ICD between AT Control System and Field Stabilization Sensor and M6 sub-systems

Issue 2.0 – 06/05/1999

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This document is intended to be used as a base for discussion to define the interfaces between the AT Control System and the Field Stabilization Sensor (FSS, STRAP System) and M6.

It describes how we intend to use the FSS from the ATCS and is based on the meeting of 28/01/1999 and on the meeting of 23/03/1999 (when a first issue of this same document has been discussed), so that we can verify that our assumptions are correct and modify whatever is necessary.

All the sections included in this proposal are or will be part of ATCS official documents (requirement, specification, design or interface documents).

It contains the following sections:

- Architectural description of the ATCS Field Stabilization and Chopping subsystems, describing how we intend to use internally the described interfaces.
- Use Cases
  Use Cases describe step by step how the ATCS interacts with external subsystems. We have included here all Use Cases related with the FSS and the M6
- Preliminary ICD between ATCS and FSS and M6

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2 Architecture

The real-time control of the Field Stabilization Sensor and of the M6 is deployed in the Sensor LCU. This same LCU is also responsible for controlling the FSS Translation Stage and having it tracking the guide star.

The tasks installed and running on this LCU are responsible for:

- Field Stabilization (and Auto Guiding)
- Chopping
- M6 position control
- FSS tracking

It is necessary that all required functions for the APD and M6 control are directly available at the LCU level, since we have no possibility, for architecture and performance reasons, to send commands from the LCU back to a workstation.

The LCU will host 3 real-time control loops that will be synchronized one each other. It will also host the FFS Translation Stage tracking control loop.

To perform some operations and in particular during system configuration and maintenance, it will be necessary to have the APD working both in:

- Closed loop, i.e. sending actual corrections to M6
- Open loop, i.e. performing all necessary calculations and calculating error vectors, but without sending corrections to M6

It will be also necessary to have "single shot" exposures, where an error vector is calculated for a single exposure (it could actually give better results to have it calculated as the mean over a small number of exposures, but this should be transparently handled).

It is also necessary in many different occasions to convert in both directions between M6 coordinates and sky coordinates. A convenient way to perform these conversions using the currently installed Interaction Matrix (or its inverse matrix) should be provided (TO BE DISCUSSED).

2.1 Field stabilization control loop

The STRAP system is directly responsible for the control of M6 in closed loop during Field Stabilization.
The ATCS Field Stabilization software needs anyway to periodically check the operation of the STRAP System and stop it if necessary.
The ATCS Requirements specify the need of synchronizing the acquisition system with the guiding loop.
This FS monitoring loop is synchronized with the STRAP diagnostic loop and NOT with the STRAP closed control loop, that has much higher frequency.
The synchronization procedure with the STRAP diagnostic loop must be analyzed in detail. It is important:

- To warrant that a coherent set of diagnostic data can be read (no write while reading)
- To measure timing jittering and maximum delay for the delivery of dignostic data.

The diagnostic data loop will be used for real time synchronization and must be very well characterized.
There are two possible ways for synchronization:

- A user function (name defined via database) is called at every cycle and receives the diagnostic data in the parameters buffer. This is done on the TCCD software and works quite well.
- A database flag is written when new data is available. To avoid that data is overwritten, a semaphore flag should be added or a minimum time delay before overwriting should be defined.

Depending on the performance of the FSS Translation Table tracking, it might be necessary to interpolate the Guide Reference Point between two updates of the FSS Translation Table position. See FSS Translation Stage Control Loop for details.

On the UTs, this is implemented between the TCCD system and the AG/FS loops by means of a user-defined function hook.
The details of the hook function are application specific, the interface is TBD (shall try to match the existing one). The function shall have access to the actual parameters describing the data acquired during this cycle (error vector, SNR, FWHM etc...).

- The STRAP can accept as configuration parameter the name of a hook function
- This function, if defined, is called by STRAP at each cycle of the control loop (both in open loop and close loop), after having evaluated the error vector.
- The function must return as soon as possible, in order not to affect the STRAP control loop performances.

On the ATCS FS control loop side:

- Typically the hook function just delivers the useful data in a proper memory area and releases a semaphore used to trigger the next iteration of the FS control loop.
- The FS control loop waits on this semaphore for a new error vector to be delivered.
- When the semaphore is released, it retrieves the error vector coordinates and can process them without interfering with the APD control loop.

The Field Stabilization Control Loop is also responsible for:

- Coordination with chopping
- Coordination with the FSS Translation Table tracking software
- Setting the APD reference point offset, if tracking FSS Translation Table will track stepwise and not continuously (TBC).

2.2 Chopping control loop

The chopping control loop will be running every time chopping is active at the selected chopping frequency.
It is responsible for:

- Opening the STRAP control loop whenever the M6 must be moved in OFF (sky) position.
  This will be done by software control or using the digital gate control line.
- Chopping M6, i.e. moving it between the two positions as configured.
- Handle M6 alignment offsets that define the logical center position based on the optical alignment.
- Keep track of the nominal offset of M6 at any time, i.e. of the fact that M6 logical center position depends on the current chopping phase.

The control loop must ensure that offsets to M6 are sent during field stabilization only with the loop open, to avoid counter reaction from the STRAP control loop.

2.3 M6 control loop

In order to compensate for possible tracking drift, the M6 control loop runs at low frequency and is responsible for keeping M6 near its (logical) center position, so as avoid the risk of reaching the limits. The absolute tilt angles of M6 are queried by the M6 Control Loop and opposite corrections are sent to the telescope altitude and azimuth axes as autoguiding offsets. The STRAP control loop will bring M6 back to the center automatically, since M6 is much faster than the main axes.

3 Use Cases

Field Stabilization

3.1 Use Case: Start Field Stabilization

Description: The Field Stabilization Loop is started with the current configuration parameters, after having checked that all start conditions are satisfied. Optionally, a preliminary exposure can be requested to automatically measure the position of the guide star and move the XY Translation Stage to the measured position.
If the system is already in closed loop when a START is received, it continues with no error indication.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: FSS Strap, TRS
Priority: Major
Performance: A couple of seconds
Frequency: After each preset when guiding is enabled with field stabilization, or at any time manually during operation while tracking or for test purpose.
Preconditions:

- FS is Idle
- FSS Strap is ONLINE
- Coude Beam Switching device allows light path to FSS
  (*Interface: IfBeamSwitchingDevice.Encoder.ReadoutPosition*)
- Guide star available
- Guiding Reference point is set
- M6 is ONLINE

Basic Course:

- Send command to start Field Stabilization.
  Variations:
    - Use **`STARTAG`** command to immediately start Field Stabilization
    - Use **`BOX2GS`** measure the error vectors and counter offset the XY Translation Stage of the same amount.

  Exception Course: Command failed
- ATCS Checks Autoguiding Conditions at start for field stabilization
  Exception Course: Command failed
- ATCS Prepares FSS Setup with selected setup configuration in continuous closed loop and M6 correction
- ATCS Starts FSS Acquisition in Closed Loop sending command STRTCLP
  Exception Course: Command failed
- ATCS launches a TRS timer with the given period for the Field Stabilization Loop
  Exception Course: Command failed
- ATCS waits for the loop to be stable (see Issue 1).
- Optionally (BOX2GS)
    - retrieve the M6 offset from center position
    - counter offset the x-y table of the same amount. The M6 is kept in close loop and goes back automatically to center position. In this way the probe is centered on the guide star.
- ATCS returns OK reply

Exception Course: Command Failed

- ATCS returns ERROR reply
  Postcondition: FS is Idle

Postconditions: These are postconditions that validate the goal of the use case.

- FS is active
- TRS timer is running
- M6 is receiving tilt corrections from FSS Strap

Issues to be Determined or Resolved:

Issue 1: It must be defined how should we wait for the loop to be stable: should we wait for a fixed time, or better should we use some diagnostic? What? Suggestions please….

Notes:

- Autoguiding and Field Stabilization are **mutually exclusive**, since only one detector is used for both. The Auto Guider sends the corrections to the Axis while alternatively FS sends corrections to M6 that in turn recenters itself on 10 second period by sending the corresponding corrections to the Axis.
  It is the same scheme as for the UTs, having M6 playing the same role as M2 for the UTs (see M6 Control Loop).
- START and STOP commands are used during nodding and during combined offsets, since I all these cases FS must be paused while the telescope and the XY table move to the new position. They have then to be restarted and we assume that probe positioning during these telescope movements is very good and no new guide star acquisition is necessary.
- See AG/FS Analysis for UTs The algorithm for differential refraction handling (different wavelength of target and guide star) could be taken from the UT adapter/rotator implementation.
- The AG/FS system currently in use on the UTs has not been properly analyzed (M.Ravensbergen never had the time to perform a complete and meaningfull analysis of the control loops involved).
  The system produces very clear positive effects when it is active, but is for sure not optimized and could be improved a lot with a proper tuning based on an analysis.
  Very good improvements on the unit telescopes could be obtained with adaptive integration time algorithms like the ones in STRAP.
- The BOX2GS option can be used to correct for catalogue error, but probably the telescope pointing will not be accurate enough to ensure the tight pointing requirements (some 0.02-0.05 arcsec) needed for the interferometric instrument. It will be then necessary to use for VLTI reference stars which coordinates are very well known (Hypparcos catalogue) and rely on these coordinates rather than on the telescope pointing. More over, the object itself will be used as much as possible to Field Stabilize and in that case the probe position shall not be adjusted.

Last modified: Fri Apr 9 08:56:17 METDST 1999

3.2 Use Case: Stop Field Stabilization

Description: Stop Field Stabilization As soon as Field Stabilization is stopped, M6 goes directly to center position. The center position is defined as (0,0) plus the offset value set in the SETUP database branch.

Use Case Type: Concrete

Role(s)/Actor(s):

Primary: Operator/Maintenance

Secondary: FSS, TRS

Priority: Major

Performance: A couple of seconds

Frequency: Before a preset when field stabilization was active, or at any time manually or when FS conditions are not met.

Preconditions:

- FSS sub-system is ONLINE

Basic Course:

- Send command **`STOPAG`** to stop the Field Stabilization
  Exception Course: Command failed

- ATCS **`Stop FSS Acquisition`**
  Exception Course: Command failed
- ATCS cancels the TRS timer for the Field Stabilization Loop
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- FS is idle

Issues to be Determined or Resolved:
Notes: The STOPAG command is used to stop both Auto Guiding and Field Stabilization, wich ever of the two is active when the command is active.
No action occurs if none is active.
See Stop Autoguiding. The two Use Cases could/should be merged in a single one taking care os the different possibilities.
During Field Stabilization, the FAS is always active in fill screen mode, so it is not necessary to explicitely switch it on as a step of the Use Case.
Last modified: Thu Apr 8 15:33:26 METDST 1999

3.3 Collaboration Case: Move Probe to Guide Star

Description: This collaboration case is responsible for moving the probes (CCD window and FSS Translation Stage) to the location of the selected guide star.
Performance: some milli-seconds
Frequency: Any time
Preconditions:

- ATCS is ONLINE
- GS coordinates are available

Basic Course:

- Call Use Case with (alpha, delta) coordinates for the probe.
- ATCS **`Set FSS Filter Wheel`** too select the neutral density filter according to the magnitude of the GS, using a lookup table based on magnitude provided by STRAP.
  Exception Course: Command failed
- ATCS **`Set FSS Aperture Field Diaphgram`**
  Exception Course: Command failed
- ATCS Sets the Guide Reference Point
  Exception Course: Command failed
  Postcondition1: FAS Reference point is set
  Postcondition2: FSS Translation Stage in position and tracking
- ATCS Prepares the FAS setup :
  - Infinite Loop
  - Full frame
  - Display
  - No computation
  - UIT set according to the magnitude of the GS (TBD)

  Exception Course: Command failed
- ATCS Starts Field Acquisition
  Exception Course: Command failed
- ATCS Set APD Gate to 100%
- ATCS Start APD initialization procedure (**Add Use CASE: this evaluates and set the APD temperatures and performs a set of initialization and optimization procedures based on the current image seen by the APD).**

- Optionally, start APD centering procedure. **(Add Use Case: in this procedure the STRAP moves around the M6 following a snake trajectory to identify the actual position of the guide star. During this phase it is necessary to check for the gate level and the overcount flag. In case of overcount, a darker neutral must be selected and the procedure restarted. This type of error should anyway occur very seldom, since the tolerance of he system covers two magnitudes. As an alternative, the FSS Translation Stage could be moved in a snake instead of the M6. In this way the image would not move).**

Exception Course: Command failed

- ATCS returns ERROR reply.

Postconditions: These are postconditions that validate the goal of the use case.

- Probes are located on the GS.
- FAS CCD displays field

Issues to be Determined or Resolved:

- In order to select the proper Neutral Density Filter, the magnitude of the guide star must be available. A lookup table based on magnitude will be provided by strap. ATCS must foresee the usage of this table for guide stars selected via a catalogue, i.e of known magnitude. For guide stars selected via the FAS, a formula or a lookup table to get the proper filter given FAS (exposure time, counts) must be foreseen.
- It has to be defined how the FSS Field Diaphragm has to be set.
- A couple of Use cases (or Collaboration Cases) (see previous notes) will have to be added to handle APD initialization and guide star locking. These procedure must be available to the operator for manual operation of the field stabilisation, via the user interfaces, but will also be used by the automatic guide star acquisition procedures at presed. How and when they will be actually used automatically will have to be defined for final design taking into account that:
    - We have to be cautios not to move M6 (and as a consequence the image) while and instrument can be taking images. This limits the possibility of using the automatic APD centering procedure.
    - The positioning of the XY Translation Stage should be precise enough to make the usage of the locking procedure not necessary

Notes:

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3.4 Collaboration Case: Field Stabilization Control Loop

Description: The Field Stabilization Loop is triggered by a timer and is responsible for updating the Interaction Matrix on the FSS Strap for field rotation compensation.

Priority: Major

Performance: TBD

Frequency: Up to 10 Hz

Preconditions:

- ATCS is ONLINE Tracking and Guiding
- FSS sub-system is ONLINE
- FS is active
- TRS timer is running

Basic Course:

- TRS timer trigger. This FS monitoring loop is sybchronized with the STRAP disgnostic loop and NOT with the STRAP closed control loop, that has much hugher freuency.
- ATCS Checks Autoguiding Conditions (for field stabilization). Typically this check is not performed at every loop, but with a lower frequency.
  Exception Course: Guiding conditions not met
- ATCS Computes Interaction Matrices.

- ATCS Updates Interaction Matrix on FSS Strap
  Exception Course: Command failed
- ATCS Retrieve and Check Error Vector from FSS Strap
  Exception Course: No error vector
- Depending on the performance of the FSS Translation Table tracking,
  it might be necessary to interpolate the Guide Reference Point between two updates of the FSS Translation Table position (TBD):
  Subflow: Update Guide Reference Point

Exception Course: No error vector

- ATCS logs an error
- ATCS checks for too many consecutive invalid error vectors
  (to allow for temporary failures, like in the case of a cloud passing by).
  Exception Course: Too many errors

Exception Course: Too many errors

- ATCS Stops Field Stabilization

Subflow: Update Guide Reference Point

- ATCS interpolates/computes the actual Guide Reference Point for FSS Strap APD
- ATCS Prepare FSS Setup with new Guide Reference Point
- ATCS Sends FSS setup to FSS Strap
  Exception Course: Command failed

Exception Course: Guiding conditions not met

- ATCS logs an error
- ATCS Stops Field Stabilization

Exception Course: Command failed

- ATCS logs an error
- ATCS Stops Field Stabilization

Postconditions: These are postconditions that validate the goal of the use case.
- Interaction Matrix is updated
- FS is active

Issues to be Determined or Resolved:
Action M.Comin, with support from G.Chiozzi:
The synchronization procedure with the STRAP diagnostic loop must be analyzed in detail. It is important:
- To warrant that a coherent set of diagnostic data can be read (no write while reading)
- To measure timing jittering and maximum delay for the delivery of dignostic data.

The diagnostic data loop will be used for real time synchronization and must be very well characterized.
There are two possible ways for synchronization:
- A user function (name defined via database) is called at every cycle and receives the diagnostic data in the parameters buffer. This is done on the TCCD software and works quite well.
- A database flag is written when new data is available. To avoid that data is overwritten, a semaphore flag should be added or a minimum time delay before overwriting should be defined.

Note 1: Depending on the performance of the FSS Translation Table tracking,
it might be necessary to interpolate the Guide Reference Point between two updates of the FSS Translation Table position. See FSS Translation Stage Control Loop for details..

Note 2: For next iteration, add the UC that catch the FSS Translation Table alarm indicating the vicinity of the limit (end of possible tracking).
This UC shall include the following steps:
Basic Course:

- ATCS Stops Field Stabilization
  Exception Course: Command failed
- ATCS sends Probe to Next Guide Star
  Exception Course: Command failed
- ATCS re-Starts Field Stabilization
  Exception Course: Command failed

Last modified: Thu Apr 8 14:42:00 METDST 1999

3.5 Use Case: Display Guide Detector Signals

Description: The image of the Field Acquisition Sensor or of the Field Stabilization Sensor is read with the requested frequency and displayed. In the case of the Field Stabilization Sensor, no real image is available, but a proper representation (TBD) of the measured error vectors, guide star intensity and other statistical parameters related to the operation of the APD sensor will provide the same level of logical information. If autoguiding/field stabilization is not active, it is possible to switch ON/OFF the display dynamically. If autoguiding is active, this is not possible. In this case, the display shall be switched ON/OFF setting the proper SETUP keyword when starting Autoguiding. The FAS is normally always active and with the display switched on since all Autoguiding and Field Stabilization commands take care of properly switching ON the display of the Guide Detector Field. The display of the FSS image can be switched ON/OFF independently from the FAS, but with the same limitations.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: FAS, FSS Strap
Priority: Desirable
Performance: a few seconds
Frequency: Whenever requested
Preconditions:

- AG & FS are IDLE
- FAS sub-system is ONLINE
- FSS Strap is ONLINE
- Coude Beam Switching device allows light path to FAS and/or FSS Strap (*Interface: IfBeamSwitchingDevice.Encoder.ReadoutPosition*)

Basic Course: Switch ON/OFF display while idle

- Send command to switch ON display with setup configuration for FAS or FSS
  Exception Course: Command failed
- ATCS Prepares FAS Setup with selected setup configuration in continuous loop and full frame mode
  Alternate Course: ATCS Prepares FSS Setup with selected setup configuration in continuous loop and no M6 correction
  Exception Course: Command failed
- ATCS Starts Field Acquisition
  Postcondition: FAS active : full frame + display
  Alternate Course: ATCS Starts FSS Acquisition
  Postcondition: FSS Strap is collecting data
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- FAS active full frame
- FSS Strap active
- FAS images and/or FFS Strap data are visualized

Issues to be Determined or Resolved:
Notes:
The current implementation of the TCCD SW does not allow to switch ON/OFF on the fly, during an infinite loop of exposures, the display of images. The switching of display is linked to the Start/Stop commands.
The STRAP SW will provide a panel editor class implementing this display and usable in ATCS graphical user interfaces. The panel class will be defined by STRAP SW people.
Last modified: Fri Apr 9 08:50:50 METDST 1999

3.6 Use Case: Set Guide Parameters

Description: Configure setup parameters for the configuration of FAS, FSS STrap, Autoguiding and Field Stabilization. The main parameters are:

- integration time
- guiding loop cycle time
- minimum number of counts on detector, for default integration time

It is not possible to change dynamically configuration parameters while Autoguiding, with the exception of the integration time and the guide reference point, that can be modified at any time by using the UC Set Integration Time for FAS and Set Guide Reference Point.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator,Maintenance
Priority: Critical
Performance: 1 second
Frequency: Whenever requested
Preconditions:

- AG/FS are IDLE

Basic Course:

- Send command to set Autoguiding setup parameters
  Exception Course: Command failed
- ATCS stores new parameters in setup configuration for AG/FS
- ATCS Prepare FAS Setup
  Alternate Course: ATCS Prepare FSS Setup
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- New setup parameters stored in setup configuration to be used for next StartAg/StartFs

Issues to be Determined or Resolved:
Notes:
Last modified: Fri Apr 9 08:06:56 METDST 1999

3.7 Use Case: Set Guide Reference Point

Description: With this function the user can define the sky coordinates in (alpha,delta) of the reference point on the Field Acquisition Sensor used for Autoguiding. The reference point is mapped on the pixel on the CCD to be used as a reference for error vector calculations.
The same coordinates are used to position the FSS Translation table for Field Stabilization.
This reference point shall be updated automatically during observation to take into account changes in the differential atmospheric refraction
between the observing and the guiding wavelength.

Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: FAS, FSS Strap
Priority: Major
Performance: 1 second
Frequency: At any time
Preconditions:

- FAS is ONLINE
- FSS Strap is ONLINE

Basic Course:

- Send new sky coordinates in (alpha, delta) for Guide Reference Point
  Exception course: Command failed
- ATCS stores and converts the Guide Reference Point coordinates to FAS / FSS coordinates
- ATCS Prepare FAS Setup with updated Guide Reference Point coordinates for the FAS
  Exception Course: Command failed
- ATCS Sends FAS Setup with updated values
  Exception Course: Command failed
- ATCS Prepare FSS Setup with updated Guide Reference Point coordinates for the FSS
  Exception Course: Command failed
- ATCS Sends FSS Setup with updated values
  Exception Course: Command failed
- ATCS Preset FSS Translation Stage to new sky position
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions:

- New guide reference point coordinates are available for Autoguiding or Field Stabilization.

Issues to be Determined or Resolved:
Notes: In the case of the Field Stabilization, the FSS Translation Table will be placed at the field position corresponding to the specified pixel in the Field Acquisition sensor. In this way, both FAS and FSS have the same object coordinates.
Notice that the FFS APD itself has a "reference point", but with a completely different meaning: in order to allow guiding for a while without moving the FFS Translation Table, it is possible to specify an offset between the center of the APD and the position of the guide star. The system will then do field stabilization keeping this offset, instead of centering the guide star on the ADP.
Last modified: Thu Apr 8 14:30:48 METDST 1999

Chopping

3.8 Use Case: Start Chopping

Description: Starts Chopping with mirror M6
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: VLTICS-ISS, Maintenance
Secondary: TRS
Priority: Major
Performance: 1 second
Frequency: At any time
Preconditions:

- ATCS is ONLINE
- Chopping configuration parameters are valid and available

Basic Course:

- Send command to start chopping
  Exception course: Command failed
- ATCS loads the chopping parameters
- ATCS launches a TRS timer with the given period for the Chopping loop
  Exception Course: Command failed
- ATCS configures Guiding (if applicable) to support guiding while chopping
  Exception course: Command failed
- ATCS sets Chopping Phase to ON
- ATCS returns OK reply and UTC of next ON phase

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- Chopping active
- Guiding (if applicable) takes chopping into account

Issues to be Determined or Resolved: How are instruments informed that chopping has started and how do they synchronize.
Notes:...
Last modified: Thu Apr 8 15:06:54 METDST 1999

3.9 Use Case: Stop Chopping

Description: Stops chopping on mirror M6
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: VLTICS-ISS, Maintenance
Secondary: TRS
Priority: Major
Performance: 1 second
Frequency: At any time
Preconditions:

- ATCS is ONLINE
- Chopping is active

Basic Course:

- Send command to stop chopping
  Exception course: Command failed
- ATCS waits Chopping phase is ON
- ATCS cancels the TRS timer associated to the Chopping Loop
  Postcondition: Chopping Loop is Idle in ON phase
  Exception course: Command failed
- ATCS return OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- Chopping inactive

Issues to be Determined or Resolved:
Notes:
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3.10 Use Case: Configure Chopping

Description: Configure chopping parameters (like throw, offset, orientation, frequency, peak-valley-ratio).
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Priority: Major
Performance: Some seconds
Frequency: At every change of chopping parameters
Preconditions:

- ATCS is ONLINE

Basic Course:

- Send command to configure chopping parameters
  Exception course: Command failed
- ATCS checks and stores chopping parameters for next start of chopping
  Exception course: Invalid configuration parameters
- ATCS returns OK reply

Exception Course: Invalid configuration parameters

- ATCS returns ERROR reply
  Postcondition: Chopping configuration is not updated

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- Chopping configuration parameters are checked and stored

Issues to be Determined or Resolved:
Notes:
Last modified: Thu Apr 8 15:06:55 METDST 1999

3.11 Collaboration Case: Chopping Control Loop

Description: The chopping control loop is triggered by a timer and is responsible for coordinating the chopping cycles.
A chopping cycle consists in 2 phases ON and OFF during which M6 is:
- **ON** : aligned on the GS (*star* phase) and
- **OFF**: off the star (*sky* phase).

The switch takes a couple of milli-seconds.
When FS is active, no correction shall occur in OFF phase.
Performance:
Frequency: Up to 5 Hz.
Chopping requirements have to be carefully analysed and the requirements for the STAP closed loop imposes limits on the chopping frequency:
- Currently the goal is to reach 5Hz chopping frequency by using just the ATs.
- Typically:
  - 5/8 STRAP loop cycles are necessary to close the loop
  - with a 17th mag star on ATs, 12 ms integration time are necessary
- Typically then about 100 Ms are necessary to close the loop
- Remain then only 100 Ms per cycle for science purposes

Preconditions:

- ATCS is ONLINE
- M6 is ONLINE
- FSS Strap is ONLINE
- TRS timer is running
- Chopping configuration parameters are valid and available

Basic Course:

- TRS timer trigger
- ATCS Computes Interaction Matrix
  Exception Course: Command failed
- ATCS performs chopping step depending on the chopping phase
  Subflow: Chop phase ON
  Exception Course: Command failed
  Subflow: Chop phase OFF
  Exception Course: Command failed

Subflow: Chop phase ON (*star* position)

- ATCS converts the chopping parameters to M6 tilt angles for the *star* position
- ATCS Set M6 Tilt Angles back to *star* position
  Exception Course: Command failed
- ATCS enables FS corrections on FSS Strap in setting the APD gain to the appropriate value.
  - ATCS Prepare FSS Setup with proper FSS Strap gain
    Exception Course: Command failed
  - ATCS Sends FSS Setup
    Exception Course: Command failed
- ATCS sets Chopping Phase to ON

Subflow: Chop phase OFF (*sky* position)

- ATCS converts the chopping parameters to M6 tilt angles for the *sky* position
- ATCS inhibits FS corrections on FSS Strap in setting the APD gain to ZERO.
  - ATCS Prepares FSS Setup with FSS Strap gain = 0
    Exception Course: Command failed
  - ATCS Sens FSS Setup
    Exception Course: Command failed
- ATCS Set M6 Tilt Angles to *sky* position
  Exception Course: Command failed
- ATCS sets Chopping Phase to OFF

Exception Course: Command failed

- ATCS Stops Field Stabilization
- ATCS logs the error
  Postcondition: Chopping is stopped

Postconditions: These are postconditions that validate the goal of the use case.
- M6 Chopping cycles are performed

Issues to be Determined or Resolved:
ACTION MCO JFA:
- Verify the exact sequence of actions to be performed when switching from object to sky and from sky to object It should be something like:
  - Object to sky:
    - Set offset for sky position in STRAP DB
    - Send SETUP to STRAP
    - Open the loop (set gate to 0 ????)
  - Sky to object

        - Set offset for center position in STRAP DB
        - Send SETUP to STRAP
        - Close the loop (set gate to 100 ????)

    It is not really clear WHEN the new offset is applied to M6: is when the SETUP is received or when the loop is closed and it is not clear if the behaviour is the same when closing and opening the loop.
    The sequence must be tested and defined such that it is warrantied that M6 switches between the two positions with the loop always open and that the loop is closed only after it has reached the object position.
- Measure the time needed to receive and handle the order to change between object and sky, including the mirror settling time. It must be possible to settle a stable chopping loop, with a defined jittering and with sinchronized opening and closing of the loop. Instruments using chopping will not receive any control signal when the mirror chops, but will trust the absolute times calculated using the chopping parameters and measured using the time bus.
- Verify the possibility of having STRAP handling 2 offsets instead of one:
    - a centering offset to define (0,0) position
    - a positioning offset to define the chopping position

    Both these offsets are always superimposed to the offset introduced by the STRAP closed control loop.

Ideally when switching from object to sky, we should just set the chopping offset and the mirror should go:

where it is now + chopping offset

i.e. it should take into account the eventual mirror drift (typically due to tracking errors or to long wind buffets) accumulated up to that time, instead of jumping simply to the chopping offset position. This would degrade the repeatibility of the positioning after switching from sky to obj or from obj to sky.

Notes:

Last modified: Thu Apr 8 15:06:53 METDST 1999

Field Stabilization / APD Sensor

3.12 Use Case: Start FSS Acquisition

Description: Start the APD measurements
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: FSS Strap
Preconditions:

- FSS Strap is ONLINE
- FSS setup is available for the requested APD configuration

Basic Course:

- Send command **`STARTOLP`** | **`STARTCLP`** to start the FSS Strap System
- ATCS Sends FSS setup configuration to FSS Strap
  Exception Course: Command failed
- ATCS Sets APD Gate to 100%
  Exception Course: Command failed
- ATCS starts APD measurements

  - **Subflow:** in Open Loop
  - **Subflow:** in Close Loop

  (*Interface: IfFss.Control.Start*)
  Exception Course: Command failed
- ATCS returns OK reply

Subflow: in Open Loop

- ATCS starts APD Cycles with Open APD Loop
  *Postcondition:*FSS Strap cycles performed in Open Loop (No M6 correction)

Subflow: in Close Loop

- ATCS starts APD Cycles with Close APD Loop
  *Postcondition:*FSS Strap cycles performed in Close Loop (with M6 corrections)

Exception Course: Command failed

- ATCS returns ERROR reply
  Postcondition: FSS Strap is idle

Postconditions: These are postconditions that validate the goal of the use case.
- FSS Strap active in Open or Close Loop
- FSS Strap data available

Issues to be Determined or Resolved: The beahviour of the M6 as controlled by the APD system must be still analyzed on more details. This will most probably cause modifications in the FSS and M6 Use Cases and the introduction of new Use Cases for the M6.
ACTION MCO: Verify the following points regarding the interaction of the STRAP system with the M6:
- the actual sequence to be used at FSS Acquisition STOP time is:
  - Set the gate to 0
  - Open the loop

  or

    - Open the loop
    - Set the gate to 0
- that M6 actually goes to the defined center position, using properly the defined offset from (0,0)
- if the offset position is applyed:
    - As soon as the SETUP with the new offset is sent
    - When the loop is OPENED/CLOSED

  This has an impact on the implementation of chopping, as will be discussed in the following sections.
- what happens when the gate is set to 0 ?
    - M6 stays in previous position (should be!)
    - M6 goes to defined offset position
- is it the same when the loop is open or closed?
- what is the behavious when the loop is opened/closed?

  Notes:
  Last modified: Fri Apr 9 09:31:10 METDST 1999

3.13 Use Case: Stop FSS Acquisition

Description: Stop the APD measurements setting the APD gate to 0 and opening the APD loop.
As soon as the loop is open M6 goes automatically to center position. The center position is defined as (0,0) plus the offset value set in the SETUP database branch.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator/Maintenance
Secondary: FSS Strap
Preconditions:

- FSS Strap is ONLINE

Basic Course:

- Send command **`STOP`** to stop the FSS Strap System
  Exception Course: Command failed
- ATCS Sets APD Gate to 0%
  Exception Course: Command failed
- ATCS Opens APD Loop
  Exception Course: Command failed
- ATCS sends command to stop FSS Strap System
  (*Interface: IfFss.Control.Stop*)
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- FSS Strap is idle

Issues to be Determined or Resolved: The beahviour of the M6 as controlled by the APD system must be still analyzed on more details. This will most probably cause modifications in the FSS and M6 Use Cases and the introduction of new Use Cases for the M6.
ACTION MCO: Verify the following points regarding the interaction of the STRAP system with the M6:
- the actual sequence to be used at FSS Acquisition STOP time is:
    - Set the gate to 0
    - Open the loop

  or

    - Open the loop
    - Set the gate to 0
- that M6 actually goes to the defined center position, using properly the defined offset from (0,0)
- if the offset position is applyed:
    - As soon as the SETUP with the new offset is sent
    - When the loop is OPENED/CLOSED

  This has an impact on the implementation of chopping, as will be discussed in the following sections.
- what happens when the gate is set to 0 ?
    - M6 stays in previous position (should be!)
    - M6 goes to defined offset position
- is it the same when the loop is open or closed?
- what is the behavious when the loop is opened/closed?

  Notes:

  Last modified: Fri Apr 9 09:36:55 METDST 1999

3.14 Use Case: Prepare FSS Setup

Description: Prepare the configuration setup for FSS
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Priority: Critical
Performance: 1 second
Frequency: At any time
Preconditions:

- ATCS is ONLINE

Basic Course:

- Send command to prepare the FSS setup
- ATCS parses and checks the FSS setup
  Exception Course: Check failed
- ATCS stores the FSS setup
  Exception Course: Command failed
  Postcondition: FSS setup is available
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Exception Course: Check failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- FSS setup is available

Issues to be Determined or Resolved: List of setup parameters for APD
Notes:
Last modified: Fri Apr 9 09:57:31 METDST 1999

3.15 Use Case: Send FSS Setup

Description: Send the configuration setup to the FSS Strap
Use Case Type: Abstract

Role(s)/Actor(s):
Secondary: FSS Strap
Priority: Critical
Performance: 1 second
Frequency: At any time
Preconditions:

- ATCS is ONLINE
- FSS setup is available

Basic Course:

- Send command to send the setup to the FSS
- ATCS sends the setup to FSS Strap
  (*Interface: IfFss.Configuration*)
  Exception Course: Command failed
  Postcondition: FSS setup is available for next FSS activation
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- FSS setup is available for next FSS activation

Issues to be Determined or Resolved:
Notes: The procedure to SETUP a STRAP configuration consists now in:
- Writing the new SETUP parameters in the corresponding database attributes in the STRAP LCU branchdedicated to this purpose
- Send "read new setup". **Action MCO: please provide details and complete list of parameters.**

We have to keep in mind the following considerations:
- Most parameters are immediately applied, also in closed loop, as soon as SETUP is processed.
- Some parameters are not applied in closed loop
- The user (ATCS) has to write directly in the database branch to set the values:
  - This is not nice and one or more commands would be preferred
  - PDU has some concerns about performances, since every SETUP processes all parameters
  - To protect the database, the attributes that can be set could be "made public" providing an include file with defines for the database symbolic (or alias) addresses. All other attributes are not public and they do not appear in any public include file. This is done for the CCD SW.

Last modified: Fri Apr 9 09:59:18 METDST 1999

3.16 Use Case: Set FSS Aperture Field Diaphragm

Description: Set the Field Stabilization Aperture Field Diaphragm to the requested aperture diameter. This action is invoked during normal operation to minimize the sky background effects on the servo-loop..
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: FSS
Priority: Major
Performance: TBD
Frequency: At any time
Preconditions:

- FSS is ONLINE

Basic Course:

- Send command **`SETAFD`** ***`<diameter>`*** to set the FSS Aperture Field Diaphragm to given diameter
  Exception Course: Command failed
- ATCS sends command to FSS sub-system
  (*Interface: IfFssFieldDiaphragm.Motor*)
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply
  Postcondition: FSS Aperture Field Diaphragm not moved

Postconditions: These are postconditions that validate the goal of the use case.
- FSS Aperture Field Diaphragm at given diameter

Issues to be Determined or Resolved: FSS Aperture Field Diaphragm diameter range
Notes:
Last modified: Fri Apr 9 12:57:52 METDST 1999

3.17 Collaboration Case: Open APD Loop

Description: Open the APD loop. The APD sensor continues to acquire photons and compute the diagnostics but no correction is sent to M6.
Performance: some milli-seconds
Frequency: At any time
Preconditions:
- FSS Strap is ONLINE

Basic Course:

- ATCS sends command to open the APD loop
  Exception Course: command failed

Exception Course:

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
The APD loop is open. No correction is sent to M6.
Issues to be Determined or Resolved:
Notes:
Last modified: Thu Apr 8 11:56:28 METDST 1999

3.18 Collaboration Case: Close APD Loop

Description: Close the APD loop. The APD sensor acquires photons, compute the diagnostics and sends correction to M6.
Performance: some milli-seconds
Frequency: At any time
Preconditions:
- FSS Strap is ONLINE
- High voltage is ON.
- APD gate is not 0.

Basic Course:

- ATCS sends command to close the APD loop
  Exception Course: command failed

Exception Course:

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
The APD loop is closed. Corrections are sent to M6.
Issues to be Determined or Resolved:
Notes: Typically 5 to 8 exposures are needed for the loop to converge.
Last modified: Thu Apr 8 11:56:28 METDST 1999

3.19 Collaboration Case: Set APD Gate

Description: Set the APD gate to the required value (0 to 100%). This gate controls the APD sensor and shall be set to zero whenever the APD is not used in order to protect it.
Performance: some milli-seconds
Frequency: At any time
Preconditions:

- FSS Strap is ONLINE

Basic Course:

- ATCS sets the APD gate to the required value
  (typically 0 or 100%)
  Exception Course: set failed

Exception Course:

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
The APD gate is set to the requested value.
Issues to be Determined or Resolved:
Notes:
Last modified: Thu Apr 8 11:56:27 METDST 1999

3.20 Collaboration Case: Update Interaction Matrix

Description: Update the Interaction Matrix for the coordinate conversion between APD and M6.
Priority: Major
Performance: TBD
Frequency: TBD
Preconditions:

- ATCS is ONLINE
- FSS Strap sub-system is ONLINE

Basic Course:

- Send command to update the IM on the FSS Strap sub-system
  Exception Course: Command failed
- ATCS updates the IM on the FSS Strap sub-system
  (*Interface: IfFss.Configuration.InteractionMatrix*)
  Exception Course: Command failed
- ATCS returns OK

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- FSS Strap Interaction Matrix updated

Issues to be Determined or Resolved:

Notes:

Last modified: Thu Apr 8 15:06:55 METDST 1999

FSS Translation Stage

3.21 Use Case: Set FSS Translation Stage

Description: Set the FSS Translation Stage position.
This action is *used* by the FSS Translation Stage Control Loop that updates periodically the XY position of the translation stage so as to keep on tracking the center of the APD device on the computed trajectory of the guide object (on-axis object itself or off-axis guide star).
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Maintenance
Secondary: FSS Translation Stage
Priority: Major
Performance:
According to IFSBA description of the FSS support (VLT-TRE-IFS-151100-032) and for a telescope plate scale of 318 um/arcsec:

- Positioning resolution: 1um, i.e. 0.0031 arcsec.
- Positioning accuracy:
    - 3um rms over 1 mm displacement, i.e.
      0.0094 arcsec over 3.14 arcsec displacement
    - 30um rms over 40 mm displacement, i.e.
      0.094 arcsec over 125.8 arcsec displacement
- Maximum translation speed: 1.6mm/s in X and Y, i.e 0.005arcsec/s

Frequency: Pseudo periodically, up to 1 Hz
Preconditions:

- FSS sub-system is ONLINE

Basic Course:

- Send command **`SETXYT <X, Y>`** to move FSS translation stage to (X,Y) position
  Exception Course: Command failed
- ATCS sends command to FSS translation stage
  (*Interface: IfFssTranslationStage*)
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply
  Postcondition: No motion

Postconditions: These are postconditions that validate the goal of the use case.

- FSS XY translation stage at given position

Issues to be Determined or Resolved:

- Update period: TBD
- Type of positioning : absolute or relative?
- Position units: sky coordinates in arcsec, or XY coordinates in milli/micrometers?

Notes: We consider a telescope plate scale of 318 um/arcsec. Close to the zenith, the max. field rotation is approximatively 1500"/s thus the linear velocity at the edge of the translation stage (20mm from center) is then up to approx. 0.15mm/s (0.00047 arcsec/s).
The APD device allows linear measurement within a radius of up to 4mm (0.126 arcsec) around the center position.
This means at least about 30s before the off-axis star moves out of the APD measurement domain.
The error vector E is computed as the distance between the actual position of the star S and the center C of the APD device plus the difference between the actual Tanslation Stage center position with its computed trajectory R. Thus: E = vector(CS) + vector(RC)
The appropriate ratio between Translation Table position update rate and accuracy of the error vector

must be determined considering the bandwidth of the Translation Table drives and the FS frequency. Example: for a guide star located 10mm off the optical axis on the APD plane, the maximum field rotation speed is 0.07mm/s. If then the max. distance to the APD center is set to 1mm (0.0031 arcsec), the update rate of the Translation Table position is once every 10 to 15 seconds.
For on-axis guiding, solely the differential refraction must be considered. The Translation Table position may then not need to get updated since all the compensations may be handled by computation.
Last modified: Fri Apr 9 12:59:03 METDST 1999

3.22 Collaboration Case: FSS Translation Stage Control Loop

Description: The FSS XY-Translation Stage control loop is responsible for the tracking of the FSS Translation Stage on a Guide Star. It is triggered by a timer positions the XY-table so that the center of the APD sensor is kept on the trajectory of the object in the Coudé focal plane. At every iteration, the reference position of the FSS XY Translation Stage in (alpha, delta) sky coordinates is converted in (X,Y) coordinates taking into account the current telescope position, the pointing model and differential refraction effects due to the difference in wavelength between the object and the guide star.
Priority: Critical
Performance: TBD
Frequency: TBD
Preconditions:

- ATCS is ONLINE
- FSS Translation Stage is ONLINE
- TRS timer is running

Basic Course:

- TRS timer trigger
- ATCS computes new (X,Y) table center position from reference (alpha,delta) and UTC
  Exception Course: FSS Translation Stage in limit vicinity
- ATCS Set FSS Translation Stage (X,Y) coordinates.
  Exception Course: FSS Translation Stage on limit
  Exception Course: Command failed

Exception Course: FSS Translation Stage in limit vicinity

- ATCS raises an Alarm (see Note2 in FS Control Loop)

Exception Course: FSS Translation Stage on limit

- ATCS cancels the associated TRS timer
- ATCS logs an error and terminates

Exception Course: Command failed

- ATCS cancels the TRS timer
- ATCS logs an error and terminates

Postconditions: These are postconditions that validate the goal of the use case.

- FSS Translation Stage position updated

Issues to be Determined or Resolved:
The sky (alpha, delta) reference position for the guide star is set by using the Preset FSS Translation Stage Use Case. This position is retrieved at every iteration and converted in (X,Y) table coordinates. Behavior in case of not valid coordinates, i.e. of coordinates outside the area reachable by the FSS Translation Stage is still to be defined.
Notes:

The Translation Stage is a tracking axis and its behavior is very similar to the adapter/rotator of the Unit Telescopes: the difference between the sky positions of the telescope (i.e. of the observed object) and of the guide star are used to calculate the (x,y) position of the table with respect to the center of the field.
The XY table positioning accuracy and positioning speed should be good enough for all our guide star tracking needs (see Set FSS Translation Stage Use Case for details on requirements and expected performance).
If not, we have to exploit the possibility of applying an offset to the APD center position, so that we:

- Move the XY table in discrete steps
- Between two positions we interpolate and use an offset in the APD.

This feature is not foreseen in the current STRAP and can be asked as a new feature in an already planned extension of the contract with the manufacturer of the system.
The problem is how to calculate the unbalancing in the APD reads to match a defined offset. These values depend strongly on the observing condition and will require some development. Also a calibration procedure will be necessary. All this cannot be foreseen for the current release of STRAP.
In the next iteration, the UC responsible of catching and handling the alarm *FSS Translation Stage in limit vicinity* shall be introduced.

Last modified: Thu Apr 8 15:06:55 METDST 1999

M6

3.23 Use Case: Center M6

Description: This action sends the mirror M6 back to its center position.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: M6
Priority: Critical
Performance: TBD
Frequency: At every preset to a new target.
Preconditions:

- M6 is ONLINE

Basic Course:

- Send command to center M6
  Exception Course: Command failed
- ATCS sends center command to M6 sub-system
  (*Interface: IfM6.Centering.Center*)
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.

- M6 at Center position

Issues to be Determined or Resolved: None
Notes: None
Last modified: Thu Apr 8 11:41:19 METDST 1999

3.24 Use Case: Set M6 Tilt Angles

Description: Set M6 tilt angles
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: M6
Priority: Critical
Performance: TDB
Frequency: Any time during maintenance operation
Preconditions:

- M6 is ONLINE
- FS is inactive

Basic Course:

- Send command to tilt M6
  Exception Course: Command failed
- ATCS sends tilt angles to M6
  (*Interface: IfM6.Tilting.SetAbs IfM6.Tilting.SetRel*)
  Exception Course: Tilt angles too big
  Exception Course: Command failed

- ATCS returns OK reply

Exception Course: Tilt angles too big

- The tilt angles are too big and would send M6 to limit
  Ignore correction
  ATCS returns ERROR reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- M6 Tilt axis are set to the new angles

Issues to be Determined or Resolved: None
Notes: None
Last modified: Thu Apr 8 11:41:19 METDST 1999

3.25 Use Case: Get M6 Tilt Angles

Description: Get M6 tilt angles. This case is used whenever required by FS or VLTICS-ISS/INS.
Use Case Type: Concrete
Role(s)/Actor(s):
Primary: Operator, Maintenance
Secondary: M6
Priority: Critical
Performance: TDB
Frequency: At any time
Preconditions:

- M6 is ONLINE

Basic Course:

- Send command to retrieve M6 tilt angles (alpha,beta)
  Exception Course: Command failed
- ATCS sends the command to M6 sub-system
  (*Interface: IfM6.Tilting.GetAbs*)
  Exception Course: Command failed
- ATCS returns OK reply

Exception Course: Command failed

- ATCS returns ERROR reply

Postconditions: These are postconditions that validate the goal of the use case.
- M6 tilt angles are returned

Issues to be Determined or Resolved: None
Notes: None
Last modified: Thu Apr 8 11:41:19 METDST 1999

3.26 Collaboration Case: M6 Control Loop

Description: The M6 Control Loop is triggered by a TRS timer and is responsible for sending regularly correction offsets to the main axes
corresponding to the actual M6 tilt angles so as to re-center M6, thus avoiding the risk of reaching a limit. If chopping is active, it will take into account that re-centering while in the OFF (sky position)

chopping phase, means to actually put M6 in the nominal chopping sky position with respect to the center.
Priority: Critical
Performance: As fast as possible
Frequency: 0.1 Hz
Preconditions:
- ATCS is ONLINE Tracking and Guiding
- FSS is ONLINE
- M6 is ONLINE
- FS is active

Basic Course:
- TRS timer trigger
- ATCS Get M6 Tilt Angles
  Exception Course: Command failed
- ATCS Computes (Inverse) Interaction Matrix
- ATCS converts M6 Tilt Angles to (alpha,delta) offsets
  Subflow: Chopping active and chop phase OFF (sky position)
- ATCS performs an Autoguider Offset to correct telescope axes of (alpha,delta)
  Exception Course: Command failed

Subflow: Chopping active and chop phase OFF (sky position)
- ATCS subtracts from the calculated (alpha,delta) offsets the component due to the fact that the M6 is currently in the OFF chopping position. The new calculated (alpha,delta) correspond to the nominal chopping position with respect to the M6 center position.
- ATCS Set M6 Tilt Angles to the new values computed in the previous step
  Exception Course: Command failed

Exception Course: Command failed
- ATCS Stops Field Stabilization
- ATCS logs an error

Postconditions: These are postconditions that validate the goal of the use case.
- M6 is recentered
- Offsets sent to main axes

Issues to be Determined or Resolved: It must be analyzed again in detail how the feedback loop to compensate with the telescope the M6 drifts due to trakcing errors will be, in particular during chopping.
D.Bonacini notices that a 0.1Hz loop is more reasonable than the 1Hz loop currently used for the unit telescopes, since it is probably much too fast and atmosphere effects cannot be averaged out.
A big difference between this system and the UT FS loop based on M2 control is that:
- On the UT we just read periodically the ABSOLUTE M2 position and we correct for that
- Here we can use the average M6 position, calculated by strap, removing the high frequency motion due to atmosphere and leaving only the actual drift.

This last approach seems much better and should be implemented also on the UTs. We will try to retrofit the system in and upgrade phase.
It is anyway required that the calculation of the average, i.e. the dignostic loop, is synchronized with the chopping and with the M6 control loop.
Notes:
Last modified: Thu Apr 8 15:06:54 METDST 1999

4 Preliminary ICD

4.1 Sensor LCU

4.1.1 LCU Configuration

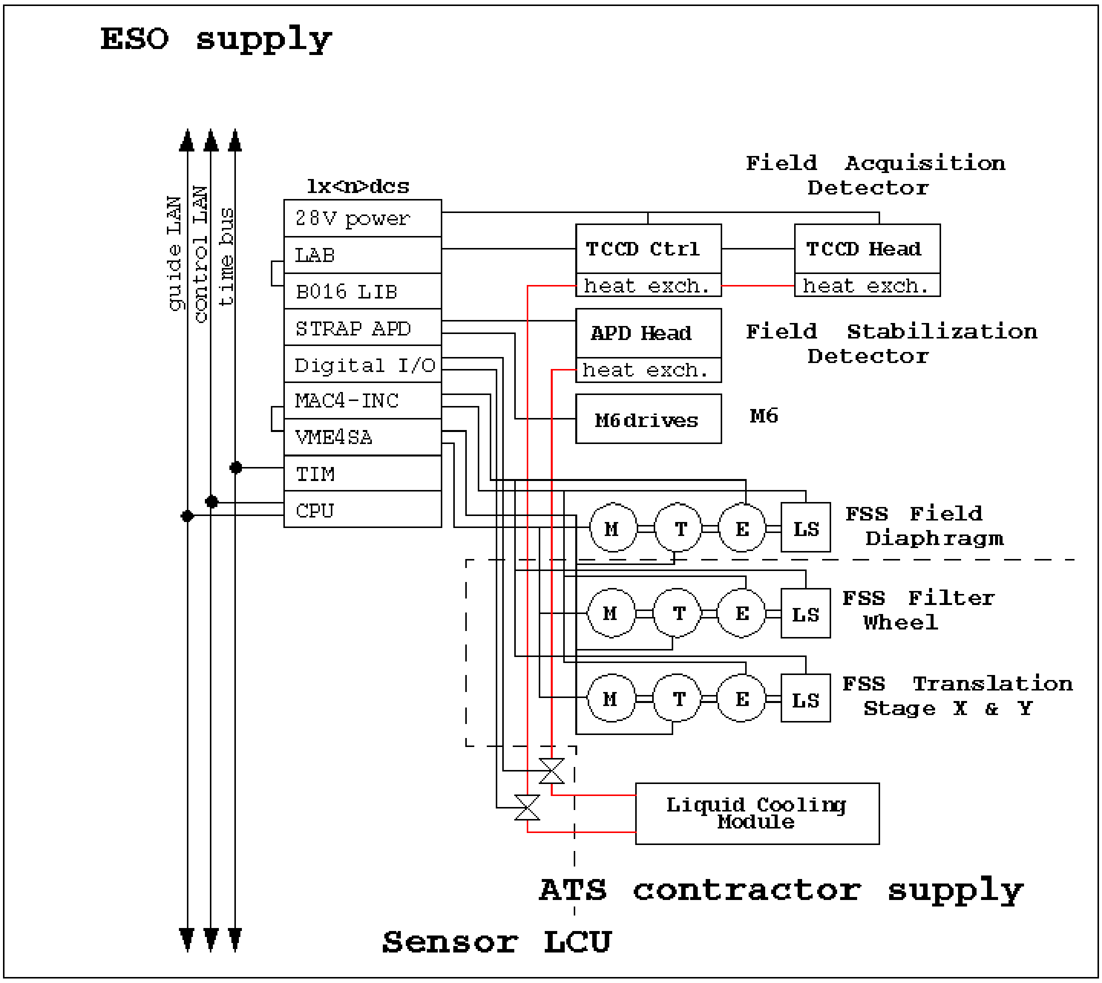
- ***CPU board: Motorola MVME 2604 (PowerPC, 333MHz, 32MB/64MB)***
- ***TIM board: ESO***
- ***STRAP VME control board (APD)***
- ***Guide/Acquisition LAN: Ethernet***
- ***TCCD boards: LIB (INMOS BO16) + LAB***
- ***Digital I/O Interface: Acromag AVME 9481***
- ***28V power supply (for TCCD)***
- ***Motion Controller: MACCON MAC4-INC***
- ***Servo Amplifier: ESO VME4SA-01***

This ICD specifies to use the couple ESO VME4SA servo amplifier and MACCON MAC4 motion controller (both supplied by ESO) for the implementation of the control.
One set of boards is necessary on this LCU to host the control of the FSS Filter Wheel, FSS Field Diaphragm and the FSS Translation Stage X- & Y-axes.
This LCU is responsible for:

- ***Field Acquisition System*** (FAS)
- ***Field Stabilization System*** (FSS)
- ***M6*** (to be replaced by Deformable Mirror)
- FSS Filter Wheel
- ***FSS Field Diaphragm***
- FSS Translation Stage

The field acquisition system, the field stabilization system and the M6 drives and the Field Diaphragm as shown on the Figure below belong to the ESO delivery. There is for that part only a mechanical interface existing (see 6.3).

Schematic:



Last modified: Tue Mar 30 07:37:12 METDST 1999

4.1.2 *Field Stabilization System (FSS)*

- ***Field Stabilization System (FSS)***
  Control of the Field Stabilization System components (detector, real time electronics, and communication link to M6).
- ***The control is deployed on the Sensor LCU.***
- ***This sub-system belongs to the ESO delivery and is not part of the AMOS contract.***

Field Stabilization System interfaces:

The applicable documents for the FSS interface are [AD 03] and [AD 04].

From:	*To:*	*Layout:*	*Function:*	*Type:*
			CONFIGURATION:	
LCU	*ATS*	*STRAP Static Configuration (Can not be modified while APD is active)*	*Static parameters:* • *Open/Close loop* • *APD Gain* • *Diagnostic sampling period* • *Number of cycles* • *Hook-function name* • *etc ... (TBD)*	*SW Command*
LCU	*ATS*	*STRAP Dynamic Configuration*	*Dynamic parameters:* • *Guide Reference Point*	*SW Command*

		(May be modified while APD is active)	• *Interaction Matrix* • *Gate for APD gain control* • *etc ... (TBD)*	
			CONTROL:	
LCU	***ATS***	***Start STRAP***	***start APD acquisition with current configuration***	***SW Command***
LCU	***ATS***	***Stop STRAP***	***stop APD acquisition***	***SW Command***
LCU	***ATS***	***Gate APD gain***	***turn gate on/off for APD gain control (used in chopping mode when alternating between object and sky)***	***SW Command or Digital Output. Digital I/O board pin TBD***
LCU	***ATS***	***Update Interaction Matrix***	***update interaction matrix (for derotating M6 corrections)***	***SW Command***
LCU	***ATS***	***Request Interaction Matrix***	***retrieve actual interaction matrix***	***SW Command***
LCU	***ATS***	***Update Reference Point (see Note 1 below)***	***update the APD reference point***	***SW Command***
			STATUS & DIAGNOSTICS:	
ATS	***LCU***	***STRAP Status***	***get STRAP status***	***SW Command / DB attribute***
LCU	***ATS***	***STRAP Diagnostics***	***request measurement diagnostics*** <u>***Diagnostics parameters:***</u> • ***r0, t0, FWHM, SNR, centroid, extrema*** • ***etc ... (TBD)***	***SW Command / DB attribute***
LCU	***ATS***	***Error Vector (see Note 2 below)***	***request the instantaneous Error Vector***	***SW Command***
			SYNCHRONIZATION:	
LCU	***LCU***	***Function Hook (see Note 3 below)***	***hook a user-defined function synchronous to the APD control loop***	***API Function***

Note 1: ***The guide reference point is theoretically the optical center of the APD sensor. Since the FSS Translation Stage is a tracking axis, its position will be updated while tracking. However, it might be necessary to interpolate its position between 2 updates. This is achieved by offsetting the APD reference point synchronously with the Translation Stage control loop. The offset shall be less than 1/2 Airy disk (i.e. approx. 0.2" on the sky) so as not to*** **loose** ***the object.***
Note 2: ***In order to compensate for tracking drift, the absolute offset of M6 is queried by the M6 Control Loop and sent to the telescope Alt/Az axes. The relative slow correction speed of the main axes allows not to recenter M6 but let the FS loop closed and active, that will bring M6 back to the center.***
Note 3: ***The ATCS Requirements specify the need of synchronizing the acquisition system with the guiding loop. On the UTs, this is implemented between the TCCD system and the AG/FS loops by means of a user-defined function hook that is invoked at each exposure. The details of the function are application specific, the interface is TBD (shall try to match the existing one). The function shall have access to the actual parameters describing the data acquired during this cycle (error vector, SNR, FWHM etc...).***

Last modified: Thu Mar 18 09:08:06 MET 1999

4.1.3 *M6 drives*

- ***M6 (to be replaced by Deformable Mirror)***
  Control of the High Frequency M6 tilt motions, required for field stabilization and

chopping. For Adaptive Optics, the M6 will be replaced by a deformable mirror controlled by appropriate electronics.

- ***The control is deployed on the Sensor LCU.***
- ***This sub-system belongs to the ESO delivery and is not part of the AMOS contract.***

Note: ***this device is controlled by the STRAP system. We need anyway the following command commands for centering and tilting M6. They will be defined in the interfaces with STRAP.***

M6 drives interfaces:

From:	To:	Layout:	Function:	Type:
			CENTERING:	
LCU	***ATS***	***Center M6***	***Send command to center M6***	***SW Command***
			TILTING:	
LCU	***ATS***	***M6 absolute (alpha, beta) tilt angles setting***	***Sets absolute M6 tilt angles (alpha, beta) in radians (two separate commands, one per axis)***	***SW Command***
LCU	***ATS***	***M6 relative (alpha, beta) tilt angles setting***	***Set relative M6 tilt angles (alpha, beta) in radians (two separate commands, one per axis)***	***SW Command***
ATS	***LCU***	***M6 absolute (alpha, beta) tilt angles readout***	***Get absolute M6 tilt angles (alpha, beta) in radians (two separate commands, one per axis)***	***SW Command***

Last modified: Tue Mar 16 13:55:26 MET 1999

4.1.4 *FSS Aperture Field Diaphragm*

- ***FSS Aperture Field Diaphragm***
  Control of the Aperture Field Diaphragm before the FSS detector.
  The set motor + tacho is connected to the ESO standard VME4SA Servo Amplifier and MAC4 Motion Controller. The tacho generator is mounted on the motor. The velocity loop is closed in the amplifier. There are two switches; one of them is used as a reference switch.

  The motor control is a pure SW interface: the target reference position and Velocity are passed to the Motion Controller via the VME bus. The motor control software is provided by ESO.

- ***The control is deployed on the Sensor LCU.***

FSS Aperture Field Diaphragm interfaces:

From:	*To:*	*Layout:*	*Function:*	*Type:*
			MOTOR:	
LCU	***ATS***	***Motor power control***	***Motor power lines***	***VME4SA Servo Amplifier. Power Output pins***
			TACHOGENERATOR:	
ATS	***LCU***	***FSS Field Diaphragm velocity control readout***	***Tacho generator signals***	***VME4SA Servo Amplifier. Tacho Input pins***
			ENCODER:	
ATS	***LCU***	***FSS Field Diaphragm encoder position readout***	***Relative encoder position of FSS Filter Wheel axis in counts***	***MAC4-INC Motion Controller. Encoder Input pins***
			SWITCHES:	
ATS	***LCU***	***Reference Switch***	***contact closed when reference switch is reached (hysteresis, backlash TBC)***	***MAC4-INC Motion Controller. Reference Switch Input***

				pin.
ATS	***LCU***	***Switch #2***	***contact closed when switch is reached (hysteresis, backlash TBC)***	***TBC***

Last modified: Tue Mar 16 09:34:09 MET 1999