MRO Delay Line

Verification plan for the MROI production delay line software

INT-406-VEN-1009

The Cambridge Delay Line Team

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Change Record

Revision	Date	Author(s)	Changes
0.1	2010-01-25	JSY	First draft.

Objective

This document defines the acceptance testing to be undertaken for the production delay line software.

Scope

This document outlines a comprehensive suite of tests intended to show that the requirements for the production delay line software [RD1] are met. These tests aim to demonstrate that the design and implementation of the software is adequate for meeting the requirements of trolley acceptance testing, PVM testing, and astronomical observations with MROI.

This version of the document concentrates on explaining our general approach to acceptance testing of the software. A subsequent revision will address the detailed correspondence between the tests and the requirements; this will be provided for the FDR.

Reference Documents

RD1 Requirement Specifications for the MROI "production" delay line software INT-406- CON-0101

RD2 MROI Delay Line Derived Requirements INT-406-VEN-0107

RD3 Delay Line Production Software Development: Statement of Work Draft 03 – March 25th 2009

Applicable Documents

AD1 List of (trolley acceptance) tests INT-406-VEN-0108

Acronyms and Abbreviations

AIV Assembly, Integration and Verification

DL Delay Line

FDR Final Design Review

FT Fringe Tracker

ISS Interferometer Supervisory System

MRAO Mullard Radio Astronomy Observatory

MROI Magdalena Ridge Observatory Interferometer

NMT New Mexico Tech

OPD Optical Path Delay

PVM Performance Verification Milestone

TBC To Be Confirmed

TBD To Be Determined

Table of Contents

1 Introduction

The test lists presented here are designed to show that the top level software requirements [RD1] and the derived requirements for the delay line [RD2], where applicable to the control software, are met and that the performance of the system is maintained over representative observing periods. The system tests are mostly a subset of those used for trolley acceptance testing [AD1], but specific tests of the interfaces to the ISS and FT are also defined.

All tests may be conducted either at atmospheric pressure or in vacuum, whichever is most convenient at the time. Tests of the prototype trolley have shown that there is no appreciable difference in performance between atmosphere and vacuum.

The schedule from the Statement of Work [RD3] is reproduced in Figure 1. This shows three software releases, the last two of which are preceded by acceptance tests (factory and site acceptance tests prior to Release 1 of the software, and on-sky tests prior to Release 2). We plan additional tests, not shown in the schedule, prior to the first software release (see Sec. 2). All of these testing phases are outlined in subsequent sections.

Each testing phase will involve several categories of test. These categories are explained in the following subsections.

1.1 System Tests

These tests demonstrate the performance of the delay line system when controlled by the production control software.

To avoid any dependence on ISS software that may not be completed in time, these tests will **initially** be performed in standalone mode using the engineering control GUI that will be delivered as part of the production software. System performance will be verified by recording telemetry using the engineering control GUI and plotting/analysing the recorded data using the supplied analysis GUI. This will have the side-effect of testing most of the analysis GUI functionality, but we plan additional tests of the GUI to verify its behaviour in a wider range of scenarios (Sec. 1.2).

Once all of the ISS software for commanding the delay lines is ready, including an operator interface, the system tests should be performed under ISS control. This will be the first opportunity for a complete test of the system bootstrap process. The engineering control GUI will still be needed to record data in a format that can be read by the analysis GUI.

Open Issue: will NMT be ready for ISS control (supervised mode) at SATs? At OATs?

The system tests will exercise all of the system commands that can be sent by either the engineering control GUI or the ISS, and will generally cover the allowed range of parameter values for each command. A preliminary list of system tests is given in Sec. 6 .

Months after contract start	Milestone	Functionalities & dependencies	Timeline assuming start date of 1 April 2009
½	Requirements review		15 Apr 2009
1	NMT delivers RTC API and documentation	Requires Cambridge access to RTC	1 May 2009
6	Preliminary design review		1 Oct 2009
12	Final design review		1 Apr 2010
15	Release of VME metrology software		1 Jul 2010
17	Factory acceptance tests start		1 Sep 2010
18	Site acceptance tests start	Requires first delay line	1 Oct 2010
20	Release of code and documentation (Release 1)	Suitable to meet needs of PVM3	1 Dec 2010
22	On-sky acceptance tests start	Requires two delay lines	1 Feb 2011
23	Release of code and documentation (Release 2)	Suitable to meet needs of PVM4-PVM13	1 Mar 2011
23	End of contract		31 Mar 2011

Figure 1: Schedule for the production delay line software, reproduced from the agreed Statement of Work [RD3]

1.2 Tests of Analysis GUI

A set of tests for the analysis GUI will be defined, comprising:

> **Analysis GUI Functionality Tests**: verify that all the controls and displays perform their intended functions
>
> **Analysis GUI Robustness Tests**: verify that the GUI behaves sensibly for various types of log file content, e.g. missing subsystems, multiple recordings per file

1.3 Tests of Command Interface to ISS

The interface that accepts system commands from the ISS will be tested using a code stub supplied by NMT that connects to the workstation and transmits a specified system command with pre-defined parameter values. The purpose of the test is to verify that (a) each of the defined system commands is received with its parameters decoded correctly, and that (b) the DL control software acts on the command and sends the appropriate response to the ISS stub. For asynchronous commands, we will test that the command completes successfully and transmits the result to the ISS. These tests will use only one set of valid parameter values per command — the full command parameter space will be tested as part of the system tests outlined above.

Commanding of multiple delay lines will be tested by operating the prototype delay line in conjunction with a number of emulated delay lines.

1.4 Tests of Monitoring Interface to ISS

An NMT-supplied stub will be used to configure and receive monitor data from the delay line systems. This will verify that the appropriate data is sent and is formatted correctly. All of the defined monitor points will be tested.

1.5 Tests of Interface to FT

The primary objective of these tests is to verify that offset demands transmitted by the Fringe Tracker at any of the allowed rates will be received and applied by the DL metrology subsystem within the required latency. The latency for position feedback from the metrology subsystem to the FT will also be measured as part of the test.

A separate test will be carried out to verify that search patterns commanded by the FT are executed correctly.

The Cavendish team are willing to write test code running under Xenomai real-time Linux that mimics the FT for the purpose of conducting these tests.

Open Issue: Should Cambridge or NMT write the test code for transmitting fringe tracking offsets and search pattern commands to the metrology subsystem?

1.6 Unit Tests of Sidereal Trajectories

The trajectory calculator module will be tested by comparing generated sidereal trajectories with the equivalent trajectories calculated by the existing COAST delay line control software, which has been used successfully on-sky.

2 Initial metrology software Factory Acceptance Tests

The planned early release of the metrology software on 1 July 2010 (Figure 1) was intended to match NMT's original schedule for procuring a second delay line (since the prototype metrology software delivered with the first trolley can only handle one delay line). The second delay line will now be installed much later. Nevertheless, we still intend to deliver an initial version of the production metrology software by July 2010, and propose to perform a limited set of factory tests (TBD) before handing over this software. If our schedule permits we will use the production metrology software for factory acceptance testing of the first production trolley, avoiding the need for separate testing of the software.

A more comprehensive set of tests will be performed as part of the FATs and SATs associated with Release 1 of the full software package.

3 Factory Acceptance Tests

These tests will be performed prior to the Site Acceptance Tests and Release 1 of the software package. The tests will utilise the prototype trolley and the 25m-long test rig at MRAO.

The FATs will comprise all of the categories of test defined in Sec. 1 . System tests will be performed in standalone mode.

4 Site Acceptance Tests

The Site Acceptance Tests (SATs) will be performed at MROI using the first production trolley. These tests will be followed by a code release that addresses any issues identified during the tests.

The DL arrangements at MROI will be slightly different to those in the Cambridge test rig (longer length, the trolley can be completely the other side of the datum switch), hence the parameter ranges used for the system tests will be altered accordingly.

We expect that the system tests will be performed in standalone mode, although supervised mode would be preferable. If supervised mode is not available we will repeat the separate tests of the ISS and FT interfaces.

5 On-sky Acceptance Tests

On-sky Acceptance Tests (OATs) can take place once **all** of the MROI systems needed for first fringes have been installed and commissioned, including two delay lines. We define this testing phase to include observations of starlight fringes in the Fringe Tracker, since that is the only definitive test of the sidereal trajectories. This will also allow a thorough test of the baseline solution software. These tests do not constitute PVM4 although some tasks are common to both milestones. The OATs will be followed by a second code release that addresses any issues encountered during the tests.

The AIV plan for the delay lines includes on-sky tests, and the contract for the 2nd trolley may specify such tests. NMT should consider whether to merge on-sky tests of the second trolley with on-sky tests of the delay line software.

A modified set of system tests will be used to test all aspects of delay line performance when operating two DLs simultaneously. Sidereal trajectories will be tested by finding starlight fringes and measuring how they drift in delay space over time. Fringe tracking is not required. The FT may be used to command the delay lines to execute search patterns in order to find fringes, but this could be done manually.

We do not expect to repeat the stub tests of the ISS and FT interfaces in this phase. However testing the delay lines under the control of the ISS and FT during this phase would be highly desirable.

6 System Test Lists

The tests are grouped under general categories that address some particular aspect of the requirements. We have followed the same grouping used for acceptance tests of the trolley [AD1], though the purpose of the tests in each group is slightly different.

Slew tests: these test the repositioning time of the trolley, the maximum velocity and acceleration, and show that the metrology system maintains lock when the shear system and steering loops are closed.

Tracking tests: these comprise constant velocity tests over a range of tracking velocities from 0.1mm/s to 15mm/s and sets of 10 minute long tracking tests to represent normal observation times.

Trajectory tests: these test the re-positioning of a trolley from tracking at one position to tracking at another position, tracking at constant accelerations and tracking reversal and tracking offsets of 0.5μm to 10μm.

Roll and shear tests: these check the operation of the shear loop, the secondary tip/tilt servo and the effect of the steering in open and closed loop.

Datum tests: these test the robustness of the datum-seeking algorithm and the repeatability that it achieves.

Focus tests: these test the operation of the cat's eye focussing system.

Limit tests: these test the functionality of the limits and the characteristics of the trolley and cat's eye servos when a limit is encountered.

Additional system tests (TBD) will only be possible on-sky with two delay lines.

6.1 Slew tests

Test No.	Test Description	Primary objective	Subordinate objectives
1	Check velocity ramping under VME control by moving fixed distances (plus and minus): 4mm, 10mm, 20mm, 50mm 100mm 200mm 500mm 2m.	Test repositioning time Delay precision	Check track/slew switching
2	Carry out a 17m slew with the maximum velocity set to +0.7m/s	Check metrology lock	Check time
3	Carry out a 17m slew with the maximum velocity set to -0.7m/s	Check metrology lock	Check time

6.2 Tracking tests

Test No.	Test Description	Primary objective	Subordinate objectives
1a	Test tracking at rates of (plus and minus) 0.1mm/s, 0.2mm/s, 0.4mm/s, 0.8mm/s and then 1 to 15mm/s in increments of 1mm/s. Steering loop open/closed as required.	Test of OPD performance	
1b	If necessary, repeat two constant	Test of steering	

	velocity tracking tests (1mm/s and 10mm/s) with steering loop closed and actuating (may need to force actuation).	influence on OPD	
2	Continuous tracking for 10 minutes at the following velocities: 0.2mm/s, -1mm/s, +5mm/s and -10mm/s.	Test of OPD performance over typical observation time	

6.3 Trajectory tests

Test No.	Test Description	Primary objective	Subordinate objectives
1	Test trajectory acquisition and time by switching from tracking at one position to tracking at another position for a range of distances e.g 4mm, 20mm, 100mm, 200mm, 500mm, 2m 10m and 14m.	Check re-acquisition time & delay precision	
2	Test tracking at constant accelerations 0.3μms^{-2}, 0.625μms^{-2}, 1.25 μms^{-2}.	Test of OPD performance	
3	Test reversing direction while tracking with a realistic trajectory.	Test of OPD performance	
4	Test response to fringe tracking offsets of 0.5µm, 1µm, 10µm	Test offset response	

6.4 Roll and shear loop tests

Test No.	Test Description	Primary objective	Subordinate Objectives
1	Slew the trolley for the full length of the test rig at a constant velocity of 90mm/s With steering and tip/tilt loops closed	Check tip/tilt	Check steering performance
2	Operate the tip/tilt actuator between its limits in both axes and measure the resulting shear of the metrology beam using the shear sensor.	Check tip/tilt range	

6.5 Datum tests

Test No.	Test Description	Primary objective	Subordinate Objectives
1	Acquire datum 10 times from close range and check the deviation from zero at the instant before the reset.	Check datum repeatability	
2	Acquire datum 10 times from different starting positions: past, at, near, far. Check deviation as for test 1	Test algorithm robustness	

6.6 Focus tests

Test No.	Test Description	Primary objective	Subordinate Objectives

1	Request a range of focus motions chosen to demonstrate the positioning resolution and repeatability.	Test focus loop	

6.7 Limits tests

Test No.	Test Description	Primary objective	Subordinate Objectives
1	Drive trolley into each pre-limit and check that trolley stops within allowed distance, will not drive further but will drive out of limit	Test limit functionality	