
# 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 |
|---|---|---|---|
| | | | |

# Issues

| No | Description | Status | Due Date | Actionee |
|---|---|---|---|---|
| 22 | ASIC radiation testing Status | Radiation testing scheduled for completion. Request to eliminate TID for 3rd and 4th GTFE run accepted, waiver **pending at Project Office** | 30 April ->June->Jan 05 >March 05>Sept 05 | Sadrozinksi/ Bright |
| 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. Received and forwarded updates from DAQ team. **Tony reviewing Mech updates. ACD updates have been reviewed and passed back to Tony.** | 12/31/04 | DiVenti |
| 37 | SIB EEPROM DPA Failure | Recent DPA passed. **Life test extended to look at low temperature performance of a few of the parts.** | | Haller |
| 40 | LAT-DAQ FPGA development and qualification | SLAC to respond to AIs' from FPGA reviews – AI's in review **4 items left, in work** | | Haller |
| 41 | Qualification of ERNI connectors | Still in work. **Connector by connector review, touch-up and approval proceeding** | | Haller |
| 42 | Power interface impedance requirements not finalized | PRU roadshow demonstrated compatibility, but the requirements were not finalized in the IRD/ICD**. Spectrum has proposed a set of requirements, counterproposal in work.** | | NASA |

# Interface Management

# Interface Document Status

- **SC-LAT ICD ICN Status**
  - **LAT signed this month**
    - **ICN-087 LAT Deliveries Table**
  - **Currently under signature review**
    - None
  - **Currently in draft or revision**
    - **ICN-099 LAT Integration Appendix**
    - **ICN-100 LAT Impedance**
    - **ICN-XXX LAT Heater Isolation Resistance**
    - **LAT-SC ICD Rev D**
- **Internal LAT ICD's**
  - **Signed off this month**
    - **None**
  - **Currently in signature review**
    - **None**
  - **Currently in update**
    - **None**

# Deliverables/Receivables

- **LAT Deliverables**
  - **Nov: None Scheduled**
  - **Dec: None Scheduled**
  - **Jan: ISIS SIU**
  - **Feb: None Scheduled**
- **LAT Receivables**
  - **Nov: SC-LAT Interface Flexure Pins**
  - **Dec: None Scheduled**
  - **Jan: None Scheduled**
  - **Feb: 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 | - | - | - | - | - | 456 | 456 | 100.0% |
| Flow Down Complete | - | - | - | - | - | 453 | 456 | 99.3% |
| Draft Verification Plan | 125 | 91 | 166 | 36 | 35 | 453 | 456 | 99.3% |
| Final Verification Plan | 0 | 0 | 20 | 0 | 35 | 55 | 456 | 12.1% |
| Verification Plan Executed | 0 | 0 | 2 | 0 | 35 | 37 | 456 | 8.1% |
| Requirement Sold | 0 | 0 | 2 | 0 | 35 | 37 | 456 | 8.1% |

- **Progress this month**
  - Continued review of all 456 Draft VPs, many VPs updated
    - 323 Level 2a/2b VPs and 133 Level 3 VPs
    - 309 requirements sold by LAT Level Test
  - Updated reqt allocations to LAT Level Test Cases due to VP review
  - Reqt issues continue to be worked, will cause reqt count to change
  - Adding Pass/Fail criteria for each reqt to VCRM
- **Status**
  - 2 duplicate requirements deleted from the VCRM
  - 42 T&DF requirements added to resolve flowdown issues
  - Verification method counts changed due to the update of the VPs

# Key Design Metrics

# Mass and Power Status Summary

- **Mass**
  - **No change**
- **Power**
  - **LAT Power Consumption Estimate has decreased by 22.2 W**
    - **EPU/SIU measured was lower than worst case predicts**
    - **A margin of 14.3% exists to LAT Power Allocation with 89% of the Estimated Power measured.**
- **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**

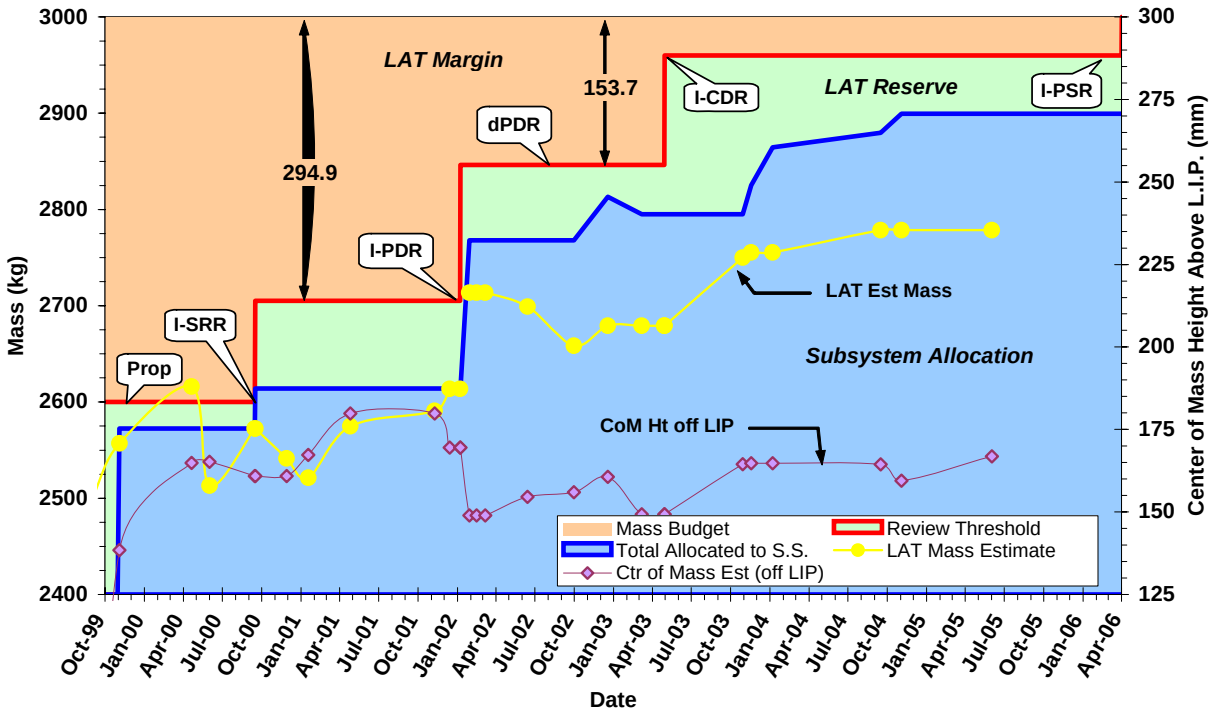
| Mass (kg) | Estimate | Alloc. |
|---|---|---|
| TKR | 523.6 | 530.0 |
| CAL | 1382.3 | 1440.0 |
| ACD | 277.6 | 295.0 |
| Mech | 355.7 | 386.6 |
| Elec | 232.0 | 240.0 |
| Systems | 7.5 | 8.0 |
| **LAT Total** | **2778.7** | **2899.6** |
| Rsrv/Margin | 221.3 | |
| Rsrv/Margin* | 8.0% | |
| Allocation | | 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 decreased by 22.2W.

- ACD Estimate no change.
- TKR Estimate no change.
- CAL Estimate no change.
- T&DF Estimate decrease by 22.2 W due to SIU/EPU measured data.

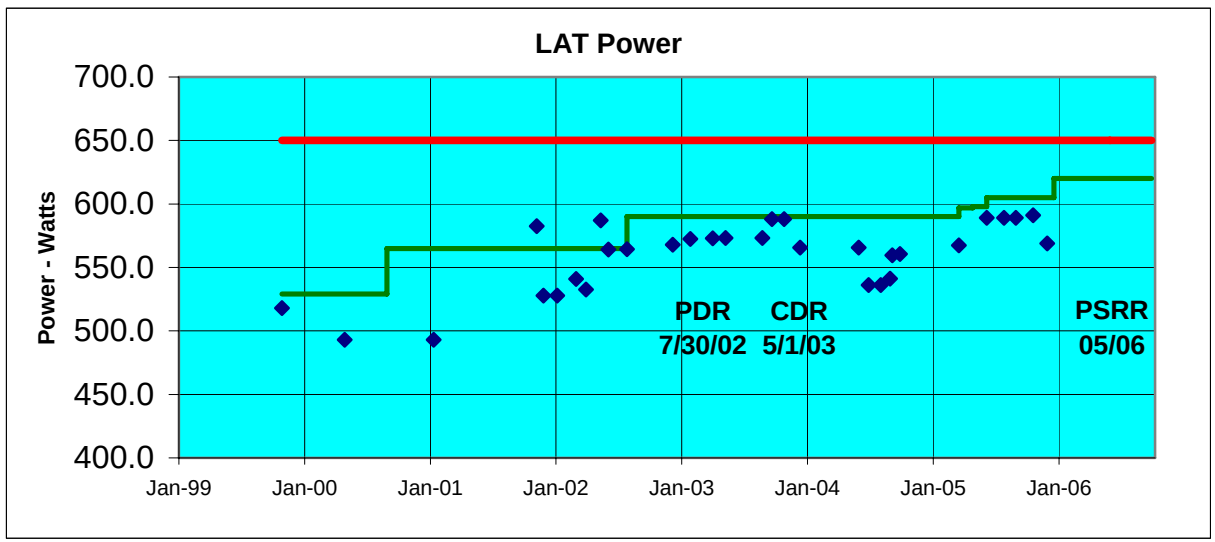
| 1-Dec-05 Item | Estimate (Watts) | PARA (Watts) | CALC (Watts) | MEAS (Watts) | SPEC (Watts) |
|---|---|---|---|---|---|
| ACD | 11.3 | 0.0 | 0.0 | 11.3 | 11.5 |
| Tracker | 159.2 | 0.0 | 0.0 | 159.2 | 160.0 |
| Calorimeter | 67.8 | 0.0 | 0.0 | 67.8 | 71.0 |
| Trigger & Data Flow | 310.2 | 0.4 | 21.0 | 268.7 | 327.5 |
| Grid/thermal | 20.4 | 20.4 | 0.0 | 0.0 | 35.0 |
| Instrument Total | 568.9 | 20.8 | 21.0 | 507.0 | 605.0 |
| Instrument Allocation | 650.0 | | | | |
| % Reserve | 14.3% | | | | |

**PDR Reserve Was 15.2%**
**CDR Reserve Was 13.4%**

**Goal for PSRR Reserve > 5%**

**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"



# 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) | <$6\times10^{-9}$ $cm^{-2}s^{-1}$ | $3\times10^{-9}$ $cm^{-2}s^{-1}$ |
| 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

- No new risks identified
- No risks retired

# 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<br>•Clarification and purchase package review to ensure accurate bids<br>•Increase production management staff<br>•I&T tracks parts needs | •Parts needs (including long term needs) are addressed weekly during I&T 2 week lookahead meeting.<br>•DAQ complete in December |

# 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<br>•Thorough qualification and acceptance tests<br>•Pre planned I&T actions for de-integration | •Qual & acceptance planning in-place<br>•I&T developing re-work contingency plans.<br>•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<br>•Ensure sufficient software test on target hardware during development to drive out any requirement disconnects.<br>• Bring packages under CCB control<br>•Define incremental release plan to FQT | •Adapting monthly demos<br>•Tracking EGSE resource utilization<br>•Updated detailed test plan released<br>•All packages in CCB<br>•Completed release **6**. Release 6 targeted for FQT |

# Top risks

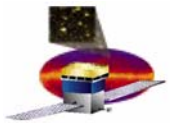
| ID # | Risk Rank | Risk Description | Risk Mitigation | Status |
|---|---|---|---|---|
| Proj Mgt - 008 | Low | If there are availability conflicts with the environmental facilities at NRL then there will be schedule delays | •Bill Rayner participates in NRL planning and is a LAT advocate | •No conflicts with current LAT schedule<br>•**No project that requires the TV chamber is currently scheduled at NRL** |
| 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<br>•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<br>•**NRL contingent to come to LAT during week of Dec 5**<br>•Pathfinder plan defined, **but implementation later than expected** |

# 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<br>Limit LAT temperature excursions to minimize possible propagation of some types of tracker issues<br>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<br>Alternate plan for placement of Tracker A and B being implemented<br>Trending tracker efficiency throughout integration testing |

# 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<br><br>2-Transition to system test using EM hardware as needed | 1-Test bed updated to accommodate calibration requirements<br>**2-Limited risk mitigation achieved through 16 tower testing using EM GASU and PDU. Further mitigation plan aborted to move to flight hardware** |
| SE-013 | Moderate | If Observatory I&T requirements and procedures are not finalized then there will be schedule delays | LAT proposed integration plan appendix to ICD | LAT prepared mechanical integration issues |



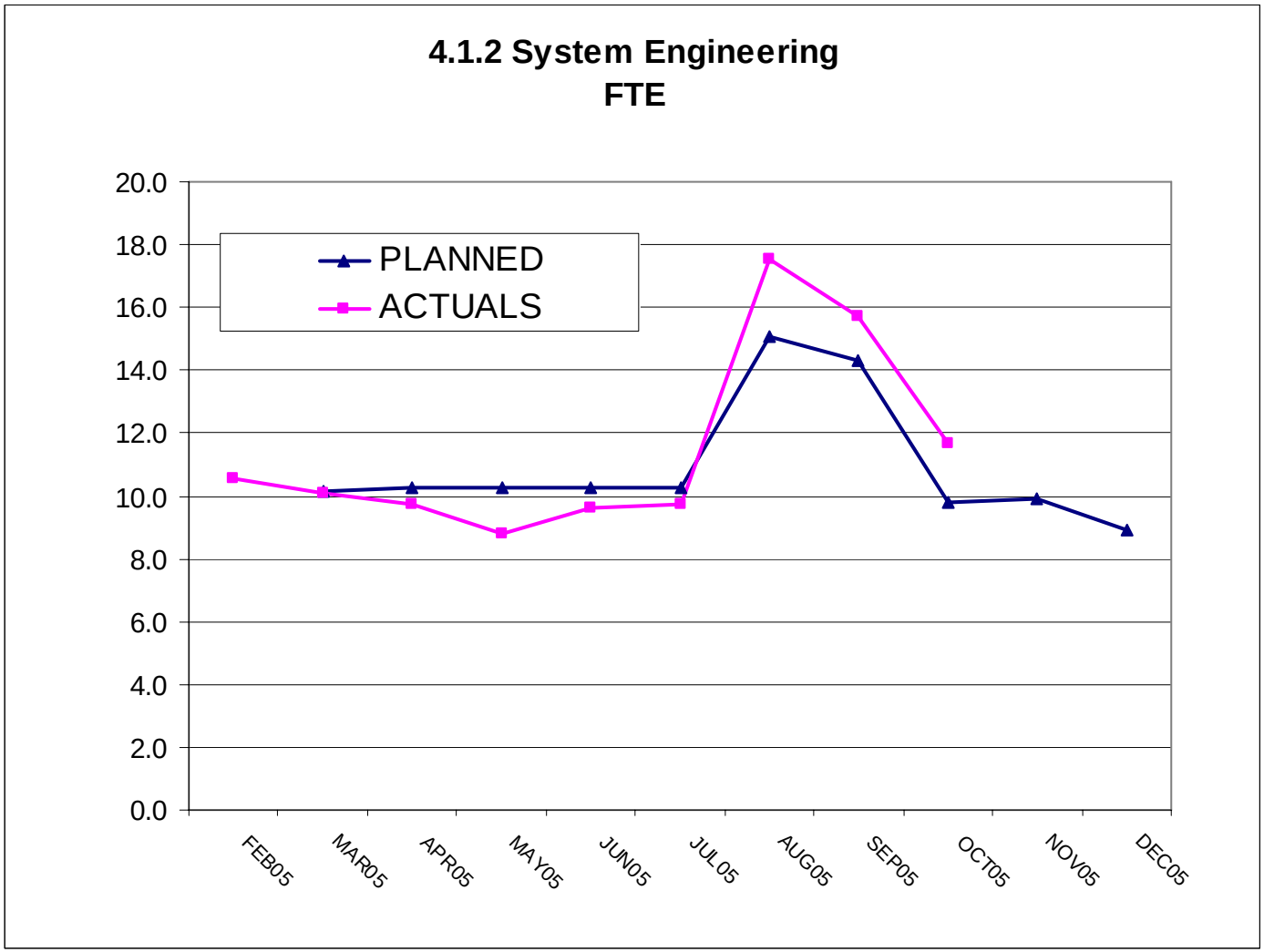
# Cost Report

| Reporting Category | Cost Incurred/Hours Worked | | | | Estimated Cost/Hours to Complete | | | Estimated Final Cost/Hours | | Unfilled Orders Outstanding |
|---|---|---|---|---|---|---|---|---|---|---|
| | During Month | | Cum. to Date | | Detail | | Balance of Contract | Contractor Estimate | Contract Value | |
| | Actual | Planned | Actual | Planned | NOV05 | DEC05 | | | | |
| 4.1.2 SYSTEM ENGINEERING | | | | | | | | | | |
| 4.1.2.1 REQ'TS MGMT, DESIGN INTEGRATION & TEST | 46 | 41 | 3,434 | 3,294 | 42 | 35 | 231 | 3,742 | 3,742 | |
| 4.1.2.3 SYSTEM ANALYSIS | 12 | 0 | 1,336 | 1,337 | 0 | 0 | 1 | 1,337 | 1,337 | |
| 4.1.2.4 QUALIFICATION & TRACKING | 117 | 41 | 745 | 730 | 42 | 35 | 449 | 1,271 | 1,271 | |
| 4.1.2.5 RISK & RELIABILITY ANALYSIS | 0 | 0 | 99 | 98 | 0 | 0 | -1 | 98 | 98 | |
| 4.1.2.6 CONFIGURATION MGMT & DOCUMENT / DATA LIBRARY | 25 | 5 | 337 | 326 | 5 | 4 | 95 | 441 | 441 | |
| 4.1.2.7 MANAGEMENT & PLANNING | 163 | 52 | 2,385 | 2,424 | 53 | 45 | 760 | 3,242 | 3,242 | |
| CAPW[3]Totals: | 363 | 139 | 8,335 | 8,209 | 141 | 120 | 1,534 | 10,131 | 10,131 | |

# Cost Variance Explanation

- **Why overrun/underrun?**
  - **Part is $100K in invoicing that hit the books this month**
- **What will be done to correct?**
  - **CR in work to allocate funding**

# FTE Report


4.1.2 System Engineering
FTE
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
PLANNED
ACTUALS
FEB05
MAR05
APR05
MAY05
JUN05
JUL05
AUG05
SEP05
OCT05
NOV05
DEC05

# FTE Variance Explanation

- **Why overrun/underrun?**
  - **Headcount up due to two people working part time who have not yet transitioned off the Systems numbers**
- **What is the impact?**
  - **No significant impact**
- **What will be done to correct?**
  - **Continuing to transition personnel**