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| nscl.PNG | National Superconducting Cyclotron Laboratory | msu.png |

Project Closure Report

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| --- | --- |
|  |  |
| Project Name | LINAC Emittance Measurement Application |
| Project Code | LEMA |
| Account | 2961-004-EE-002 |
| Department | EE |
| Project Leader | Robert Gaul III |
| Project Coordinator | Vasu Vuppala |

|  |  |  |  |
| --- | --- | --- | --- |
|  | Name | Signature | Date |
| Prepared By | Vasu Vuppala |  |  |
| Reviewed By | Robert Gaul III |  |  |
| Approved By | John Vincent |  |  |

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Version | Date | Author | Description |
| 1.0 | 6/7/10 | Vuppala | Initial |
|  |  |  |  |
|  |  |  |  |
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# Project Closure Summary

## Project Overview

This project resulted in the development of the LINAC Emittance Measurement Application (LEMA). LEMA is essential for the commissioning and operation of ReA3’s LINAC. ReA3 is a new radioactive beam re-accelerator being commissioned for the Coupled Cyclotron Facility (CCF), and will be used in the Facility for Rare Isotope Beams (FRIB). LEMA evaluates the ion beam emittance in the transverse direction at different points along the beam-line. It collects data from slits and beam current monitors using EPICS, analyzes the data, and graphically displays the results to visualize beam emittances. LEMA was developed using C++ and Qt to allow portability, graphics performance, and easier communication with the beam instruments.

## Reason for Project Closure

The project was successfully completed and delivered to the customer.

## Project Highlights

* LEMA is crucial to the commissioning and operation of ReA3
* It was one of the first projects to follow the new project management and software engineering processes developed in the EE department.
* It involved working with the groups (Accelerator R&D and Operations) with different and varying needs

# Project Performance

## Project Snapshot

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Status | Work Order # | Schedule | | Cost/Effort | |  | Closure Date |
| Start | Completion | Estimate | Actual | Week |
| Deadline | [2961-004-EE-002](https://intra.nscl.msu.edu/workorders/workorderDetail.php?workorderID=8715) | 5/28/2010 | 8/30/2010 | 456 | 456 | 0 | 9/24/2010 |

## Earned Value Management (EVM)



Figure EVM - Performance Indices

Figure 1 shows the Cost and Schedule Performance Indices during the project. Refer to the LEMA EVM Report for a comprehensive EVM-based performance analysis. The project stayed ahead of the schedule for most of its duration except at the end.

The project went over the budget during the release of Version 1.0 Alpha due to the extra effort spent on packaging, and being ahead of schedule. It stayed that way till almost the end of the project when it finally ended within budget.

## Reasons for Variances (Schedule and Budget)

The project was delayed by almost a month but was within budget. This was due to the following reasons:

* The hardware for testing the application was not ready. The application had to be finally tested on alternate hardware. While testing it was found that the alternate hardware had problems which had to be fixed.
* The Linux test machine’s package database got corrupted and the OS had to reinstalled
* The duration for Customer Satisfaction Survey (CSS) was not accounted for in the schedule

## Metrics

The various metrics for the project are listed in Table 1.

Table Metrics

|  |  |  |
| --- | --- | --- |
| # | Metric | Results |
| 1 | Budget | Within budget. Budget ; $31,920.00. Final Cost : $ |
| 2 | Schedule | Small slippage. Due : 8/30/2010. Completion: 9/ |
| 3 | Milestones | 4/5. Alpha delayed by a week. Rest on time. |
| 4 | Customer Feedback | Average: 8.40/9.0 |
| 5 | Goals & Objectives | All goals and objectives of the project were met |
| 6 | Quality | Met all the quality requirements |

# Project Analysis

## Lessons Learned

* Packaging on 3 platforms takes considerable effort. Estimate it properly.
* Same with testing on 3 platforms; it takes a decent amount of effort
* Obviously, test environment must not include the development environment. Should be vanilla production environment.
* Do not test the application with personal account. Create clean test account instead.
* Keep design and SRS documents synchronized (backward engineering) after every release
* Real EPICS channels will not work the same way as the dummy channels. Try to have the real ones established as soon as possible.
* Include time for Customer Satisfaction Survey in the project schedule
* Document the build process. Time was wasted to fixing problems that were encountered in previous releases
* Keep the end-user (Operations) involved from the beginning. This helps with user-interface design.
* Customer Satisfaction Survey can take 1-2 weeks. Allow time for it in the schedule.

## Effort Estimates

Table 2 shows the difference in actual and estimated efforts (in Person Hours). The estimated contingency of 38 hours was entirely used.

Table Effort Estimates vs Actuals

|  |  |  |  |
| --- | --- | --- | --- |
| WBS ID | Task Name | Final Estimate | Actual |
|  |
| 1 | LEMA | 418 | 455 |
| 1.1 | Project Management | 38 | 34 |
| 1.1.1 | Initiation | 7 | 5 |
| 1.1.2 | Planning | 7 | 8 |
| 1.1.3 | Execution | 12 | 8 |
| 1.1.4 | Monitor and Control | 7 | 8 |
| 1.1.5 | Closure | 5 | 5 |
| 1.2 | Training | 34 | 42 |
| 1.2.1 | Mathematics | 18 | 18 |
| 1.2.2 | Packaging | 16 | 24 |
| 1.3 | Design | 40 | 40 |
| 1.3.1 | Architecture | 20 | 21 |
| 1.3.2 | Low Level | 20 | 19 |
| 1.4 | Implementation | 246 | 278 |
| 1.4.1 | Hardware Data Collection | 86 | 94 |
| 1.4.1.1 | 45 Degree Slit | 43 | 43 |
| 1.4.1.2 | 2-jaw Slit | 43 | 51 |
| 1.4.2 | GUI | 120 | 116 |
| 1.4.2.1 | UI Skeleton | 20 | 23 |
| 1.4.2.2 | Static Settings | 20 | 20 |
| 1.4.2.3 | Graphing | 80 | 73 |
| 1.4.3 | Release Management | 40 | 68 |
| 1.4.3.1 | Build | 20 | 20 |
| 1.4.3.2 | Package | 20 | 48 |
| 1.5 | Testing | 20 | 26 |
| 1.5.1 | Benchmark Testing | 20 | 26 |
| 1.6 | Documentation | 40 | 35 |
| 1.6.1 | Installation Manual | 20 | 19 |
| 1.6.2 | User Manual | 20 | 16 |

## Project Chronology

* 05/19/10 – Kick-off meeting.
* 05/20/10 – Estimate WO submitted
* 05/21/10 – WO Approved by customer
* 06/01/10 – PPP Submitted. Approved by DH
* 06/02/10 – PPP approved by Customer
* 06/07/10 – PP submitted. Approved by DH.
* 06/08/10 – PP approved by customer
* 07/05/10 – Alpha release delayed (missed milestone) due to packaging problems
* 07/16/10 – Alpha released (a week late)
* 08/30/10 – Tested with alternate hardware. Version 1.0 released for Win and Mac
* 09/13/10 – Version 1.0 released for Linux
* 09/15/10 – Customer Surveys sent out

Check the LEMA Project Status Report for a detailed description of various activities during the course of the project.

## Leftover Tasks

* LEMA Version 1.0 will be tested with the RFQ in a subsequent project
* Several of the changes suggested to improve the user-interface will be incorporated in LEMA Version 2.0 which will be developed as part of another project

# References

1. Quark, The NSCL EE Process Infrastructure, <https://intra.nscl.msu.edu/departments/electronics/quark/quark.php>
2. NSCL ESH Management System, <https://intra.nscl.msu.edu/safety/>
3. LEMA Project Schedule Baseline, MS Project File, Bundle #227, Section LEMA
4. LEMA EVM Report, LEMA-EVM.xlsx in LEMA project directory
5. LEMA Project Status Report, LEMA-PSR.docx in LEMA project directory

# Glossary

|  |  |
| --- | --- |
| Item | Description |
| APG | Accelerator Physics Group |
| DES | Design Engineer |
| DEV | Development Engineer |
| EE | NSCL’s Electronics Department |
| EPICS | Experimental Physics and Industrial Control System |
| ESH | Environment, Safety, and Health |
| EVM | Earned Value Management. A technique for measuring project performance. |
| LEMA | LINAC Emittance Measurement Application |
| LINAC | Linear Accelerator |
| NSCL | National Superconducting Cyclotron Laboratory |
| PL | Project Leader |
| PC | Project Coordinator |
| Quark | EE’s Process Infrastructure Web Portal <https://intra.nscl.msu.edu/departments/electronics/quark/quark.php> |
| RE | Release Engineer |
| ReA3 | The Re-Accelerator Project |
| SME | Subject Matter Expert |
| TE | Test Engineer |
| TW | Technical Writer |
| VE | Value Engineering |
| WBS | Work Breakdown Structure |
| Work Package | Leaf node of a WBS |