



Appendix A

ASDM Tables, Current Proposal

Communication with TelCal through the established mechanisms and proper documentation of the [ALMA](#) data requires the creation of a new [ASDM](#) Table, `CalAppPhase` as described in Section [A.1](#). Documentation of existing types appears in [\[RD10\]](#). A discussion appears in Section [A.2](#).

A.1 CAL APP Phase

This table, shown in Table [A.1](#), provides the results of the TelCal phase calculation on the “slow” timescale loop, *i.e.* at the end of a subscan and based on the data within that subscan following the last “slow” phase adjustment.

Adjustments to a number of phasing loop parameters such as the composition of the phased array, the choice of reference antenna, or the optimal comparison antenna will be made through the `ParameterTuning` interface. When made, these are advisory to TelCal and are intended to take affect for the processing of subsequent scans and are then reflected in this table. Complete descriptions of the columns follow:

basebandName : For [ALMA](#), a baseband pair is the signal path identified by a second local oscillator, and has two polarizations. For the [APP](#), this corresponds to the two [PICs](#) in one quadrant. This will be one of `BB_1` through `BB_4` or `BB_ALL` if all four quadrants are operated identically.

startTime : The start of the interval in which the phase solution was calculated, *i.e.* at the beginning of the “valid for TelCal” portion of the subscan.

calDataId : Provides a link to the `CalData` table containing information about the data used to produce the result (*e.g.* scan number).

calReductionId : Provides a link to the `CalReduction` table which contains information concerning the data reduction.

endTime : The end of the interval in which the phase solution was calculated, *i.e.* the end of the last subscan.

startValidTime : The phase data shall be considered invalid for application before this time.

endValidTime : The phase data shall be considered invalid for application after this time.

tuningTime : The time of the last adjustment to the phasing analysis via the `ParameterTuning` interface.

tuningToken : A parameter supplied via the `ParameterTuning` interface to indicate the form of adjustment made.

phasingMode : The mode in which the phasing system is being operated; see Section [A.2](#).



Table A.1: CalAppPhase ASDM Table

Name	Type(Shape)	Comment
<i>Key</i>		
basebandName	BasebandName	identifies the baseband
startTime	ArrayTime	start of phase interval
calDataId	Tag	refers to a unique row in Cal-Data Table
calReductionId	Tag	refers to a unique row in CalReduction Table
<i>Required Data</i>		
endTime	ArrayTime	end of phase interval
startValidTime	ArrayTime	time-bound on validity
endValidTime	ArrayTime	time-bound on validity
tuningTime	ArrayTime	time of last tuning
tuningToken	string	tuning token
phasingMode	string	applicable phasing mode
numPhasedAntennas	int	N_p , number in phased sum
phasedArray	string [N_p]	phased antennas
refAntennaIndex	int	index ($0..N_p-1$) of the reference antenna in phasedArray
candRefAntennaIndex	int	index ($0..N_p-1$) of a candidate (new) reference antenna in phasedArray
quality	float [N_p]	quality of phased antennas
numValues	int	N_v , number of data values
phaseValues	float [N_v]	array of phase data values
numChannels	int	N_d , number of data channels
numCompare	int	N_c , number of comparison antennas
compareArray	string [N_c]	comparison antennas
compAntennaIndex	int	index ($0..N_c-1$) of the comparison antenna in compareArray
candCompAntennaIndex	int	index ($0..N_c-1$) of a candidate (new) comparison antenna in compareArray
efficiency	float [$N_d \times N_c$]	efficiency of phased sum
phasedSumAntenna	string	the phased sum antenna
<i>Optional Data</i>		
numSupports	int	N_s , number of supporting data values
phaseSupports	float [N_s]	array of supporting data values

phasingType : Indicates one of several possibilities for converting the phase data into **TFB** commands; see Section [A.2](#).

numPhasedAntennas : The number of antennas included in the phased sum.

phasedArray : The names of the antennas contributing to the phased sum.

refAntennaIndex : The index of the reference antenna in **phasedArray**.

candRefAntennaIndex : TelCal may recommend the adoption of a candidate (new) **refAntenna** with this entry. Note that the **VOM** may not adopt the recommendation.

quality : A normalized figure of merit expressing the quality of the solution for each of the **phasedArray** members.



- numValues** : The number of phase data values present in the table; see Section [A.2](#).
- phaseValues** : An array containing the phase data values.
- numChannels** : The number of data channels for which efficiency data is presented.
- numCompare** : The number of antennas not included in the phased sum.
- compareArray** : The names of the antennas not in the phased sum, which could be used as comparison antenna. The array of available antennas has $(N_p + 1 + N_c)$ members; N_p are in the phase-sum, one *is* the phased-sum, and N_c are not.
- compAntennaIndex** : The index of the comparison antenna in **compareArray** used in efficiency or quality measurements.
- candCompAntenna** : TelCal may recommend the adoption of a candidate (new) **compAntenna** with this entry. Note that the [VOM](#) may not adopt the recommendation.
- efficiency** : An array of normalized efficiencies for the phased sum for each data channel. The **compAntenna** values are to be used for decisions; the other values are advisory.
- phasedSumAntenna** : The name of the antenna whose data is discarded in favor of the phased sum. The antenna is also known as **cai63Antenna**. The efficiency is measured through the correlation of this antenna with the **compAntenna** or its peers.
- numSupports** : The number of supporting data values present.
- phaseSupports** : An array of N_s supporting data values. The presence and use of this array is unspecified, but might include channel average frequencies or supplementary **quality** data as an assist in the implementation.

A.2 ASDM Discussion

In order to work with the existing TelCal infrastructure, it is necessary to define a new table so that phasing activities can be processed by TelCal and documented in the [ASDM](#). Since this table are small, infrequent and new, the impact on other consumers of the [ASDM](#) (*e.g.* [CASA](#)) should be nonexistent, and the impact on [ALMA](#) (disk space or communications bandwidth) trivial.

Note that aside from this table, TelCal will receive important instructions through another interface, the **ParameterTuning** interface. These include the **sourceModel** and algorithm to be used for phasing the array and are made on a per-[VLBI](#) scan basis. Also adjustments to the phasing array calculations will be made through this interface as circumstances change. The [ASDM](#) table provides information (time and type) of such modifications.

The design of the phasing system is such as to allow future implementations to exceed the capabilities of the current scope; thus this table has been defined with an eye for flexibility beyond the current [APP](#) project scope. Equally, provision is made to allow some evolution within the current project scope to proceed without invalidating this table. For the present, all needs can be met with a character string, **phasingMode**, which specifies to all consumers of this table how the data was derived, and how to interpret the data values. As a practical matter, the string token provides a relatively small number of bits of information (see discussion in Section [5.4.1](#)) and could as well be implemented as an enumeration or an **int** with bits defining certain choices in which of the implemented capabilities to use:

Active/Passive/Model at least 2 bits

use-WVR/no-WVR 2 bit (also: relative or absolute)

use-RDC/no-RDC 1 bit

Simple/Complex at least 1 bit



and independent of these, an enumerator of different data packing formats used to interpret `phaseValues`. Some obvious choices are:

- one phase per polarization per channel-average per antenna,
- four phases per antenna (*i.e.* a delay-like solution in two polarizations),
- 2×32 -phases per antenna, or
- any of the above, but with additional parameters supplied to allow some secular variation, *e.g.* a slow variation of phase with time.

Generally speaking, TelCal would be providing one phase per channel-average datum, but as there are 32 `TFBs` per polarization, there are situations where it is desirable to provide more channel-averages than needed, or fewer phase solutions than channel averages. So an allowance for these cases is also in the mix. The channel average frequency spectral window is in any case available to TelCal as input, so it need not be provided in this table; but to a user of the `CalAppTable` (other than the main user, control/correlator) the link to the channel average spectral window through the (`calDataId` + `basebandName`) is a little intricate, so the frequencies could be explicit here as optional data (as a component of the `phaseSupports` data which is more generally cast to allow other usage).

The `APP` project is planned to always operate in a dual-polarization mode, but potentially some projects might choose to work with just one polarization. If so, flagging that is yet another consideration. In addition to that consideration, in the “Complex” case where the `CDP` nodes are assigned a perform fitting on the “fast” cycle, this table could be used to provide those nodes the expected phases in the source model and, *e.g.* the antenna weighting or the matrix to be used in the least-squares-fit solution process. These notions are discussed in [RD2]; most likely the `APP` project will only implement the “Simple” mode with one phase per channel-average.

Finally, the `quality` parameter is intended to allow simple heuristics (*e.g.* threshold based) to be used automatically to adjust the optimal set of antennas used for phasing. TelCal can compute this based on RMS residuals of the fit, for example. However there may be other choices. The `phasingMode` would be a place to indicate what method was chosen. (The command choice would be made the `ParameterTuning` interface.)

It is currently envisioned that TelCal would provide calculation of the existing phase error rather than the value of correction to be made. That is TelCal is providing a report of the phase error per polarization per antenna for the `CCC` to correct. (The alternative of providing the correction is algebraically identical; however this choice is probably less confusing—TelCal tends to report how things are, rather than how to make things otherwise.)

A.3 Additional ASDM Modifications

In addition to this ASDM table we need to extend two enumerations: `ScanIntent` should accommodate two more entries: `CALIBRATE_APPPHASE_ACTIVE` (indicating continuous phasing on strong target source) and `CALIBRATE_APPPHASE_PASSIVE` (indicating monitoring of phasing for a weak target source). The enumerator `CalType` should have one more entry: `CAL_APPPHASE` (calibration result type, referenced by the `ASDM Scan` table).

Note however, that we are in the process of reconciling our needs with those which the `VLA` has already used (see Section 4.1.3, so the precise set of changes is not established at this time.)