MRO Delay Line

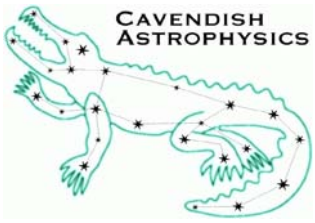
List of Production Trolley Factory Acceptance Tests

INT-406-VEN-0207

The Cambridge Delay Line Team

rev 0.1

15 April 2011



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Change Record

Revision	Date	Author(s)	Changes
0.1	2011-04-16	MF	First draft – based on List of tests (AD02)

Objective

This document defines the list of tests to be undertaken for the factory acceptance testing of the production delay line trolley.

Scope

The list is a comprehensive suite of tests defined to show that the derived requirements are met and to the extent possible in a prototype test facility that the top-level requirements can be met in the fully operational delay line. The tests listed in this document apply only to factory acceptance testing of the production trolley though they have been derived from the test defined in AD02.

These tests aim to demonstrate that the performance of the production trolley and the closed loops involving the metrology system and shear system meet requirements. The metrology system with which these test are conducted is the Zygo system and not the prototype metrology design which is proposed for MROI. The trolley passed pre-FAT tests in the lab using the Agilent metrology system designed for MROI.

Reference Documents

RD1 Results of the Risk Reduction Experiments Rev. 1.0, 6th December 2005

RD2 Top-level requirements INT-406-TSP-0002

Applicable Documents

These are other review documents for review which are directly applicable, e.g.

AD01 Derived Requirements INT-406-VEN-0107

AD02 List of Tests INT-406-VEN-0108

Acronyms and Abbreviations

BCA Beam Combining Area

BCF Beam Combining Facility

BRS Beam Relay System

DL Delay Line

DLA Delay Line Area

ICD Interface Control Document

ICS Interferometer Control System (now SCS)

MROI Magdalena Ridge Observatory Interferometer

MRAO Mullard Radio Astronomy Observatory

NMT New Mexico Tech

OPD Optical Path Delay

SCS Supervisory Control System

TBC To be confirmed

TBD To be determined

Table of Contents

1 Introduction

The test list presented here is designed to show that the top level and derived requirements are met and that the performance of the system is maintained over representative observing periods. A short description of each test is given together with any specific conditions that should apply for the duration of the test. The derived requirement with which the test is associated is given in the last column of the tables. A top level requirement is identified with the letters TL followed by the section number and paragraph number.

Tests are grouped into categories for convenience of referencing but this is not meant to imply any particular significance or order in testing.

Most tests are conducted at a pressure <1.5 mb but substantial subset of these tests are also performed at atmospheric pressure before the test rig is pumped down. The differences between testing at atmosphere and testing under vacuum are explained below

1.1 Grouping of Tests

Tests are grouped under general categories that address some particular aspect of the requirements. These groups are:

Slew tests: these test the repositioning time of the trolley, the maximum velocity and acceleration, the power consumption and trolley temperatures, 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, sets of 10 minute long tracking tests to represent normal observation times and tracking over joins to assess the effect of the join.

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. They also provide information on the deviations of the delay line pipe.

Datum tests: these test the repeatability of the datum switch and the overall stability of the datum over a period of time.

Focus tests: these test the resolution and stability 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.

1.2 Test conditions

1.2.1 Testing at atmosphere

Testing at atmosphere is much more convenient than testing under vacuum conditions. Most tests that are met at atmosphere can be expected to meet the requirements under vacuum. The main difference in testing at atmosphere is that air in the pipe will be pushed about by the trolley and so servos will have to work harder and there is more coupling from the trolley to the cat's eye. On the other hand air damping is also increased. The delay line pipe is left partially open at the metrology end to allow air to flow in or out and reduce the effect on the trolley.

1.2.2 Testing under vacuum conditions

When testing under vacuum the proper metrology window end plate is installed on the delay line pipe and metrology windows are fitted. There are no science beam ports. The test rig is evacuated to approximately 0.5 mbar.

2 Test Lists

2.1 Test at atmosphere

2.1.1 Trolley slew tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived/ Requirement
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	2.2.1 2.2.2 (TL 5.2.4)
2	Carry out a 17m slew with the maximum velocity set to +0.7m/s	Check metrology lock	Check time Check power	2.2.1 2.2.2
3	Carry out a 17m slew with the maximum velocity set to -0.7m/s	Check metrology lock	Check time Check power	2.2.1 2.2.2

2.1.2 Trolley tracking tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived Requirement
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 closed.	Test of OPD performance		(TL 5.2.6)
1b	If necessary, repeat a constant velocity tracking test where steering is actuated.	Test of steering influence on OPD		(TL 5.2.6)
2	Continuous tracking for 10 minutes at the following velocities: 0.2mm/s, -1mm/s, +5mm/s and -10mm/s. (log in sections 120s to limit the size of log files)	Test of OPD performance over typical observation time		(TL 5.2.6)
3	If necessary repeat tracking tests across joins – position trolley so as to cross join.	Test of performance over join		(TL 5.2.6)

2.1.3 Trolley trajectory tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived Requirement
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 4 mm, 20 mm, 100 mm, 200 mm, 500 mm, 1 m and 10 m	Check re-acquisition time & delay precision		(TL 5.2.4)
2	Test tracking at constant accelerations 0.3 μms^{-2}, 0.625 μms^{-2}, 1.25 μms^{-2}.	Test of OPD performance		(TL 5.2.6)
3	Test reversing direction while tracking with a realistic trajectory.	Test of OPD performance		(TL 5.2.6)
4	Test response to fringe tracking offsets of 0.5µm and 1µm (also 10µm if can be rate limited)	Test offset response		(TL 5.2.11)

2.1.4 Trolley roll and shear loop tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Slew the trolley for the full length of the test rig at a constant velocity of 90 mm/s With steering and tip/tilt loops closed	Check tip/tilt	Check steering performance Check shear residuals	2.4.1
2	Slew the trolley at 0.7 m/s	Check tip/tilt range	Check shear residuals	“
3	Track the trolley at 15mm/s	Check shear residuals	-	“
4	Slew the trolley for the full length of the test rig at a constant velocity of 90 mm/s while logging with steering loop off but centred and check roll.	Check centre position of steering	-	“
5	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	-	2.1.2.2
6	Using the same results gathered in (4) obtain the slew rate of the tip/tilt device in both axes.	Check tip/tilt slew rate	-	2.1.2.3

2.1.5 Datum tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Acquire datum 10 times from close range and check the deviation from zero at the instant before the reset.	To check datum switch repeatability		(TL 5.1.1) (TL 5.2.4)
2	Acquire datum 10 times from different starting positions: at, near, far. Check deviation as for test 1	To check datum stability		(TL 5.1.1) (TL 5.2.4)
3	Acquire datum at various times through testing phase. Check deviation as for test 1	To check intra-night stability		(TL 5.1.1) (TL 5.2.4)
4	Acquire datum the following day. Check deviation as for test 1	To check inter-night stability		(TL 5.1.1) (TL 5.2.4)

2.1.6 Focus mechanism tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Request a range of focus positions to demonstrate the positioning resolution and repeatability (±5 μm, ±10 μm & ±20 μm)	Test focus resolution	Test repeatability	2.1.3.1

2.1.7 Trolley limits tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Drive trolley into each velocity pre-limit and check that velocity is limited to 100 mm/s	Test velocity limit functionality		2.3.1
2	Drive trolley into each final limit, check that trolley stops within allowed distance and will not drive further but will drive out of limit	Test final limit functionality	Check cat's eye current limit.	-

2.1.8 Vacuum integrity test

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Pump down to 3 mbar and check pressure over next few hours.	Test of vacuum seals		4.1.3

2.2 Tests under vacuum

2.2.1 Trolley slew tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived Requirement
1	Carry out a 17m slew with the maximum velocity set to +0.7m/s	Check metrology lock	Check velocity Check acc'n	2.2.1 2.2.2
2	Carry out a 17m slew with the maximum velocity set to -0.7m/s	Check metrology lock	Check time Check power	(TL 5.2.6) 2.5.1
3	Carry out a sequence of slews at maximum velocity equivalent to 380m of delay line travel	Check temperatures Check power	Check steering performance	2.5.1

2.2.2 Trolley tracking tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived Requirement
1	Test tracking at rates of (plus and minus) 0.1, 0.2, 0.4, 0.8 and 1mm/s, then 2 mm/s to 15 mm/s in 1 mm/s steps. Roll & shear loops closed.	Test of OPD performance		(TL 5.2.6)
2	Continuous tracking for 10 minutes at the following velocities: 0.2mm/s, -1mm/s, +5mm/s -10mm/s & +15mm/s. (log in sections 120s to limit the size of log files)	Test of OPD performance over typical observation time		(TL 5.2.6)
3	Conduct tracking tests across selected joins at ±0.2 mm/s, ±1 mm/s ±5 mm/s, ±10mm/s and ±15mm/s for both front and rear wheels.	Test of performance over join	Check that specifications are not exceeded for >0.5s in 60s	(TL 5.2.6)

2.2.3 Trolley trajectory tests

Test No.	Test Description	Primary objective	Subordinate objectives	Derived Requirement
1	Test trajectory acquisition and time by switching from tracking at one position to tracking at another position: 4 mm, 10 mm, 20 mm, 50 mm, 100 mm, 200 mm, 500 mm, 1 m , 2m, 10 m and 15 m.	Check re-acquisition time		(TL 5.2.4)
2	Test tracking at constant accelerations 0.3 μms^{-2}, 0.625 μms^{-2}, 1.25 μms^{-2}.	Test of OPD performance		(TL 5.2.6)
3	Test reversing direction while tracking with a realistic trajectory.	Test of OPD performance		(TL 5.2.6)
4	Test response to fringe tracking offsets of ±0.5 µm ±1 µm and ±10 µm	Test step response		(TL 5.2.11)

2.2.4 Trolley roll and shear loop tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Slew the trolley for the full length of the test rig at a constant velocity of 90 mm/s With steering and tip/tilt loops closed	Check tip/tilt	Check steering Check shear residuals	2.4.1
2	Slew the trolley at 0.7 m/s	Check tip/tilt range	Check shear residuals	“
3	Track the trolley at 15mm/s	Check shear residuals	-	“
4	Slew the trolley for the full length of the test rig at a constant velocity of 90 mm/s while logging with steering loop off but centred and check roll.	Check centre position of steering	-	“
5	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	-	2.1.2.2
6	Using the same results gathered in (4) obtain the slew rate of the tip/tilt device in both axes.	Check tip/tilt slew rate	-	2.1.2.3

2.2.5 Focus tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Request a range of focus positions to demonstrate the positioning resolution and repeatability (±5 μm, ±10 μm & ±20 μm)	Test focus resolution	Test repeatability	2.1.3.1
2	Step through focus range in 100 μm increments and back.	Check the focus range	Check repeatability	“
3	Tracking test at 1mm/s at either end of focus range	Check focus mechanism		“

2.2.6 Datum tests

Test No.	Test Description	Primary objective	Subordinate Objectives	Derived Requirement
1	Acquire datum 10 times from different starting positions: at, near, far. Check deviation as for test 1	To check datum stability		(TL 5.1.1) (TL 5.2.4)
2	Acquire datum at various times through testing phase. Check deviation as for test 1	Intra-night stability		(TL 5.1.1) (TL 5.2.4)
3	Acquire datum the following day. Check deviation as for test 1	Inter-night stability		(TL 5.1.1) (TL 5.2.4)