

Major Scientific Milestones

1. Start of Scientific Commissioning
2. Start of Early Science
3. Inauguration
4. Completion of Construction

In addition we should track two other very important markers:

- a. First Call for Proposals
- b. 66 antennas in service.

The first of these is obviously of the highest importance to the user community and the second corresponds to the previous “Start of Full Operations” and is therefore kept in the list to provide continuity.

Definitions / Requirements

Start of Scientific Commissioning

Three antennas operational on the high site

Front-ends containing at least bands 3,6,7 & 9

Cal units with hot and ambient loads

Complete BE and phase stable¹ LO system

Correlator able to process three inputs

Fringes and phase closure demonstrated

Software for basic operations and data reduction

Note that several important but not absolutely vital items have been left out here: e.g. water vapour radiometers and solar filters.

Other items might not be the final versions, e.g. calibration loads, FE power supplies, or not completely characterized, e.g. FE's.

¹A reasonable goal at this stage would be 1 radian of phase in 30 minutes at 300GHz.

Definitions / Requirements

Start of Early Science

- At least sixteen 12m antennas fully commissioned.
- Receiver bands 3, 6, 7, and 9 available on all antennas plus bands 4 and 8 on as many antennas as we can manage.
- Sufficient antenna stations to provide a range of configurations covering the shortest spacings out to at least 1 km.
- Synthesis mapping of single fields plus pointed mosaic mode.
- A basic set of spectral modes, including numbers 70, 7, 9, 12 and 18 in the table. (This set was already selected by ASAC.)
- Linear and circular polarization of compact sources.
- Single-dish mapping of extended objects in both continuum and spectral line modes including on-the-fly observing.
- Calibration of all the above to a level comparable with existing millimetre-wave arrays – requires hot/ambient loads and WVRs.
- Software to support users' applications, the preparation and execution of observations and off-line data reduction.

Commission activities continue after the start of Early Science, which requires simultaneous operation with at least 2 subarrays.

Definitions / Requirements

“Inauguration” (proposed new milestone)

This will mark the point at which ALMA has qualitatively reached its full capabilities, although not all of the antennas will be completely kitted-out by this stage. We expect that the facility will be scheduled for scientific observations for about 75% of the time at this point.

Requirements

- Regular operation with ≥ 50 fully-equipped¹ antennas. (This includes both 12m and 7m antennas.)
- All antenna stations complete, providing synthesis mapping with high fidelity using the full set of array configurations.
- Simultaneous operation of ≥ 4 subarrays possible.

¹ Fully-equipped means a minimum of four receiver bands – typically bands 3, 6, 7, and 9 plus some of 4, 8 and 10, plus a full set of electronics, radiometers and calibration devices.

Definitions / Requirements

Inauguration Requirements (continued)

- Capability for combining data from the 12m array with data from the ACA including “zero-spacing” data, and multi-configuration images
- Linear and circular polarization, including mosaicing of sources that are larger than the primary beam.
- High time resolution observations, e.g. of solar flares.
- All major software systems available, making ALMA fully useable by astronomers who are not synthesis experts¹.
- Accurate calibration of all the above.

The goals set for the calibration of ALMA data are very stringent and we may not achieve all of them by this point, but we must be doing a lot better than is currently achieved at these wavelengths.

Some capabilities will still be under development at this stage – e.g. on-the-fly aperture-synthesis mosaics, high-precision polarization maps of extended sources, and some of the less popular correlator modes .

¹At this stage ALMA staff will still be performing a lot of data verification but the users will receive the images ready for analysis & interpretation.

Definitions / Requirements

End of Construction

- By definition this occurs when all the items defined in the current baseline have been delivered and accepted.
- This should clearly include a full sets of spare components and resolution of substantial non-conformities in the performance of all major components and sub-systems.

For practical reasons it may be necessary to exclude some items from this so that the construction effort can be wound up at an appropriate time. The most obvious case is the final deliveries of the band 10 cartridges, which were only recently given approval.

Additional Major Markers

First Call for Proposals

This will go out when we have progressed far enough with the integration and commissioning to be confident that we will be ready for the Start of Early Science in 8 months time.

The deadline for these proposals will be 2 months after the call, allowing 6 months for assessment and for the preparation of the detailed observing plans.

After this we will move on to a regular cycle of calls for proposals, each of which will include a description of the capabilities that are expected to be available in the relevant observing period.

66 Antennas in Service

Although this will of course be an key moment for everyone involved, this point does not mark a qualitative change in ALMA's scientific capabilities. The main reason for including it is to maintain continuity with the previous schedule.

This occurs when we have commissioned all 66 antennas with full sets of electronics and FE's with at least bands 3,6,7 and 9.

Second-level Scientific Milestones

In addition to the major milestones, the following important steps will be tracked and reported to the community. They will not necessarily happen in this order

- Astronomical Signals with an ALMA Antenna and ALMA Front-End.
- Astronomical Fringes with two ALMA Antennas FE's, and Correlator. (Presumed to be at the OSF.)
- Astronomical Fringes at the high site.
- Phase Closure with three antennas at AOS.
- Solicitation of Ideas for Science Verification Targets.
- Aperture Synthesis Image with Six or more antennas.
- Demonstration of Phase Correction with WVR's.
- Continuum Total Power Image using a 12m antenna with a nutating subreflector.
- Release of first Science Verification data (perhaps with the Call for Proposals for Early Science)
- First sub-millimetre wavelength synthesis image.

Second-level Scientific Milestones

(continued)

- Polarization Images.
- Release of First Public Images.
- Astronomical Signal with an ACA 7m Antenna.
- Phase closure with 3 ACA 7m antennas.
- Aperture synthesis image with Six or more 7m antennas.
- Maps combining 12-m and ACA antennas.
- Maps combining zero-spacing with 12-m and ACA.
- First mage at a frequency higher than 850 GHz.
- High resolution images using baselines of ~4km.
- “Extreme” resolution images with the longest baselines.

Some of these are well linked to the acceptance and integration of deliverables, and can therefore be tracked easily by the IPS, but many depend on less concrete steps which will be harder to predict. We need to identify these items explicitly in the commissioning plans and link them into the IPS.