# The ALMA Software System

***B.E. Glendenning***[1]

[1]National Radio Astronomy Observatory, P.O. Box O, Socorro NM 87801 USA; bglenden@nrao.edu

## Abstract

The ALMA Radio Telescope has a large, integrated, software system to handle all aspects of telescope operation. This software has been developed by a large international consortium of collaborating institutions. This paper briefly describes the scope of the software effort, the technical approach which has been implemented, and the management approach which has been used to oversee its development.

## 1. Scope

The Atacama Large Millimeter/Submillimeter Array (ALMA) is a radio telescope being constructed at a high site in northern Chile. The telescope will consist of 54 12m and 7 12m relocatable antennas. Associated with the antennas is a considerable quantity of electronic equipment at each antenna to receive, digitize, and transmit data from a number of frequency bands, and to receive it centrally and cross-correlate the data in two correlators.

The scope of the software system includes the following elements:

1. Phase 1 (proposal) and Phase 2 (detailed observing program) preparation by the Astronomical Community.
2. A technical infrastructure (ALMA Common Software – ACS).
3. Real-time and near real-time control of all the ALMA equipment.
4. Automatically derived online calibrations.
5. A distributed petabyte scale Archive of all the raw data, monitor points, and observatory-derived results.
6. Operational GUIs and tools, including various data and online calibration driven quicklook displays.
7. Software to dynamically schedule observing to ensure that the scientifically best programs are observed which are consistent with the current state of the telescope (e.g., weather, hour angle, configuration) and observatory policies (e.g., partner shares).
8. An offline data processing package (Common Astronomy Software Algorithms – CASA) and associated data standards for manual data processing.
9. A pipeline package for automatic production of images.
10. Miscellaneous observatory management software (TAC support functions, QA, program tracking, etc.).

In additional to these technical work areas there are also items that require effort that do not deliver functional software:

11. Software management.
12. Requirements management and development.
13. Software engineering (software standards, processes).
14. Integration, test, and support.
15. Analysis and design.

## 2. Technical Approach

The ALMA software has been designed from the beginning as an integrated end-to-end system. Java and C++ are the primary implementation languages, and Python is used where scripting interfaces are required. The Common Object Request Broker Architecture (CORBA) is used as a middleware layer. Interactions with observing hardware typically occur over Controller Area Network (CAN) buses – several at each antenna as well as centrally, although some devices communicate over Ethernet. Data descriptions ("header" data) and auxiliary data are produced in XML format, and the bulk (correlator) data is in an efficient in-house format. Bulk data is saved in the European Southern Observatory's Next Generation Archive System (NGAS), and other data is stored in Oracle corporation relational/XML database software. The initial data rate at the end of construction (2013) is specified to be 200 TB/y, replicated in 5

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

archive installations in 4 continents. The data rate will increase considerably with time as the correlator hardware is capable of producing well in excess of 3 PB/y.

## 3. Management Approach

The ALMA software has been developed by an international team in 4 continents – the ALMA Computing Integrated Product Team (CIPT), in collaboration with the Department of Computing of the Joint ALMA Observatory in Chile. Over 500 FTE-y of effort will have gone into the entire software system by the end of the construction project in 2013. ALMA had a front-loaded requirements gathering process, and integrated end-to-end software design, technical standards enforced by the required use of ACS, and only modest requirements for a common development process given the diversity of involved institutions and personnel. Software is tested in the Northern Hemisphere on Standard Test Environments (STEs), a standard rack of computers with some simulation capabilities, and in Chile on a mixture of STEs, a standalone single baseline interferometer, and on the actual array.

Additional details and lessons learned will be provided during the presentation of this paper.