LBT-ADOPT
TECHNICAL REPORT

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A O S
Functional Description

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ABSTRACT

In the following memo we describe the functionalities required to AOS (Adaptive Optics Subsystem) in order to manage interaction between the LBT Adaptive Optics system and the TCS.

Contents

Glossary of terms and acronyms

AO System. The hardware and software components of the LBT first light Adaptive Optics System. Includes the Wavefront Sensor, the Adaptive Secondary Mirror, the AO Computer and some auxiliary devices (such as networking hardware).

AO-CI. The AO Software Command Interpreter: a component of AO-SW which can execute scripts.

AO Computer. The computer (or farm of computers) running the AO-SW.

AO Console. The operator console of the AO Computer.

AO-SS. the script executed to startup the AO-SW.

AO-SW. The software dedicated to the managements of the Adaptive Optics System. Its main component is the Supervisor.

AOS. A part (subsystem) of TCS dedicated to interaction with the AO-SW.

AO Supervisor. The software system which manages all the components of the AO System

`DD`**.** Data Dictionary, the TCS own variable repository.

IIF. Instrument Iterface, the set of commands provided by TCS to instrument software [6].

`MsgD`**.** Message Dispatcher, the AO Supervisor message dispatching utility.

PCS. Point Control System, the TCS subsystem which manages pointing and tracking of the telescope.

PSF. PSF Control System, the TCS subsystem which manages the control of the optical PSF.

`RTDB`**.** AO Real Time Database, the AO Supervisor own variable repository.

TCS. Telescope Control System. The software dedicated to the management of the LBT telescope.

TCS Computer. The Computer (or farm of computers) running the TCS.

Technical Viewer. An auxiliary CCD used by the Wavefront Sensor to acquire the reference star.

1 Introduction

1.1 System Architecture

The Adaptive Optics Subsystem (AOS) is the subsystem of TCS providing all the functionalities needed for interaction between the LBT Adaptive Optics system and the rest of the telescope, including instruments.

General issues about the interaction between AO System and the TCS have been discussed in [1] and in figure 1 the relationships between relevant software components are shown.

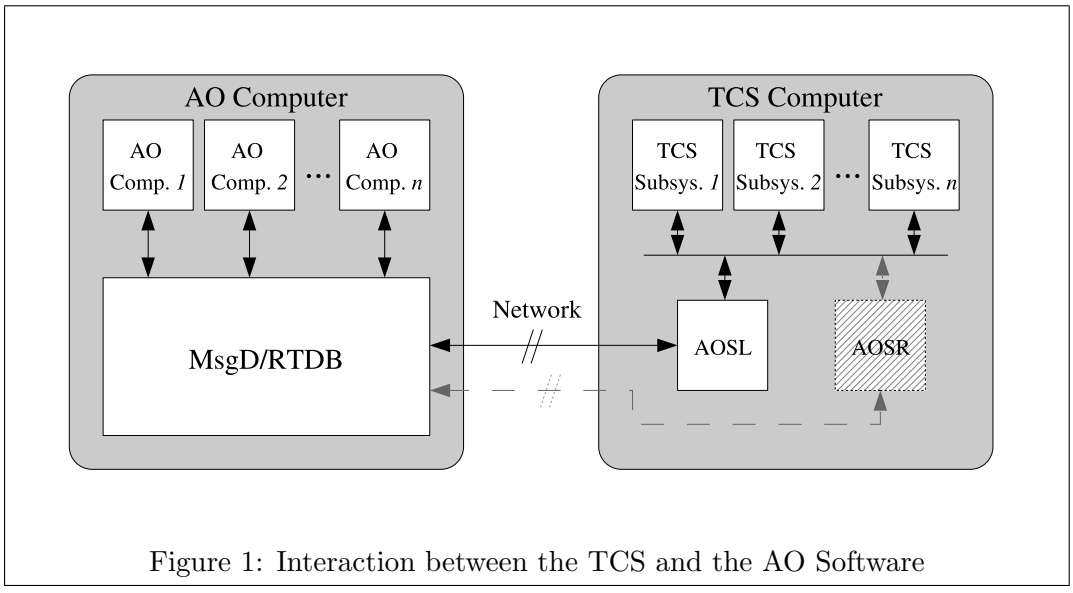

Figure 1: Interaction between the TCS and the AO Software

In general, communication between AOS and the AO Supervisor will be based on the two mechanisms defined in AO-Sup: access to `RTDB` variables and direct messages sent through the `MsgD` to some AO-Sup component.

AOS will maintain a subset of the TCS status variables reflected in the `RTDB` so that AO-Sup component have them available, and will have read access to the full set of AO-Sup status variables.

1.2 Supervisor Service States

AO-Sup supports four “Service States”, indicating the mode of interaction with the TCS.

1. STANDALONE, when the AO system is operational but will neither request nor accept interaction with the TCS. All communications from AOS will be simply ignored. AOS will, anyway, be able to read the `AOServStat` variable holding the current service status of the AO System (see also sect. 5.1).

2. ENGINEERING, when the system is performing calibration or maintenance function, and requires services from the TCS (to operate telescope devices or to point a suitable reference star).

3. READY, when the system has successfully completed the automatic bootstrap procedure waiting for one of the following events to happen: 1) the TCS sends a request to start OBSERVATION state (see sect. 2.1), 2) an operator at the AO console issues one of the state change commands: shutdown, or change service status to either STANDALONE or ENGINEERING.

4. OBSERVATION, when the AO System is supporting an observation.

Notably AO-Sup, in its interaction with TCS, will operate as master when in ENGINEERING service status and as slave when in OBSERVATION service status[1].

1.3 AO System Operating Modes

When operating in support of an observation the AO System will provide four modes of operation [2].

- **FIX-AO**. Fixed Mode Operation. It is the seeing limited mode where the Adaptive Secondary mirror holds a fixed "flat" shape defined by a pre-calibrated vector of mirror commands. Depending on the particular kind of observation a specific "flat" vector may be selected.
- **TTM-AO**. Tip-Tilt Mode Operation. It is an AO mode with only tip-tilt correction performed by the secondary mirror.
- **ACE-AO**. Auto Configured Adaptive Optics Operation. It is the full AO corrected mode, with AO loop parameters automatically selected by the AO System based on reference source charactreristics.
- **ICE-AO**. Interactively Configured Adaptive Optics Operation. It is a full AO corrected mode where the observer is given the possibility to adjust AO loop parameters.

2 AOS Operational Functions

AOS, being an interfacing layer between the TCS and AO-Sup will both define commands to be used by other subsystems of the TCS to operate the AO System and, on the other side, it will receive messages from AO-Sup and translate them into proper commands to be executed by TCS[2].

In the following two sections we describe the two set of operational commands in some deeper details.

[1]Note that master operation here means that operation requests are originated by AO-Sup; but TCS will be able, anyway, to send a limited number of requests to AO-Sup too. And vice-versa, when operating as slave AO-Sup will mainly wait for requests from the TCS, but will anyway send a limited number of requests to TCS.

[2]The identification of the set of functions is the result of discussions with various people both from Arcetri and from Tucson: N. Cushing, M. De La Pena, S. Esposito, R. Green, J. Kraus, A. Riccardi, P. Salinari, M. Wagner, with a special mention to J. Hill.

2.1 Commands accepted by AOS from other TCS subsystems

Commands to be used by instruments during observation, which are translated by AOS into commands for the AO-Sup are listed in table 1 and are described in some details in the following paragraphs.

Command	State	Description
StartObs	READY	Start an observation
PresetFlat	OBSERVATION	Preset AO System for seeing limited operation
PresetAO	OBSERVATION	Preset AO System for adaptive operation
AcquireRefAO	OBSERVATION	Acquire the reference star and become ready for closing the AO loop
GetSnap	OBSERVATION	Get a snapshot image of the AO field of view
RefineAO	OBSERVATION	Modify some AO loop parameter
StartAO	OBSERVATION	Start the AO mode (i.e.: close the AO loop)
OffsetXY	OBSERVATION	Offset AO pointing
OffsetZ	OBSERVATION	Offset AO focus
CorrectModes	OBSERVATION	Apply mirror shape correction
Stop	OBSERVATION	Stop current operation
Pause	OBSERVATION	Temporarily suspend current operation.
Resume	OBSERVATION	Resume suspended operation.
Terminate	OBSERVATION	Terminate an observation.
UserPanic	OBSERVATION ENGINEERING READY	Emergency shutdown request

Table 1: Commands accepted by AOS from TCS

2.1.1 StartObs

This command is used by the TCS to request the AO System to move from READY service status to OBSERVATION service status, this must be done at the beginning of an observation.

No parameters are required.

AOS will send the request message to AO-Sup and wait for an acknowledge. AO-Sup will perform the required operations (e.g.: it will modify the behaviour of the engineering interface at the AO Console) and acknowledge the request. At the end AOS will properly update the value in `DD`.

2.1.2 PresetFlat

This command is issued in OBSERVATION service status in order to request the AO System to prepare itself for the FIX-AO[3] mode of observation.

This mode doesn't require a reference star, but it will be possible to select among several different "flats" depending on the type of observation.

[3]See sect 1.3.

PresetFlat Command Parameters

Name	Type	Units	Comment
FlatVector	string		The name of a specific vector selected from a set

After sending the command to AO-Sup the AOS will wait for a status change of the corresponding AO variable. It will then reflect the service status into DD.

2.1.3 PresetAO

This command is issued in OBSERVATION service status in order to prepare the AO System for an observation in adaptive mode, i.e.: one of TTM-AO, ACE-AO, ICE-AO[4].

Following this command the AO System will perform all set up operations needed to prepare for the acquisition of a reference star[5].

When the PresetAO command has been completed telescope has reached the pointing position the command AcquireRefAO will be issued to proceed with reference source acquisition.

The command must specify all parameters needed to set up the AO System for the requested operating mode as detailed in the following table.

PresetAO Command Parameters

Name	Type	Units	Comment
AOMode	string		Either TTM-AO, ACE-AO or ICE-AO
WFS	string		Specifies the source of WFS data
SOCoords	float[2]	mm	Position of the scientific object in focal plane coordinates
ROCoords	float[2]	mm	Position of the reference object in focal plane coordinates
RotAngle	float	radians	Angular position of rotator[a]
Mag	float	TBD	Magnitude of reference star
Color	float	TBD	Color Index of reference star
R0	float	TBD	Extimated value of R0 (optional)
Wspeed	float	m/s	Wind speed
Wangle	float	radians	Wind direction

[a]This is the extimated value at the pointing position

After sending the command to AO-Sup, AOS will wait for a change of the corresponding AO variable. It will then reflect the new value into DD.

The AO system is expected to perform all set up operation needed except acquiring the reference object, which will be performed when the subsequent AcquireRefAO command will be issued.

[4]See sect. 1.3.

[5]The setup operation has been splitted in two steps (PresetAO and AcquireRefAO) in order to allow the AO System to perform potentially time consuming adjustments (such as moving the mechanical assets of the WFS) while the telescope is slewing to point the source.

At the end of preset the AO System will send an acknowledge to the AOS.

2.1.4 AcquireRefAO

This command is issued after a `PresetAO` in order to request the AO System to proceed to reference object acquisition.

Before issuing this command the AOS must check both that the previous `PresetAO` command has been successfully completed and that the telescope has reached the pointing position and the guiding system is operating.

If the above preconditions are fullfilled, the AO System must find the reference star within the field of view of the Technical Viewer and thus is able to adjust the mechanical position of the WFS to put the reference star in the right spot. Then it will compute parameters needed for optimization of the AO loop and set up all the needed optic devices.

During the execution of the command some indication of partial completion of the operation will be sent back to the AOS[6].

The command does not require parameters from the AOS, in that all the needed pieces of information have been communicated by the previous `PresetAO` command, but at the end it will send back the computed AO loop parameters as detailed in the following table.

Parameters sent back by `AcquireRefAO` command

Name	Type	Units	Comment
`CompStatus`	string		Completion status. Either OK or an error message
`NModes`	integer		Number of corrected modes
`Itime`	float	s	CCD integration time
`Nbins`	integer		CCD binning
`TTMod`	float	TBD	Tip-Tilt internal mirror modulation
`F1spec`	string		Selected position of filter wheel # 1
`F2spec`	string		Selected position of filter wheel # 2
`Sthrel`	float[3]	TBD	Measured Sthrel ratio in J,H,K bands
`R0`	float	TBD	Measured R0
`MSNratio`	float[672]	TBD	Measured S/N per mode
`TVframe`	jpeg		Snapshot of the stellar field from the Technical Viewer

After receiving the parameter block, the AOS will usually issue either a `StartAO` or a `RefineAO` command.

2.1.5 GetSnap

The `GetSnap` command may be used to get a snapshot of the current field of view of the AO subsystem[7]. The image may be used e.g.: for displaying the AO field to the operator console.

[6] Note that the AO setup procedure may require several seconds to be completed.
[7] This actually corresponds to the readout of the Technical Viewer

2.1.6 RefineAO

The `RefineAO` command is used to support the ICE-AO operating mode. It may be used to request the AO System to modify the value of some AO loop parameter before closing the AO Loop. The command must specify the set of AO loop parameters selected by the observer as detailed in the following table.

`RefineAO` command parameters

Name	Type	Units	Comment
`NModes`	integer		Number of corrected modes
`Itime`	float	s	CCD integration time
`Nbins`	integer		CCD binning
`TTMod`	float	TBD	Tip-Tilt internal mirror modulation
`F1spec`	string		Selected position of filter wheel # 1
`F2spec`	string		Selected position of filter wheel # 2

This command can be issued only in reply to the successful completion of a previous `AcquireRefAO` command. It is thus assumed that the reference object selected in the previous `PresetAO` command is still correctly positioned

AO-Sup will perform the necessary adjustments to the AO loop parameters and reply with the same parameter block described for the `AcquireRefAO` command (see sect. 2.1.4).

Parameters sent back by `RefineAO` command

Name	Type	Units	Comment
`CompStatus`	string		Completion status. Either OK or an error message
`NModes`	integer		Number of corrected modes
`Itime`	float	s	CCD integration time
`Nbins`	integer		CCD binning
`TTMod`	float	TBD	Tip-Tilt internal mirror modulation
`F1spec`	string		Selected position of filter wheel # 1
`F2spec`	string		Selected position of filter wheel # 2
`Sthrel`	float[3]	TBD	Measured Sthrel ration in J,H,K bands
`R0`	float	TBD	Measured R0
`MSNratio`	float[672]	TBD	Measured S/N per mode
`TVframe`	jpeg		Snapshot of the stellar field from the Technical Viewer

The AOS can issue an arbitrary number of `RefineAO` commands before requesting the closing of the AO loop with a `StartAO` command.

2.1.7 StartAO

The `StartAO` command is issued by AOS to request the closing of the AO loop. It doesn't require any parameter in that it is only needed to synchronize the AO operation with the scientific instrument operation and when it is issued the AO System must be fully ready to close the AO loop.

After sending the corresponding command to AO-Sup, AOS will wait for a change of the corresponding AO variable.

It will then reflect the value into `DD`. The instrument software will thus be able to know form this status variable when the AO system is ready to start scientific data acquisition.

2.1.8 OffsetXY

This command is issued in OBSERVATION service status in order to offset pointing of the AO System (i.e.: by moving the WFS stages). The command is meaningful only when the AO System is operating in closed loop mode: the secondary mirror will follow the offset, so that this operation results in an offset of the field on the scientific camera.

The command requires two delta position values:

`OffsetXY` command parameters

Name	Type	Units	Comment
`DeltaXY`	float[2]	mm	Requested position offset

2.1.9 OffsetZ

This command is issued in OBSERVATION service status in order to offset the focus position of the AO System (i.e.: by moving the WFS stages). The command is meaningful only when the AO System is operating in closed loop mode: the secondary mirror will follow the offset, so that this operation results in an change of focus on the scientific camera.

The command requires one delta value:

`OffsetZ` command parameters

Name	Type	Units	Comment
`DeltaZ`	float	mm	Requested focus offset

2.1.10 CorrectModes

This command is used in OBSERVATION service status to apply a modal correction to mirror shape (e.g.: to make active optics corrections in seeing limited mode). A vector of Δ values must be specified.

`CorrectModes` command parameters

Name	Type	Units	Comment
`DeltaM`	float[672]	TBD	Modes correction vector

AOS will send the related request message to AO-Sup. No reply is expected to this command. Possible error conditions are notified by AO-Sup with the proper message.

2.1.11 Stop

This command will be issued to stop the current operation. After this command any setting defined by a previous `PresetAO` command will be canceled. The command requires a string parameter containing a description of the reason for stopping (see also sect. 2.1.15).

`Stop` command parameters

Name	Type	Units	Comment
`Msg`	string		Reason for stopping

AOS will send the request message to AO-Sup and wait for acknowledge. Then it will properly update the related variable in `DD`.

2.1.12 Pause

Temporarily suspend current operation; the AO System must remain ready to resume the suspended operation. AOS will send the related request message and wait for acknowledge, then it will reflect the status in `DD`. AO-Sup will take the proper action (e.g.: open the AO loop) and then acknowledge the request. The command may be followed by either the `Resume` or the `Stop` command.

2.1.13 Resume

Resume suspended operation after a `Pause`. AOS will send the related request message and wait for acknowledge, then it will reflect the status in `DD`. AO-Sup will resume the operation and acknowledge the request.

2.1.14 Terminate

This command is issued at the end of an observation night to terminate operations. After the command the AO-Sup will properly put all devices into safe conditions and go back to READY service status. The actual shutdown of AO hardware, and possibly of the AO-Sup and AO Computer can then be performed by the operator at the AO-Console.

2.1.15 UserPanic

This command is issued whenever some TCS subsystem (including an instrument) detects any dangerous conditions and decides to to perform a fast shutdown; the command may be also fired by the observer or operator at some user interface. AOS will send the corresponding request message to AO-Sup and Immediately close the connection. AO-Sup will will do its best to shutdown as soon as possible. After the acknowledge no other interaction will be possible between AOS and AO-Sup; i.e.: the command cannot be canceled. The command requires a string parameter containing a description of the event which caused it (see also sect. 2.1.11).

`Panic` command parameters

Name	Type	Units	Comment
`Msg`	string		Reason for panic

2.2 Commands issued by AO-Sup to request services from TCS

Commands sent by AO-Sup to AOS in order to request services from the Telescope are subdivided into three subset. The first subset includes housekeeping commands listed in table 2.

Command	State	Description
RequestService	ENGINEERING	Request exclusive service from TCS (functionally equivalent to IIF `Register` operation)
EndOfService	ENGINEERING	Notifies to the rest of TCS that AO System has finished with AO engineering operations, and releases telescope resources.
LogItem	ENGINEERING OBSERVATION	Requests to log some piece of information into the TCS Logging System.
Stop	ENGINEERING	Terminate current operation
Warning	ENGINEERING OBSERVATION	Notify warning condition
Error	ENGINEERING OBSERVATION	Notify error condition
Panic	ENGINEERING OBSERVATION	Notify some AO System panic condition

Table 2: Commands Issued by AO-Sup. I - Housekeeping commands

The second set of commands, listed in table 3, are used when the AO System is performing engineering operations which do not require pointing and tracking in the sky. In this mode of operation the AO System may need to directly control devices such as the hexapode or the rotator.

Command	State	Description
SetAltAz	ENGINEERING	Set telescope position (alt-azimuth, not tracking)
SetHexapod	ENGINEERING	Set hexapode position
SetRotator	ENGINEERING	Set rotator angle
SetTertiary	ENGINEERING	Set tertiary position.

Table 3: Commands Issued by AO-Sup. II - Low level commands

The third subset of commands, listed in table 4, are used when the AO System is performing engineering operations which require pointing a suitable object and tracking on it. In this mode of operation AO-Sup will behave much like an instrument and will not be able to directly control devices such as the hexapode or the rotator because they are under the control of PCS.

Command	State	Description
ActivatePreset	ENGINEERING	Activate telescope preset GUI
PointTelescope	ENGINEERING	Point telescope and start tracking (this is a simplified version of the PresetTelescope function of IIF)
OffsetPointing	ENGINEERING	Request a pointing offset to the telescope
OffloadModes	ENGINEERING	Offload accumulated errors.

Table 4: Commands Issued by AO-Sup. III - Pointing commands

2.2.1 RequestService

Notifies that the AO System wants to start engineering operation and needs service from some telescope subsystem. AOS will first check that the telescope is in suitable status (e.g.: no instrument has currently authorization to operate the telescope). If the request is accepted AOS will set a proper flag into the telescope status so that other subsystem will not receive authorization to control TCS functions and will request the TCS to activate the related focal station; then it will set an `RTDB` variable reflecting the authorization status. The authorization status will be checked by AO-Sup prior of issuing any other request to AOS.

2.2.2 EndOfService

Notifies to the rest of TCS that AO System has finished with AO engineering operations, and releases telescope resources.

2.2.3 LogItem

Requests to log some piece of information into the TCS Telemetry System.

AO-Sup will have it's own logging system for telemetry data to be used for troubleshooting and engineering tasks. A selected subset of the telemetry data will be stored in the TCS telemetry stream by means of `LogItem` commands.

2.2.4 Stop

Request AOS to stop current operation.

2.2.5 Warning

This command is used by AO-Sup to notify that it has detected some condition which may potentially cause an error (e.g.: some mechanical device is close to a limit position). In ENGINEERING mode AOS will simply update the proper variables, while in OBSERVATION mode it will also notify the operator on the telescope console. Actions to be performed by AOS following a `Warning` command vary, depending on the reason why the warning was generated.

As an example, the `Warning` command will be used to notify the need to offload accumulated modal errors with the following procedure. AO-Sup keeps updated a vector of variables indicating current modal error (see `OffModes` variable in section 3.2). The `Warning` command is a suggestion that it is time to offload the accumulated errors in order to avoid a possible error condition. The AOS, when receiving the `Warning` command, will simply fire a specific event. It will be responsibility of the instrument software to catch the event, read from AOS `DD` variables the amount of the current modal error and take proper action. Note that properly behaved instrument software should provide for early mode offload by polling the related `DD` variables, before an offload modes warning is issued by AO-Sup.

2.2.6 Error

This command is used by AO-Sup to notify that it has detected some error condition (possibly because a previous warning notification has not been properly managed) and has stopped the current operation. In ENGINEERING mode AOS will simply update the corresponding variables, while in OBSERVATION mode it will also notify the operator on the telescope console.

2.2.7 Panic

This command notifies that AO-Sup has detected a dangerous error condition and has initiated a shutdown procedure. AOS will stop any current operation and provide that a notification is displayed on the operator's console. After this the AO System will be set in a safe status and it may be necessary that an operator go to the AO engineering console to further investigate the problem and take proper actions.

2.2.8 SetAltAz

This command is used in ENGINEERING service status to request TCS to set telescope position in alt-azimuth coordinates when the telescope is not tracking. AOS will issue the proper command to the MCS. The current position value and operation status will be reflected in the related variables in `RTDB`.

2.2.9 SetHexapod

This command is used in ENGINEERING service status to set hexapode position. AOS will issue the proper commands to the OSS. The current hexapode position and command completion status will be reflected in the corresponding variables in `RTDB`.

2.2.10 SetRotator

This command is used in ENGINEERING service status to control the rotator position. AOS will issue the proper commands to PCS to get the desired rotator angle. The current rotator position and command completion status will be reflected in the corresponding variable in `RTDB`.

2.2.11 SetTertiary

This command is used in ENGINEERING service status to set the position of Tertiary mirror. AOS will issue the proper commands to PCS to get the desired tertiary position. The current tertiary position and command completion status will be reflected in the corresponding variables in `RTDB`.

2.2.12 ActivatePreset

This request is used used in ENGINEERING service status to activate the TCS Preset GUI by which an operator can select a suitable reference star for AO operation. The preset GUI must allow the AO engineer to control all details of telescope presetting: setting and authorizing the proper focal station, selecting a suitable star from a catalog, pointing, start tracking, etc.

When the preset operation is terminated, AOS is notified and it will send to AO-Sup the same request message used for the `PresetAO` operation. AO-Sup will thus be able to acquire the reference star and proceed with engineering operations.

2.2.13 PointTelescope

This request is used to request pointing of the telescope to a given sky position and start tracking.

2.2.14 OffsetPointing

This command is used to request a pointing offset to the telescope. AOS will issue the proper commands to fulfill the request. No acknowledge will be provided (AO-Sup will be able to check the pointing status in the related variables as soon as they are updated by AOS).

2.2.15 OffloadModes

This command is issued by the AO System to request the TCS Arbitrator to offload accumulated errors[8]. AOS will issue the proper commands to the TCS.

3 Variables

3.1 TCS variables reflected in `RTDB`

AOS will maintain a number of variables updated into `RTDB` (see table 5, providing proper refresh when needed. Variable update will be implemented by polling the `DD` at a constant rate of approximately 2 Hz.

Note that most of the variables names actually correspond to data structures including several items.

[8] Note that this is specific of ENGINEERING service status. See section 2.2.5.

Variable	Type	Description
AOSVersion	String	A string specifying the version of AOS software.
TelStatus	Struct	Status of the telescope. This is a block of data representing the telescope status as recorded in the TCS. AO-Sup will use this value to know which operations are allowed at any time.
TelPointingEqu	Float	Current pointing equatorial coordinates. These include both "target" and "achieved" AR and DEC.
TelPointingAlt	Float	Current pointing alt-azimuth coordinates.
HexapodPos	Float	Current hexapode position
RotatorPos	Float	Current rotator angle
TertiaryPos	Float	Current tertiary position
Environment	Struct	A block of data with current environment and weather information (temperature, pressure, humidity wind speed and direction, and the like)

Table 5: Variables in RTDB

Variable	Type	Description
AOVersion	String	Version of AO-Sup
AOServStat	String	Current AO service status. TCS subsystems may use this value to know whether they are allowed to operate the AO System. One of the values of this variable will be STANDALONE which means that AOS must not attempt to do any operation on the AO System.
AOStatus	String	Current AO System operating status. It specifies current mode of operation ("FIX-AO", "TTM-AO", "ACE-AO", "ICE-AO", are possible values) and related parameters.
ImageQuality	Float	Image quality statistics. They are meaningful only while operating in close loop.
OffModes	Float	Low order modes which could be offloaded by some telescope device. These values may be used by instrument software to command TCS to adjust the pointing when needed (see also section 2.2.5).
OffFlags	Boolean	Flags indicating which modes are approaching limit conditions (see also section 2.2.5).

Table 6: Variables in DD

3.2 AO System variables reflected in DD

The set of variables which describe the status of the AO system are listed in table 6. They are updated as needed by AOS by means of the variable change notification mechanism provided by RTDB.

4 Watchdog security

In order to cope with possible failures either in the software or in the hardware (e.g.: in the network connections) AO-Sup and AOS will periodically send each other a special echo request and wait for

a reply with a suitable timeout. If the request is not replied within the given time frame both AO-Sup and AOS will go into error condition and take proper safe actions. This, obviously, will happen only when the current service status involves communication between AO-Sup and AOS (i.e.: in OBSERVATION and ENGINEERING service modes).

5 Status transitions

In the following sections we describe the steps followed by both AO-Sup and AOS to initiate (or reply to) a change of service status.

5.1 Initial Rendez-vous

Because AO-Sup and AOS are loosely coupled and there is the need to operate AO-Sup without a working TCS and vice-versa, to avoid deadlocks the initial rendez-vous will proceed as follows:

1. AO-Sup is normally waiting for connections from clients. So it will accept a request for connection from AOS at any time, independently on its current service status. Any AO-Sup component which may request service from AOS must anyway check that AOS is ready before proceeding.
2. When starting AO-Sup will create an `AOServStat` variable in `RTDB` with an initial value STANDALONE.
3. AOS at start will connect to `MsgD` and wait for `AOServStat` to be created. When the variable becomes available it will read the value. As long as the service status is not OBSERVATION AOS must simply wait for a change of variable value.
4. When AO-Sup is ready to proceed (i.e.: has performed all intial cheks and initializations of the hardware devices it will go to READY service status. This is actually a "point of switch" from where the AO system may proceed to either the OBSERVATION status (following a request issued by the AOS) ot to some servicing status: ENGINEERING or STANDALONE (following a request from the operator at the AO Console).
5. As soon as AOS is notified by AO-Sup of service status change to either ENGINEERING or OBSERVATION, it will create the TCS variables into `RTDB`, copy the initial values of AO-Sup variables into `DD` and then will notify to `MsgD` that it is ready.

After this initialization AO-Sup and AOS will start performing the required tasks.

5.2 Driving AO-Sup in READY service status

During normal operation, after initialization, the AO System will proceed to READY service status in order to be ready either for a request from the operator at the AO Console or for a `StartAO` request issued by AOS.

The READY service status will also be restored when the AOS will issue a `Terminate` command at the end of an observation.

Finally an operator at the AO Console will be able to return the system to READY status at the end of maintenance operations, performd in either STANDALONE or ENGINEERING mode.

5.3 Shutting down TCS

Whenever the TCS must shut down, for any reason it will send either a `Terminate` command or a `UserPanic` command to AO-Sup (see sect 2.1), according to the reason for TCS shutdown.

The AO System will perform the operations necessary to properly stop current work and return to READY status.

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