The Atacama Large Millimeter/submillimeter Array (ALMA), a collaboration involving 20 countries, is probably the most ambitious ground-based astronomical project ever undertaken. Extending over 16 km (10 miles), high on the remote Chilean Atacama Desert at 5,000 m (16,500 feet) elevation, ALMA took a decade to build at a cost of more than one billion dollars. *The ALMA Telescope: The Story of a Science Mega-Project* is a highly personal and very readable account of how ALMA grew out of three independent initiatives in the United States, Europe and Japan, told by three authors each of whom was intimately involved in some aspect of ALMA. Paul Vanden Bout was the Director of NRAO who oversaw the planning for ALMA and became the first ALMA Director. Robert Dickman was the National Science Foundation (NSF) Program Officer who skillfully shepherded the project through the NSF funding labyrinth. Adele Plunkett, who worked at ALMA and participated in the early commissioning of ALMA represents the new generation of radio astronomers skilled in millimeter-wave astronomy.

Unlike the postwar explosion in centimeter and meter-wavelength radio astronomy (Kellermann et al., 2020; Orchiston et al., 2021; Sullivan, 2009), for several reasons, millimeter-wave astronomy grew more slowly. In part, it was difficult to build antennas with the required precision to operate at millimeter wavelengths. Also, the technology for millimeter-wave receivers lagged far behind receivers built for longer wavelengths. Finally, most sources of cosmic radio emission are much weaker at these shorter wavelengths. Aside from the thermal radio emission from a few planets, there was little to observe at millimeter wavelengths until the surprising 1970 discovery of strong radio emission from interstellar carbon monoxide (CO) (Wilson, 2008; Wilson, et al., 1970). Discoveries of other molecules quickly followed and the race was on to exploit this unexpected new opportunity (Kellermann and Bouton, 2023).

In the US, following the failure to fund the ambitious 25-meter diameter millimeter-wave telescope, a hastily organized invitation-only meeting called for the construction of a large millimeter-wave array. Although the NRAO was blamed for the loss of the 25-m funding, it was, nevertheless, assumed that NRAO would lead the design and construction of a national millimeter array (MMA). In Europe, building on the very successful Sweden-ESO (SEST) submillimeter-wave telescope and the IRAM millimeter array on the Plateau de Bure in the French Alps, ESO astronomers developed plans for their Large Southern Array (LSA). Similarly, following the construction of a 45-m radio telescope and millimeter-wave interferometer, Japanese radio astronomers planned for their 50-element Large Millimeter/submm Array (LMA).

Meanwhile the US Millimeter Array was working its way through multiple NRAO and NSF review committees, only to be stalled by an NSF requirement that the project receive international funding. Vanden Bout’s hastily proposed multiple bilateral agreements for cooperation with the Netherlands, Japan, Canada, and then ESO generated concern in Europe about the good faith intentions of the Americans and determination that the Europeans did not want to play second fiddle to an American project. Subsequent discussions led to an agreement to combine the MMA and the LSA on a single site in Chile as part of a joint project with equal contributions...
from both ESO and North America. This was later formalized as the Atacama Large Millimeter Array (ALMA), and when Japan joined the collaboration as a smaller partner, it became the Atacama Large Millimeter/Submillimeter Array. Agreements on who would hire the staff in Chile, the street address of the ALMA headquarters building, and most importantly the choice of antenna contractor were increasingly controversial and required multiple conferences and meetings to resolve. In spite of the agreement that all the antennas would have a common design, different business practices and priorities, and a suspected leak of a confidential cost bid, led to three different antenna designs for the ALMA 12-meter diameter dishes, one each from the US, Europe, and Japan.

The American, European, and Japanese teams were each independently impressed by the apparent excellent atmospheric conditions found on the Atacama Desert, and they quickly agreed on the ALMA site on Llano de Chajnantor plateau, near the border with Bolivia. However, they were perhaps overly optimistic about the lack of precipitation and the practical challenges encountered in building and operating a sophisticated scientific instrument in the thin air of the 5,000-m elevation site.

The high altitude, armed border guards, buried land mines, a commercial pipeline that traversed the site, multiple Chilean entities each demanding a piece of the action, a massive underestimate of construction costs and subsequent descoping or re-baselining as it was called, differences in cultural, legal, procurement, and employment practices, along with competing national interests were all challenges, that were mostly, but not entirely overcome. However, the authors do not address the reasons for the unrealistic initial cost estimates which were the basis of funding proposals in both the US and Europe, or to what extent the proposers were unwilling or unable to face the realities of building and operating a complex scientific instrument at a remote site with only half the sea level oxygen content.

Two curiosities are worth mentioning. As Director General of ESO, Riccardo Giacconi, who won the 2002 Nobel Prize for his discovery of cosmic X-rays, negotiated the initial agreement with Vanden Bout on behalf of ESO to join forces with NRAO/AUI to jointly build the MMA and LMA on a common site in Chile and championed the agreement with the ESO Board. However, soon after that, Giacconi retired from ESO and returned to the United States where he became President of Associated Universities (AUI). In his capacity as AUI President, Giacconi then led the negotiations for the United States in the ALMA agreement and had overall responsibility for NRAO’s role in the joint project (see Giacconi, 2008: 331–334, 353–356). Also bizarre, Taiwan participates in ALMA both as part of the North American (US and Canada) consortium as well as part of the East-Asia consortium (Japan and Korea).

As measured by the number of new discoveries reported in the scientific literature, the proliferation of scientific publications, and the unprecedented oversubscription rate for observing time, ALMA has been a huge success, meeting or exceeding all the scientific expectations. Illustrative of ALMA’s impact was the spectacular image of the protoplanetary disk known as HL Tau, which showed more detail than the preconstruction computer simulations, with dramatic evidence for planets forming around a parent star (Brogan et al., 2015: 184). One area, however, that did not meet expectations was the impact of the Chajnantor climate. Although the Atacama Desert is normally one of the driest places in the world, it also experiences the extreme weather conditions of high winds and heavy snowfall characteristic of a 5,000-m high site. Pre-construction apocryphal stories about there being only one centimeter of precipitation per century, were replaced by stories of snow drifts that blocked the road to ALMA as well as the huge piles of snow by the antennas and other ALMA buildings on the site.

As the authors readily acknowledge, their book largely reflects the history of ALMA as seen from a US perspective although they include short vignettes written by people from around the world who were involved in the construction and operation of ALMA, and Ishiguro et al. (2022) have given a report of the Japanese participation in ALMA. Readers of The ALMA Telescope: The Story of a Science Mega-Project will eagerly await full-length English-language rejoinders from those involved in the European and Japanese ALMA programs. Meanwhile astronomers, historians, science administrators, along with science and engineering students, and others interested in how modern scientific facilities happen, will enjoy this entertaining and nicely illustrated Open Access eBook.
or the attractively priced paperback version.

References


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The discovery of thousands of exoplanets, some Earth-sized and in the habitable zone of their respective stars, has given rise to interest in extraterrestrial intelligence not only in the natural sciences but also in the humanities and social sciences. Even prior to these discoveries historians of astronomy had realized the importance of ideas of extraterrestrial life to the history of astronomy and culture in general, though they often differed in their emphasis and interpretations (Crowe, 1986; Dick, 1996; Guthke, 1990). This historical interest has continued (Connes, 2020; Vakoch, 2013), and current developments have led to embryonic fields such as astroethics (Impey, 2013), astrotheology (Davis, 2023; Dick, 2018a; Peters, 2018), and astroanthropology (Peters, in press). Now two German sociologists have given us an interesting volume on what they term exosociology. This book is an English translation of the original German edition published in 2019, and as such will be available to a much broader audience. The Foreword, by the well-known historian of astronomy Dieter B. Hermann and written shortly before his death in 2021, gives the book an enthusiastic endorsement. He considers it a broadening of the scope of history of astronomy, since its basic premises are astronomical. So should we all.