Software Requirements Specification for Delay Line Control System

INT-406-TSP-0003

revision 2
draft

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Revision History

Revision	Date	Author	Description
1	2007-04-13	TC	Initial draft.
2	2007-04-24	TC	Revised after input from Cambridge DL software group.

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1. Preface

1.1. Scope

This document provides the Software Requirements Specification for the Magdalena Ridge Observatory Interferometer (MROI) Delay Line Control System.

Software Requirements Specification (SRS) documents capture the user need and contract between the software development team and the customer. The SRS describes functional and non-functional requirements which drive implementation of the software product.

This document follows the guidelines for an SRS described in "MROI Software Project Management Plan" INT-409-xxx.xxx.[1].

1.2. Context

The Delay Line Control System (DLCS) provides the real-time control, monitoring, and data acquisition for the MROI Delay Line (DL) system. The DL system is described in "Requirements Specification for the MROI Delay Line System", INT-406-TSP-0002 [2].

1.3. Intended Audience

The primary audiences for this document are the stakeholders of the DLCS and the software engineering staff of the MROI. It is intended that software developers will base their design on this SRS, and testers will use this document as a reference to verify that the system satisfies requirements.

1.4. Evolution of the SRS

The information in an SRS is intended to be evolving, but varying slowly, across the entire duration of the software project. The SRS achieves greater fidelity as the project progresses and requirements understanding matures. Each revision provides a baseline for software development activities and formally identifies the user needs for the DLCS.

The initial version of the SRS coincides with the development of the Delay Line Top-Level System Requirements. Revisions to this document are anticipated in conjunction with the development of the DL Conceptual Design, DL Preliminary Design, DL Final Design, and Software Change Orders. Revisions are also anticipated in conjunction with the evolution and progression of software development life-cycles, and developmental iterations.

1.5. Document Conventions

Each software requirement in this document is labeled for identification purposes with a unique tag in accordance with guidelines described in "MROI Software Project Management Plan" [1].

1.6. References

[1] "MROI Software Project Management Plan" INT-409-xxx-xxxx.

[2] "Requirements Specification for the MROI Delay Line System", INT-406-TSP-0002.

[3] "Software Glossary for the Interferometer Software Project", INT-409-TSP-XXXX.

1.7. Terms, Acronyms, and Abbreviations

The following terms, acronyms and abbreviations are provided here as an aid to the reader. Additional terms, acronyms, and abbreviations which the reader will find useful to properly interpret this SRS are defined in “Software Glossary for the Interferometer Software Project”[3].

2. System Overview

This section presents a high-level overview of the Delay Line Control System (DLCS).

2.1. System Context

The Delay Line Control System provides the realtime control and data acquisition software for the Delay Line system. This includes all Delay Line subsystems, as well as the Delay Line system as a whole.

2.2. Essential Mission

The essential mission of the MROI DLCS software is to compensate for geometric delay and atmospheric wavefront disturbances in the star light optical path by real-time adjustment of the optical path delay. To accomplish this, the DLCS will position the delay line optics in accordance to baseline offsets, sidereal tracking of star position, and offsets calculated by the group delay Fringe Tracker.

This essential mission is depicted in the Use Case diagram in Illustration 1.

Illustration 1: The Use Case diagram for the Delay Line Control System essential mission.

2.3. Sub-system Summary

To achieve this essential mission, the DLCS software must control the actuation of moving parts belonging to the DL trolley subsystem, control shear disturbances in the light path, accurately measure the position of a delay line trolley cats-eye mirror, calculate demand positions, and apply offsets calculated by the Fringe Tracker.

This section provides a brief summary of each major sub-system and identifies their primary function to provide the reader with background for interpreting the requirements in the sections which follow.

2.3.1. Trolley Subsystem

The primary function of the Trolley Subsystem is to accurately position a cats-eye mirror within the length of the delay line pipes. The accurate positioning is accomplished by a two stage servo. A course control stage provides drive of wheels of the trolley, and a fine control stage drives a voice coil pushing on a mirror assembly.

Secondary functions are to provide control of trolley roll and to adjust tip-tilt of the cats-eye secondary mirror for compensation of beam shear.

2.3.2. Metrology Subsystem

The primary function of the Metrology Subsystem is to accurately measure the position of the trolley optics, and send corrections to the trolley subsystem.

2.3.3. Shear Subsystem

The primary function of the Shear Subsystem to measure the position of the out-coming beam light, and send corrections to the tip-tilt of the cats-eye secondary.

2.3.4. System Controller

The primary function of the System Controller is to generate tracking demands for the delay line, and provide a command interface to the DLCS from the Interferometer Control System.

3. User Expectations

3.1. User Classes and Characteristics

This section describes the general characteristics of the intended users.

3.1.1. PI Astronomer

The PI Astronomer user class is primarily interested in knowing that the delay line was performing correctly during the acquisition of science data. The performance metrics of interest are the OPD error and the OPD jitter, both as a function of time.

3.1.2. Staff Operator

The Staff Operator user class is primarily interested in operating the delay line at a simple interactive level requiring a minimum of expertise and skills relying on the system automation along with routine judgments based on simple metrics.

3.1.3. Staff Interferometrist

The Staff Interferometrist is primarily interested in detailed operation of the delay line and optimizing system performance using a high degree of expertise and skill to monitor and tune system parameters, configure safety operating ranges, setup and align components after significant reconfiguration and relocation, diagnose system failures, and override system faults with degraded operating modes.

3.1.4. Staff Engineer

The Staff Engineer is interested in very low level control and monitoring of every delay line system parameter along with history, including hardware reconfiguration, troubleshooting, and override of all operating ranges and lockouts.

3.1.5. Staff Expert

The Staff Expert user class is primarily interested in remote monitoring of operations and system performance via a low bandwidth connection with the option of taking control in appropriate situations.

3.2. Critical Use Cases

TBD

3.3. Primary Operating Scenarios

TBD

4. Major Features (FE)

This document section specifies the major features of the DLCS. This section is organized by delay line subsystem. However this organization does not intent to imply that features are restricted to a particular subsystem. Features may involve the interaction of multiple sub-systems.

4.1. Trolley Subsystem

4.06.05-FE-007 Trolley Mechanical Datum Feature.

Description: The DLCS shall execute a command which drives the Trolley to a mechanical fiducial sensor and detects the position of this datum to a precision of better than 10-um.

Priority: high.

4.06.05-FE-008 OPD Precision Feature.

Description: The DLCS shall be able to introduce any commanded OPD change within its stroke with an intra-night repeatability of better than 10 um rms, and a night-to-night repeatability of better than 100 um rms.

Priority: high.

4.06.05-FE-009 Slew Speed Feature.

Description: The DLCS shall be able to execute a Trolley slew from any position in the available stroke to any other position in less than 5 minutes. The DLCS shall be able to execute a Trolley slew between any two points within its available stroke, corresponding to a change in OPD of up to 30 meters (15 meters physical motion) in less than 30 seconds, including the time taken to accelerate and decelerate to/from sidereal tracking speeds.

Priority: high.

4.06.05-FE-010 Sidereal Tracking Stability Feature.

Description: The DLCS shall be able to execute Trolley sidereal tracking, introducing a smoothly changing OPD trajectory with speeds of up to 30 mm/s (15 mm/s physical motion) and accelerations of up to 2.5 um/s2. Jitter shall be less than lambda/20 in 2t0. Therefore, the OPD shall follow the commanded trajectory with a jitter of less than 15 nm rms as measured over any 10 ms integration period, a jitter of less than 41 nm rms over any 35 ms integration period, and a jitter of less than 55 nm rms over any 50 ms integration period. It shall be acceptable to acceptable to exceed these jitter limits for a total of 0.5 seconds during any 60 second tracking interval.

Priority: high.

4.2. Metrology Subsystem

4.06.05-FE-001 Metrology Position Correction Feature.

Description: The DLCS shall compute the position corrections from the Metrology readout, and send these to the Trolley cats-eye voice coil actuator. The loop frequency shall be TBD Hz. The latency from readout to correction shall be less than TBD usec. The jitter shall be less than TBD usec.

Priority: high.

Stimulus: Timing Reference System

Input: Trolley trajectory demands and actual Trolley position readout from Metrology.

Processing: Computer position error.

Output: Corrections sent to trolley cats-eye voice coil actuator.

4.06.05-FE-002 Fringe Tracker Position Correction Feature.

Description: The DLCS shall accept an external offset demand signal from the group delay Fringe Tracker, and include these in the Metrology position correction loop. The Fringe Tracker correction loop frequency shall be at least 15 Hz, and have a step response time (command to 90% response) of less than 30 ms for step sizes of up to 10 um. It is a goal that the DLCS should respond to offset demands with sampling rates of up to 200 Hz with a step response time of less than 2 ms for step sizes of up to 0.5 um. The latency from Fringe Tracker readout to correction shall be less than 1 msec. The jitter shall be less than TBD usec.

Priority: high.

Input: Fringe Tracker position offset demands.

Processing: Add position correction to Metrology position error.

Output: Corrections sent to trolley cats-eye voice coil actuator.

4.3. Shear Subsystem

4.06.05-FE-004 Shear Tip-Tilt Position Correction Feature.

Description: The DLCS shall measure pupil shear via the shear camera, and send tip-tilt position corrections to the Trolley cats-eye secondary mirror actuators. The loop frequency shall be 30 Hz. A moving average filter shall be applied, and corrections shall be sent at rate of 10 Hz. The latency from readout to correction shall be less than 10 msec. The jitter shall be less than TBD msec. Closed loop bandwidth shall be 1 Hz.

Priority: high.

Input: Shear camera image.

Processing: Compute tip-tilt position error from moving average centroid position and desired fiducial position.

Output: Corrections to the Trolley cats-eye secondary mirror actuator.

4.06.05-FE-011 Pupil Shear Correction Criterion Feature.

Description: The DLCS shall correct the pupil shear position leaving no more than 1 mm rms variation in the position of the center of the starlight exit beam compared to a reference position, provided the input starlight beam has been aligned with the mean direction of the delay line travel. It shall be permitted to exceed this shear criterion when the delay line is slewing as long as the delay line trolley metrology signal is not lost.

4.06.05-FE-012 Mean Direction Coarse Measurement Feature.

Description: The DLCS shall execute an alignment procedure covering the travel stroke of the trolley, measuring the shear position at 10cm intervals while moving over a range of constant velocities between tracking speed and slew speed. The measurements shall be completed in 10 minutes.

4.06.05-FE-013 Mean Direction Fine Measurement Feature.

Description: The DLCS shall execute an alignment procedure covering the travel stroke of the trolley, measuring the shear position at 10cm intervals, while moving at tracking speed during measurements and slewing at a faster speed between measurements. The measurements shall be completed in 20 minutes.

4.4. System Controller

4.06.05-FE-013 Trajectory Commanding Feature.

Description: The DLCS shall

4.06.05-FE-014 Coherencing Mode Feature.

Description: The DLCS shall

4.06.05-FE-015 Cophasing Mode Feature.

Description: The DLCS shall

4.5. Automation

4.06.05-FE-006 Automated Sequencing and Operation Feature.

Description: The DLCS shall provide a control architecture for highly automated sequencing and operation. **TBD This requirement lacks objective measure**. ?Unattended overnight operations except for fault conditions?

4.06.05-FE-016 Find Fringes Feature.

Description: The DLCS shall TBD.

4.06.05-FE-017 Respond to Change of Trajectory Feature.

Description: The DLCS shall follow demanded trajectory at tracking speed and then respond to a change of trajectory by slewing to the new trajectory and then return to tracking speed.

4.6. Diagnostics

4.06.05-FE-005 Remote Diagnostic Architecture Feature.

Description: The DLCS shall have a control architecture that allows for remote diagnostic testing of all DL hardware.

4.06.05-FE-018 Calibration of OPD Feature.

Description: The DLCS shall TBD.

5. Computations and Algorithms

The DLCS software is required to perform computations and algorithms.

5.1.1. Computations

4.06.05-FE-014 Trajectory Computation.

Description: The DLCS shall TBD.

5.1.2. Algorithms

4.06.05-FE-015 Blind Search Spiral Search Algorithm.

Description: The DLCS shall

6. Hardware Interfaces (HI)

This section provides requirements for hardware interfaces. This section is organized by delay line subsystem.

6.1. Trolley Subsystem

4.06.05-HI-001 Drive Wheel Hardware Interface

Description: The DLCS shall interface with the Delta Tau PMAC2A motion controller (P/N PMAC2A-PC104 + Opt2A + Opt12).

4.06.05-HI-007 Tilt Sensor Hardware Interface

Description: The DLCS shall interface with the tilt sensor (P/N SCA111TD02).

4.06.05-HI-008 Cats Eye Differential Sensor Hardware Interface

Description: The DLCS shall interface with the cats eye differential sensor (P/N Micro-epsilon U15

+ DT3010A signal conditioner).

4.06.05-HI-009 Secondary Tip-Tilt Piezo Hardware Interface

Description: The DLCS shall interface with the secondary tip-tilt piezo (P/N PiezoJena PSH 10/2).

4.06.05-HI-010 Secondary Focus Drive Hardware Interface

Description: The DLCS shall interface with the secondary focus drive (P/N 8301 Picomotor actuator plus 8703 drive module).

4.06.05-HI-011 Accelerometer Hardware Interface

Description: The DLCS shall interface with the accelerometer (P/N Analog Devices ADXL103/203).

4.06.05-HI-012 ADC Hardware Interface

Description: The DLCS shall interface with the Analog to Digital Converter (P/N Diamond Systems: Diamond-MM-48-AT HE104-HV).

4.06.05-HI-015 Trolley Subsystem CPU Hardware Interface

Description: The DLCS shall provide a CPU hardware interface for the operations on Arcom PC-104 bus single board computer (P/N Arcom Viper).

6.2. Metrology Subsystem

4.06.05-HI-002 Metrology Hardware Interface

Description: The DLCS shall interface with the Zigo measurement board via a VMEbus adapter card (P/N ZMI4002).

4.06.05-HI-004 Timing Reference Hardware Interface

Description: The DLCS shall interface with the Symmetricom Time Reference Module via a VMEbus adapter card (P/N TTM635VME).

4.06.05-HI-005 Trolley Voice Coil Drive Hardware Interface

Description: The DLCS shall provide a hardware interface for the cat's-eye voice coil drive (P/N ACAL Technology TVME 200-10 and IP220A-8).

4.06.05-HI-014 Metrology Subsystem CPU Hardware Interface

Description: The DLCS shall provide a CPU hardware interface for the operations on Concurrent Technologies VMEbus single board computer (P/N VP325/022-23U Concurrent Technologies).

6.3. Shear Subsystem

4.06.05-HI-003 Shear Camera Hardware Interface

Description: The DLCS shall interface with the Unibrain Fire-i B/W digital board camera (P/N TBD) via Firewire via a built-in Firewire interface compatible with TBD or a TBD MANUF Firewire (P/N TBD) PCI adapter card.

4.06.05-HI-013 Shear Subsystem CPU Hardware Interface

Description: The DLCS shall provide a CPU hardware interfaces for operations on Arcom Apollo 1U rack-mount computer (P/N Arcom Apollo).

6.4. System Controller

4.06.05-HI-006 Timing Reference Hardware Interface

Description: The DLCS shall interface with the Symmetricom Time Reference Module via a PCIbus adapter card (P/N TBD).

6.5. Diagnostics

TBD: Diagnostic components, cameras, shutters?

7. User Interfaces (UI)

The DLCS software is required to provide user interfaces to interact with the Delay Line system. This section provides and overview of each interface between the software product and its users.

7.1. Trolley Subsystem

4.06.05-UI-001 Trolley Performance User Interface

Description: The DLCS shall provide a user interface for displaying trolley performance.

4.06.05-UI-005 Trolley Position User Interface

Description: The DLCS shall provide a user interface for displaying trolley position.

4.06.05-UI-006 Trajectory Display User Interface

Description: The DLCS shall provide a user interface for displaying demanded trajectory, and trajectory error as a function of time.

7.2. Metrology Subsystem

4.06.05-UI-003 Metrology Performance User Interface

Description: The DLCS shall provide a user interface for displaying metrology closed loop performance, including OPD error and OPD jitter.

7.3. Shear Subsystem

4.06.05-UI-002 Shear Tip-Tilt Performance User Interface

Description: The DLCS shall provide a user interface for displaying shear camera images, and shear performance including tip-tilt error and SNR confidence values.

7.4. System Controller

4.06.05-UI-004 System Controller Command User Interface

Description: The DLCS shall provide a user interface for providing commands to the System Controller.

4.06.05-UI-008 System Controller State and Performance User Interface

Description: The DLCS shall provide a user interface for providing system controller monitoring, including mode, state, OPD error, and OPD jitter.

7.5. Diagnostics

4.06.05-UI-007 Telemetry History Graph User Interface

Description: The DLCS shall provide a user interface which provides telemetry history covering a period of 1-5 minutes in the form of a moving graph.

4.06.05-UI-009 Telemetry Moving Averages User Interface

Description: The DLCS shall provide a user interface which displays moving averages of control loop errors.

8. Communications Interfaces (CI)

The DLCS software is required to communicate with internal and external computing systems. This section provides and overview of the DLCS software communications interfaces.

8.1. Trolley Subsystem

4.06.05-CI-001 Trolley Subsystem Telemetry Communications Interface

Description: The DLCS shall provide a communications interface for trolley subsystem telemetry.

8.2. Metrology Subsystem

4.06.05-CI-002 Metrology Subsystem Telemetry Communications Interface

Description: The DLCS shall provide a communications interface for Metrology Subsystem telemetry.

4.06.05-CI-003 Fringe Tracker Offset Demand Communications Interface

Description: The DLCS shall provide a communications interface for the fringe tracker offset demand.

8.3. Shear Subsystem

4.06.05-CI-004Shear Subsystem Telemetry Communications Interface

Description: The DLCS shall provide a communications interface for shear subsystem telemetry.

4.06.05-CI-005 Tip-Tilt Correction Demand Communications Interface

Description: The DLCS shall provide a communications interface for sending tip-tilt correction demands to the cat's-eye secondary.

8.4. System Controller

4.06.05-CI-006 System Controller Telemetry Communications Interface

Description: The DLCS shall provide a communications interface for system controller telemetry.

4.06.05-CI-007 ICS Supervisory System Command Communications Interface

Description: The DLCS shall provide a communications interface for responding to system commands from other ICS systems.

8.5. Archiving System

4.06.05-CI-001 Trolley Telemetry Communications Interface

Description: The DLCS shall provide a user interface which displays moving averages of control loop errors.

9. Nonfunctional Requirements

Specify static and dynamic numerical requirements placed on the software or on human interaction with the software.

Static numerical requirements may include the number of terminals to be supported, the number of simultaneous users to be supported, and the amount and type of information to be handled.

Dynamic numerical requirements may include the number of transactions and tasks and the amount of data to be processed within certain time period for both normal and peak workload conditions.

9.1. Operating Environment (OE)

4.06.05-OE-001 Cambridge Test Rig Operating Environment

Description: The DLCS shall be capable of limited operation at the Cambridge Test Rig for the purposes of conducting integration testing and Factory Acceptance Tests.

4.06.05-OE-002 R&ED Test Stand Operating Environment

Description: The DLCS shall be capable of demonstrating operation at the R&ED Test Stand for purposes of conducting assembly and integration testing, and Campus Acceptance Tests.

4.06.05-OE-003 Beam Combining Facility Operating Environment

Description: The DLCS shall be capable of full operation at the Beam Combining Facility.

4.06.05-OE-004 DLA Temperature Operating Environment

Description: The DLCS shall be operational and meet all performance requirements within the DLA building maintained at temperatures between -10C and 25C (14F and 77F). The DLCS shall be capable of surviving DLA building temperatures from -30C to 32C (-20F to 90F) without damage. The DLCS shall be capable to survive DLA building relative humidity up to 90% without running the risk of condensation.

9.2. Performance Requirements (PR)

There are no performance requirements identified.

9.3. Safety Requirements (SF)

There are no safety requirements identified.

9.4. Software Quality Attributes (QA)

There are no software quality requirements identified.

9.5. Operations (OP)

9.5.1. Administration

9.5.2. Maintenance

9.5.3. Installation

9.5.4. Configuration

9.5.5. Startup and Shutdown

9.5.6. Recovery

9.5.7. Fault Tolerance

9.5.8. Logging

9.5.9. Monitoring Operations

9.6. System Attributes (SA)

The following items provide a partial list of system attributes that can serve as requirements that should be objectively verified.

9.6.1. Reliability

4.06.05-SA-002 Reliability

Description: The DLCS shall be designed with high reliability and fault tolerance. **TBD this requirement needs measurable quantization.**

9.6.2. Availability

4.06.05-SA-003 Availability

Description: The DLCS shall be expected to be in continuous use, and unplanned periods of unavailability shall be less then 10%.

9.6.3. Security

9.6.4. Maintainability

4.06.05-SA-001 Preventative Maintenance Regime

Description: The DLCS shall accommodate a preventative maintenance regime that is undertaken no more frequently than once per 2 years. **TBD This requirement cannot be met with computers?**

4.06.05-SA-004 Preventative Maintenance Regime

Description: The DLCS shall be implemented to accommodate a hardware preventative maintenance regime that is undertaken no more frequently than once per 2 years.

9.6.5. Portability

9.6.6. Scalability

9.6.7. Portability

9.6.8. Robustness

9.6.9. Recoverability

10. Data Dictionary (DD)

10.1. Trolley Subsystem

10.2. Metrology Subsystem

10.3. Shear Subsystem

10.4. System Controller

A	B	Name/Purpose	Unit	Range	Resol.	Accur.	Measure	Rate
1	1							
2	2							
3	3							
4	4							

11. Database Requirements

11.1. Engineering Archive

TBD

11.2. Science Archive

TBD

12. Other Requirements

12.1. Design and Implementation Constraints (CO)

Specify requirements imposed by standards, hardware limitations, etc.

4.06.05-CO-002 JPL RTC Design Constraint

Description: The DLCS software must utilize the Jet Propulsion Laboratory (JPL) Real-Time Control (RTC) framework. RTC is a toolkit for developing real-time control applications, such as interferometer control systems. Communications Interfaces shall be provided by Jet Propulsion Laboratory (JPL) Real-Time Control (RTC) framework. Communications include special inter-process communications (IPC), standard Ethernet network commanding and responses, and telemetry, status and event messaging handling.

4.06.05-CO-001 Cambridge Prototype Software Implementation Constraint

Description: The DLCS software shall be capable of interfacing with the Cambridge Prototype Software during the initial phases of software development. This requirement shall be phased out as capability is ported to the JPL RTC framework and this compatibility requirement is deprecated and removed.

4.06.05-CO-003 DLA Power Dissipation Implementation Constraint

Description: The Trolley control electronics for a set of ten delay lines shall dissipate no more than 10 x 200 W (2kWatts) in total within the DLA.

4.06.05-CO-004 BCA Power Dissipation Implementation Constraint

Description: Effort shall be taken to minimize the power dissipated by the by the DLCS and any of its associated electronics located within the BCA.

12.2. Assumptions and Dependencies (AS, DE)

List factors that affect the requirements. These factors are not design constraints, but areas where future changes might drive change in the requirements.

12.3. Business Rules (BR)

TBD.

13. Issues List

This section is a dynamic list of the open requirements issues that remain to be resolved. The issues here include items flagged as TDB, pending decision, information that is needed, conflicts awaiting resolution, and the like.