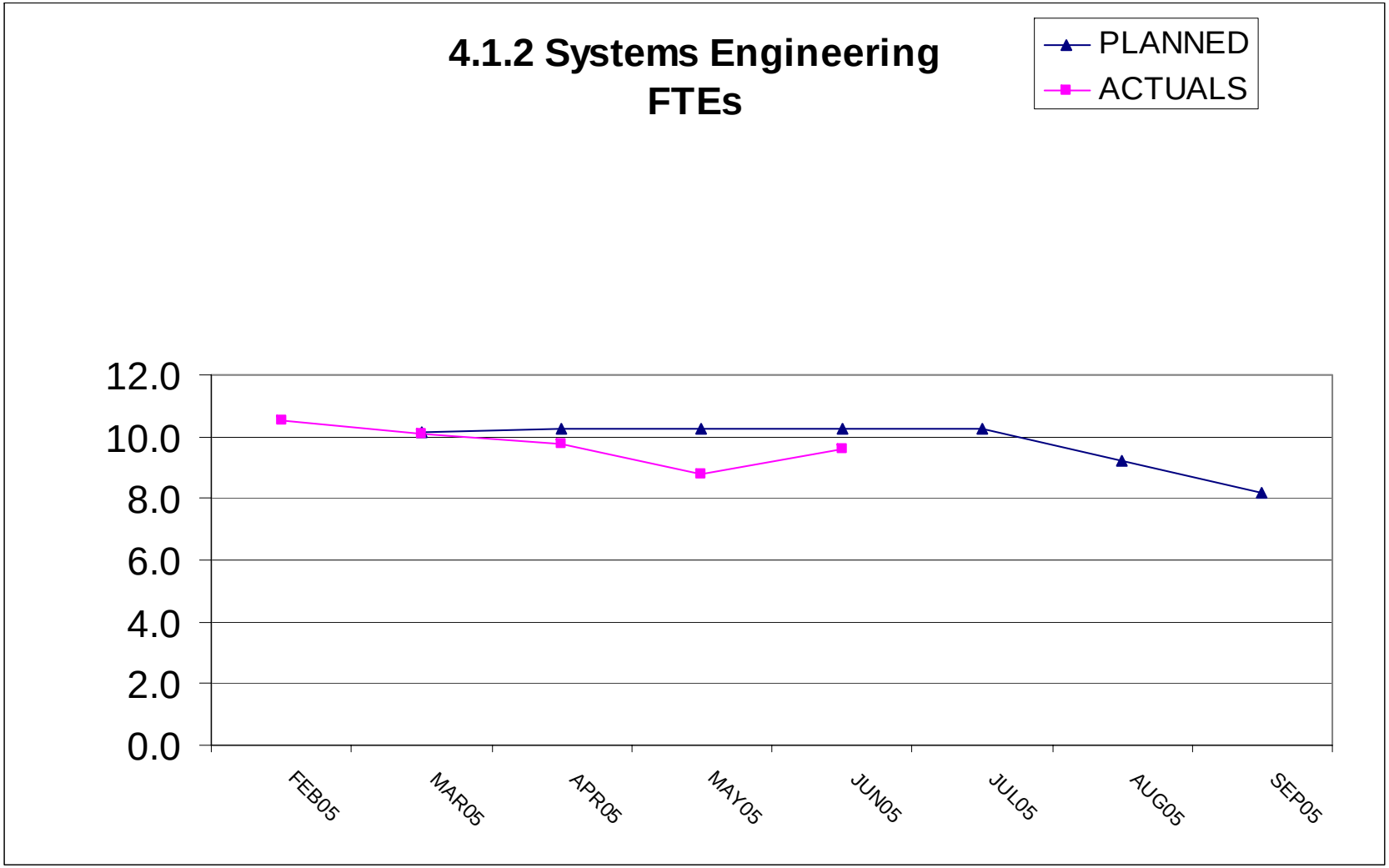
Cost Report

Reporting Category	Cost Incurred				Estimated Cost			Estimated Final Cost		Unfilled Orders
	During Month		Cum. to Date		Detail		Balance of Contract	Contractor Estimate	Contract Value	Outstanding
	Actual	Planned	Actual	Planned	JUL05	AUG05				
4.1.2 SYSTEM ENGINEERING										
4.1.2.1 REQ'TS MGMT, DESIGN INTEGRATION & TEST	37	29	3,144	3,170	26	30	53	3,253	3,253	0
4.1.2.3 SYSTEM ANALYSIS	0	11	1,040	1,002	10	11	-27	1,034	1,034	0
4.1.2.4 QUALIFICATION & TRACKING	109	62	647	510	56	64	-78	689	689	0
4.1.2.5 RISK & RELIABILITY ANALYSIS	0	0	99	98	0	0	-1	98	98	0
4.1.2.6 CONFIGURATION MGMT & DOCUMENT / DATA LIBRARY	5	10	296	294	9	10	7	321	321	0
4.1.2.7 MANAGEMENT & PLANNING	27	52	2,030	2,140	49	38	134	2,252	2,252	0
CAPW[3]Totals:	178	163	7,255	7,214	150	154	88	7,647	7,647	0

Cost Variance Explanation

- Why overrun/underrun?
  - On plan
- What will be done to correct?
  - No correction needed

FTE Report


4.1.2 Systems Engineering
FTEs
PLANNED
ACTUALS
12.0
10.0
8.0
6.0
4.0
2.0
0.0
FEB05
MAR05
APR05
MAY05
JUN05
JUL05
AUG05
SEP05

FTE Variance Explanation

- Why overrun/underrun?
  - On plan
- What is the impact?
  - None
- What will be done to correct?
  - No correction needed