VLT TIME REFERENCE SYSTEM SPECIFICATION

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CHANGE RECORD

ISSUE	DATE	SECTION AFFECTED	REMARKS
Draft 1	19 Jan. 93	All	first issue
Draft 2	23 Feb. 93	all	see revision bars meeting report 3 Feb.
Draft 3	08 Mar 93	2.2, 7	meeting report 3 Mar
		all	editorials
Draft 4	14 Apr. 93	all:	editorials
		3, 7.1.3, 7.1.4:	Introduce 'local mode' switching instead of 'internal clock'
		7.1.2:	New chapter heading.
Issue 1	4 May. 93	all:	Editorials
		6.2:	Error budget changed.
		3.4, 8	New chapter: Display

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1. SCOPE

This document describes the specifications for the VLT Time Reference System (TRS).

Verification of each specification is given in square brackets just above each specification. This is according to the following table:

ROD	Review of design
I	Inspection
T	Test
ADx	Refers to the verification methods in the applicable document

The last method is used in cases where a reference is made to an applicable document.

2. RELATED DOCUMENTATION

2.1. APPLICABLE DOCUMENTS

The below listed documents are applicable for the Time Reference System and are cited in this specification. If a conflict arises between this specification and one or more of the applicable documents, this specification shall prevail.

AD1: VLT-SPE-ESO-10000-0003, issue 1, 5 Feb. 1992.
"Electro Magnetic Compatibility and Power Quality Specification. Part 2, Electromagnetic disturbance emission and immunity limits of electric and electronic equipment"

AD2: VLT-SPE-ESO-10000-0015, issue 2, 9 Apr. 1992.
"Electronic Design Specification."

AD3: VLT-SPE-ESO-10000-0004, issue 4, 1 Dec. 1992.
"VLT Environmental Specification"

AD4: VLT-SPE-ESO-10000-0013, issue 2, 1 Jul. 1992
"Service connection point, Functional and Interface Requirements"

AD5: VLT-SPE-ESO-10000-0002, issue 2, 11 Mar 1992.
"Electromagnetic compatibility and power quality specification - part 1 - electromagnetic environment of the VLT observatory and EMC levels of the power system."

2.2. REFERENCE DOCUMENTS

The following documents are listed for reference and background information.

TBD
"Time Reference System Design Report."

VLT-SPE-ESO-17210-0356 (in preparation)
"CCS-LCU Time Interface Module Driver Specification."

3., DESCRIPTION OF THE CONFIGURATION

This chapter describes the layout of the TRS. No specifications are stated here: they are in the chapters that describe each unit.

The configuration for the TRS comprises the following elements.
These are illustrated in figure 1.

3.1. CENTRAL TIME STANDARD (CTS).

This consists of a GPS receiver coupled to a local frequency standard. The CTS provides the central reference clock for all LCUs at the Observatory and allows UTC time to be maintained between updates from the GPS satellites. The UTC time is encoded for serial transmission within the Observatory site via the Time-Bus.

3.2. TIME-BUS.

This consists of a fibre-optic star-type transmission network. Branches and spurs of the network are created where necessary by the insertion of Time-Bus Distribution Boxes (TBDBs) at appropriate points.
The Time-Bus feeds all Service Connection Points (SCPs) and, from there, individual LCUs. Some LCUs may have a direct connection to the Time-Bus, or be connected via a special purpose junction box rather than the SCP (for example the M1-cell LCU).

3.3. TIME INTERFACE MODULE.

This module resides in the LCU. It receives the encoded time signal from the Time-Bus, and uses it to clock and load a counter. It uses an autonomous oscillator in the absence of Time-Bus signals. It will provide the various timers that are programmable by the user.

3.4. DISPLAY

The time display can be connected to the Time Interface Module for testing and monitoring of the UTC that is received by the Time Interface Module.

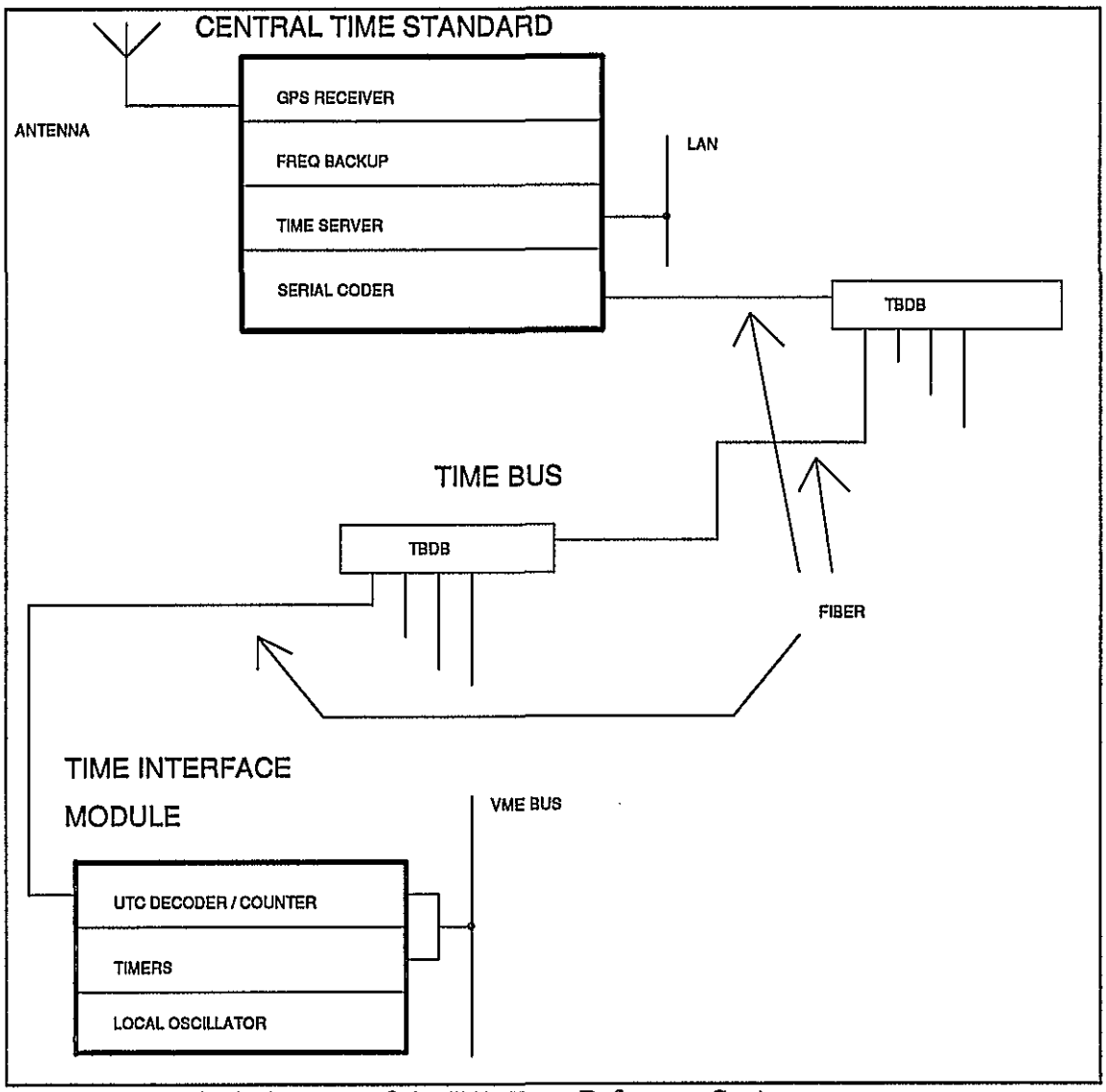

Fig. 1.Block diagram of the VLT Time Reference System

4. SPECIFICATIONS OF THE TIME REFERENCE SYSTEM

This chapter contains the specifications that apply to the TRS. Additional and detailed specifications are in the chapters that describe the elements: chapters 5., 6., and 7.

4.1. ACCURACY

[ROD]
Available international time standards are derived from UTC, and this shall be the basis of the TRS.

Note: This may be converted to UT1 and Sidereal Time (if necessary) by external systems, i.e. not part of the TRS.

[ROD,T]

The accuracy of the UTC time signal, as measured at the time of an interrupt on the VMEbus of any LCU within the Telescope Area, shall be

<= 9 microsec.

The error budget allocation between the various TRS components is:

4 microsec for the Central Time Standard,
2 microsec for the Time-Bus,
2 microsec for the Time Interface Module.

These errors may be traded against each other if necessary.
Note: A value of 2 microsec is budgeted for the propagation delay (static) of the Time Bus fiber.

4.2.ELECTROMAGNETIC COMPATIBILITY

[AD1]
The TRS shall comply with the EMC specifications, AD1 and AD5. Details for the TRS are mentioned in this chapter.

[AD1]
The CTS and the Time Bus Distribution Boxes shall be treated as 'equipment' in the sense of the EMC specification, while the TIM shall meet the EMC specification when mounted in a VME chassis and in a cabinet.

4.2.1. Emission

[ROD]
The TRS shall comply with the IEC/CISPR international standard concerning emission of information technology equipment, i.e. CISPR 22 Class B (or comparable and approved by ESO, e.g. CENELEC EN 55022 Class B).

Note: CISPR 22, "Limits and methods of measurements of radio interference characteristics of information technology equipment".

4.2.2. Immunity

[ROD]
The TRS shall comply with the IEC international standard concerning immunity of industrial-process measurements and control equipment, i.e. the series IEC 801 (or comparable and approved by ESO).
The levels to be chosen are those for 'light industry' as defined by IEC/CENELEC standards.

Note: IEC 801, "Electromagnetic compatibility for industrial-process measurements and control equipment".

4.3. ELECTRONIC DESIGN

[AD2]
The TRS shall comply with the Electronic Design Spec., AD2, with the following remarks:

a. The specifications in the chapter 'Optical indicators' of AD2 do *not* apply for the CTS.

Note: AD2 covers:

a. Signal interconnection between electronic boxes.
b. Signal interfacing.
c. Grounding.
d. Cabling.

e. Mounting for electronic units.
f. Electrical power.
g. Commercial electronic equipment (Standard parts).

4.4. ENVIRONMENTAL

[ROD]
The CTS shall comply with the Environmental Specification, AD3, with the remarks:

4.4.1. Thermal

[ROD]
Installation location is different for the three elements of the TRS, which results in different functional and operational temperatures according AD3:

a. The CTS will be located in the control building and shall therefore comply with the temperature range of the control building as defined in AD3.
b. The Time-Bus and the TBDBs will be partially 'Underground installations' and partially 'unit telescope' as defined in AD3.
The operational temperature range for the Time-Bus and the TBDBs shall be the range valid for the 'Unit Telescope' as defined in AD3.

5. SPECIFICATIONS OF THE CENTRAL TIME STANDARD

5.1. FUNCTIONS

[ROD,T]
The CTS shall perform the following functions:

a. Reception of the Universal Time signal from the Global Positioning System (GPS) satellite.
b. Back-up frequency standard.
c. Generation of a serialised time signal.
d. Time server function for the local area network.
e. Local display.

5.1.1. Reception of the GPS signal

[ROD]
The CTS shall receive and use the GPS satellite signal to derive the UTC.

[ROD,I]
The CTS shall be located in the central control building on the telescope site.

[ROD,I]
The antenna cable from the GPS antenna to the CTS shall allow the installation of a surge arrester and equipotential bonding at the entrance of the control building.

Note: The distance between antenna and electronic unit will be less than 20 meters.
Note: to be verified with building design.

5.1.2. Back-up Frequency standard

[ROD,T]

The Back-up standard shall maintain the specified accuracy of the CTS for a period of 10 hours.

Note: This will allow continuation of the astronomical observations till the next morning.

5.1.3. Serialised time signal

[ROD,T]

The serialised signal shall meet the following specifications:

a. It shall be a digital signal.
b. A pulse width modulated digital signal with a carrier frequency of 1 MHz is preferred.
c. It shall contain the full UTC information, including Modified Julian Date.
d. Although MJD is preferred, Day of the Year plus Year is also acceptable.
e. It shall comply with the specified accuracy.
f. It shall have a repetition rate (i.e. the repetition rate of the full time and date information) of >= 1 Hz.

Note: specification a. and c. will not be fulfilled if the unit has the analogue modulated signal (IRIG A or B coding), which is commonly used. If the standard product has an IRIG output, the (digital) modulation signal must be internally accessible so that the digital signal can be used by ESO.

5.1.4. Time server function

[ROD,T]

The CTS shall also act as a time server function on the control local area network (Control LAN). This will be used to synchronise the work stations on the network.
The accuracy specification does not apply for this mode.

The specifications of this server function are:

a. LAN used: IEEE 802.3 (Ethernet), upgradable to FDDI.
b. Typical accuracy of 1 millisecond.
c. Software shall provide a LAN socket supporting the Internet Network Time Protocol

5.1.5. Local display

The local display of the CTS is intended for test & maintenance only.

[ROD,I]

It shall display at least the hours, minutes and seconds.

5.2. ACCURACY

[ROD,T]

The accuracy of the CTS shall be sufficient to maintain the central frequency standard to within

+/- 4 micro seconds

of the true UTC time.

It applies to the serial output signal as described below, not to the LAN server function.
This number includes:

a. The intrinsic errors of the GPS signal, during the longest expected interval between updates of the GPS time.
b. The short term stability.
c. The long term stability.
d. Back-up frequency stability as specified below.
e. Drift over the operational temperature range of the CTS as defined in chapter 4.4.

5.3. MOUNTING

[ROD,I]

The CTS shall be delivered as one unit, either

a. Mounted in a stand alone cabinet (19 inch), or
b. One 19 inch crate.

5.4. MAINS POWER

The mains power for the CTS is 230V AC single phase. This is an Uninterruptable Power Supply. Battery back-up is not needed in this case.

Note: If needed, 400 V AC three phases can be supplied to power the CTS. This is not an UPS and the CTS shall be supplied with a battery back-up in this case.

6. SPECIFICATIONS OF THE TIME-BUS

6.1. FUNCTIONS

[ROD,I]

The Time-Bus shall transmit the encoded time and synchronisation signals to:

a. All SCPs as defined in AD4, and
b. Other required locations: TBD

[ROD]

The Time-Bus shall consist of a Time-Bus fiber network and Time-Bus distribution boxes.

6.2. TIME DELAY

[ROD,T]

The maximum transmission delay between the CTS and LCU within the Telescope Area shall not exceed:

2 microsec.

This number includes:

a. Propagation delay in 5 TBDBs.
b. Jitter due to dispersion and electronic jitter in the 5 TBDBs.
c. Temperature drift over the operational temperature range of the Time-Bus as defined in chapter 4.4.

Note: the propagation delay of the Time Bus fiber is not specified as this number is given by the installed fiber length. A value of 2 microsec is budgeted.

Option:

[ROD,T]

Transmission distances up to 3 km shall be possible. The use of intermediate repeaters shall be allowed for transmission over distances longer than 400 metres, although the number of these shall be kept to the minimum.
The time delay specification does not apply for this requirement.

6.3. TIME BUS DISTRIBUTION BOXES.

[ROD,I]

No more than 5 TBDBs shall be interposed between the CTS and any LCU Time Interface Module.

[ROD]

All TBDBs shall have the same number of signal outputs to simplify maintenance, even though not all may be used at every location.
The number of outputs per TBDB shall be optimised in relation to the optimum Time-Bus network layout. This number is provisionally fixed at 4.

[ROD]

The TBDB shall have an electronic extension possibility to drive more than one 1 TBDB so that more outputs than the amount mentioned above can be made available.

[ROD,T]

TBDBs shall provide the possibility of electrically monitoring the transmitted time signals for test purposes without disturbing the time signal transmission to the SCPs.

6.3.1. Mains power

The mains power for the TBDB is 230V AC single phase. This is an Uninterruptable Power Supply.

Power consumption:TBD W per TBDB

6.3.2. Dimensions

TBD

7. SPECIFICATIONS OF THE TIME INTERFACE MODULE

7.1. FUNCTIONS

[ROD]

The Time Interface Module (TIM) shall provide the following functions:

a. Reception and decoding of the serialised UTC signal from the Time Bus.
b. Generation of synchronous clock frequencies.
c. Local oscillator as backup clock.
d. UTC counter and register, accessible from the VME bus.
e. 6 programmable general purpose timers, each 16 bit.
f. Interrupts to the VME bus.
g. Outputs for display and external hardware.

7.1.1. Time bus signal

[ROD,T]
The Time Interface Module (TIM) shall receive and decode the Time-Bus signal.

[ROD,I,T]
The TIM shall have a LED that indicates the correct reception of the Time-Bus signal, colour green: OK. status, switchable.
This status shall be accessible from the VME bus.

[ROD,I]
The TIM shall have a LED showing the second pulses of the UTC, colour yellow, switchable.

7.1.2. Clock frequencies

[ROD]
The TIM shall generate clock frequencies of 1 Hz to and including 1 MHz in steps of a factor 10. The clock frequencies shall be synchronous with the UTC and have a delay that is budgeted in the TIM timing accuracy specification described in chapter 7.4.

[ROD,I]
The clock frequencies shall be available for external equipment and for clocking the general purpose timers as described in chapter 7.1.5.

7.1.3. Local oscillator.

[ROD,T]
If there is no Time Bus signal available, the TIM shall automatically switch over to a local oscillator that shall have a short term stability of $<= 1 \times 10^{-8}$. This operational mode shall be called 'local mode'. Using the Time Bus signal shall be called 'normal mode'.
This 'local' status shall be accessible from the VME bus.

[ROD,T]
The error that is introduced by the switching from 'normal' to local shall be less than:

2 microseconds

[ROD,T]
If the Time Bus signal returns after being not available, the TIM shall not automatically switch back from 'local' mode to 'normal' mode.
Note: this will prevent uncontrolled jumps in the UTC.

[ROD,T]
Switching between 'local' and 'normal' mode shall also be possible with VME bus commands.

7.1.4. UTC counter

[ROD]
The UTC counter shall be clocked:

a. In 'normal' mode: by the Time Bus signal.
b. In 'local' mode: by the local oscillator.

[ROD,T]
It shall be possible to read the UTC counter value from the VMEbus.

[ROD,T]

The resolution of the UTC counter shall be 1 microsec.

[ROD,T]

The UTC counter shall count binary for fraction of the second (the microsecond part) and BCD for the seconds, minutes, hours and day of year/MJD part.

[ROD,T]

Loading of the counter shall be done,

a. in 'normal' mode: When a decoding cycle of the Time Bus signal is ready, the UTC value shall be loaded into the UTC counter.
b. in 'local' mode: the time of the UTC counter shall be programmable from the VMEbus.
   This would be used for test purposes and for operation when no Time-Bus information is available.

[ROD,T]

The UTC counter shall have two programmable cyclic interrupts, one interrupt every 10 millisecond and the other every 1 second.

7.1.5. General purpose timers

[ROD,T]

The TIM shall have 6 programmable timers, each of them 16 bit wide and software programmable in:

a. Mode of operation: repetitive, single shot.
b. Clock rate: one of the clock frequencies as described in chapter 7.1.2.
c. Gating source:
   i. Software gate: timer starts after register access.
   ii. Lock: no gating.
   iii. Hardware gate: external input signal.
   iv. Gate on next 100 millisecond edge.
d. Interrupt enable / disable.
e. Interrupt clear.

[ROD,T]

The status and the count value of each general purpose timer shall be available on the VME bus.

7.1.6. Interrupts

[ROD,T]

The TIM shall identify, by means of a register, the nature of any interrupt source of the TIM which has occurred.

[ROD,T]

Simultaneous operation of all interrupts shall be possible.

7.1.7. Propagation delay compensation

Optional:

The TIM shall provide the possibility of compensating the transmission delay of the Time-Bus. The empirically measured Time-Bus delay for any TIM location shall be set using PC-board switches within the TIM. When a delay has been

set, it will automatically be added to the UTC time received from the Time-Bus each time it is received (i.e. internal TIM clock time = UTC received from Time-Bus + delay time). It shall be possible to set the delay time in the range 0 - 15 microsec (preferably 0 - 31 microsec) in steps of 1 microsec. It shall be possible to read the set delay from the VMEbus.

7.2. INPUTS / OUTPUTS

[ROD,T]

The TIM shall have as input signals:

Signal:	Connector location:
The Time Bus signal	Front
Hardware gate signals for all general purpose timers	Back

[ROD,T]

The TIM shall have as output signals:

Signal:	Connector location:
All TIM internal clocks	Back
All general purpose timer outputs	Back
A set of signals that allow the connection of the display, see chapter 8.	Front

7.3. VME BUS INTERFACE

[AD2]

The TIM shall comply with the VME bus specification as defined in the Electronic Design specification, AD2.

7.4. TIMING ACCURACY

[ROD,T]

The Time Interface Module shall generate interrupts to the VME bus with an accuracy of:

<= 2 microsecond.

This number includes:

a. propagation delay in the module.
b. jitter.
c. temperature drift over the operational range of the TIM as defined in chapter 4.4.

8. SPECIFICATIONS OF THE DISPLAY

[ROD]

The Display shall be not an integrated part of the TIM, but shall be a stand alone 19 inch unit.

[ROD,I]

The Display shall show the UTC in the form of BCD hours / minutes / seconds of the TIM where it is connected to.
The height of the BCD numbers shall be greater than or equal to 1 inch.

[ROD,I]

The maximum length of the cable between the TIM and the display shall be 3 meters.

9. LCU REQUIREMENTS

[ROD]

LCUs requiring a time precision of <= 1 sec shall integrate a TIM into the LCU electronics and have a direct connection to the Time-Bus.

LCUs that do not require high precision may dispense with the TIM and obtain UTC and Sidereal Time from the central data-base via the LAN. This would provide a nominal accuracy of 1 sec.

10. ACRONYMS

[BCD] Binary Coded Decimal
[CTS] Central Time Standard
[GPS] Global Positioning System
[IERS] International Earth Rotation Service
[LAN] Local Area Network
[LCU] Local Control Unit
[LED] Light Emitting Diode
[MJD] Modified Julian Date
[SCP] Service Connection Point
[TBD] To Be Defined
[TBDB] Time-Bus Distribution Box
[TAI] Temps Atomique International
[TIM] Time Interface Module
[TRS] Time Reference System
[UT1] Universal Time (corrected for polar motion)
[UTC] Coordinated Universal Time

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