6

Organizing ALMA

"Organizing is what you do before you do something,
so that when you do it, it's not all mixed up."

Unknown – misattributed to A.A. Milne

The agreement of 25–26 June 1997 between ESO and NRAO stated a "*resolve to organize a partnership that will explore the union of the LSA and MMA into a single, common project …*". The organization proceeded in stages, with the establishment of working groups, advisory committees, and eventually, the appointment of a board to oversee the project. The organizational tasks were different in Europe and the United States for their respective projects. Until the assignment of tasks to Integrated Product Teams (IPTs) by the ALMA Coordinating Committee (ACC) in 2000, tasks were addressed on each side by separate working groups. NRAO was about to receive MMA design and development funding from the NSF, whereas the ESO Council had not yet received a proposal to build the LSA. Despite the lack of a formal, coordinated management structure at the beginning, the groups worked well together in an atmosphere that was extraordinarily collegial. The recommendations of the working groups ultimately came to define ALMA. However, at the same time that the working groups were discussing science requirements and array specifications, a completely different challenge for the budding partnership became urgent, namely a proposal by a commercial firm to build a gas pipeline directly across the Chajnantor site.

Gaz Atacama

A company called Gaz Atacama (GA) had a plan to lay a pipeline from Argentina to Tocopilla, just north of Antofagasta on the Chilean coast. The pipeline would supply natural gas from Argentina to plants generating

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electricity for the Chilean mining industry. NRAO became aware of the plan when GA requested a right of way from the Ministry of National Assets, "Bienes Nacionales" (BN), the Chilean government agency that owned the land. As discussed in Chapter 4, AUI had already secured the mining claim in 1996 and CONICYT had also requested a very large land concession for the MMA on behalf of NRAO/AUI. Paulina Saball, the Undersecretary of BN asked both interested parties – NRAO and GA – to reach an agreement or she would pick a winner. The negotiations began in November 1997. The NRAO team was led by Eduardo Hardy and included Peter Napier, the MMA project manager, and Jeff Kingsley. The parties agreed to separate their projects by a distance of 200 m, that is, GA had a buffer zone 400 m wide. The buffer zone would be violated in three places where the antennas would be transported across the pipeline. At those spots, provisions were to be made to reinforce the pipeline. It was agreed that the pipeline monitoring equipment, which was to transmit data by radio, would avoid doing so in the area of the site. Finally, a tap in the pipeline was promised by GA so that the MMA could draw gas to generate electricity. A legally binding agreement[1] was signed in April 1998. But the rights of the two parties to the land would not become legal until 2004, following long negotiations with the Chilean government.

Although ALMA never used any gas from their pipeline tap, construction of the pipeline did provide a bonus. In the late 1970s and 1980s, the Chilean Army had laid mines along Chile's long border with Argentina, as well as with Bolivia and Peru to the north, fearing possible invasions during times of conflict and chaos. Chile ratified the Ottawa Convention (the Anti-Personnel Mine Ban Treaty) in 2001 and the government set to work removing the mines they had previously buried. It was a long process because in the intervening years, many of these mines had moved with soil that washed down the mountainside gullies and the mine locations were no longer accurately known. As a precaution, GA conducted a sweep for mines along the pipeline route and the project could proceed with confidence that the area was safe. One mine was found by accident when one of the GA bulldozers drove over it in a ravine near the Jama Pass highway far below the site. The driver lost an eardrum in the explosion. The pipeline project had an unexpected outcome. Before gas began flowing, the Argentine government decided not to export their gas after all.[2]

Land Concession

Concluding an agreement to build and operate the MMA, and then ALMA, on the Chajnantor site would prove to be a long and difficult process.

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Essentially no progress was made[3] until the Ministry of Foreign Affairs took eventual control on 26 July 2001. In a large meeting that day, chaired by Ambassador Luis Winter of the Ministry of Foreign Affairs, no less than 14 different entities were told to come to an agreement with the ALMA representatives on the conditions for their approval. The U. Chile had already concluded agreements with AUI, first for the MMA and later for ALMA, granting access to the land; it was indicated that site studies, construction, and operation of an observatory were permitted in exchange for the 10 percent of observing time in compliance with Law 15172, that was to be administered by U. Chile for the benefit of all Chilean astronomers. Such an agreement would be congruent with the agreement between ESO and Chile, signed in 1996, that gave 10 percent of the observing time on ESO's telescopes to Chilean astronomers.[4] There was little further progress until 19 February 2002 when the Undersecretary of the Ministry of Foreign Affairs, Cristián Barros, asked both sides for the list of requirements essential to ALMA and to the agencies involved. On 20 May 2002, negotiations under Barros began. Vanden Bout was the head of the negotiating team, but Daniel Hofstadt for ESO and Eduardo Hardy for AUI did all the real work.

Following the successful negotiations, the Treasury Department issued two decrees, first for the MMA, specifying AUI's exemptions from import duties and value-added taxes, among other details; the second for ALMA, specifically redefining the MMA as the "*fraction of ALMA belonging to AUI in Chile.*" The Labor Department agreed to follow inspection rules consistent with immunities granted by the Ministry of Foreign Affairs. A land concession to Radioastronomía Chajnantor, Limitada (RCL), a joint company held by ESO and AUI, was granted by BN in return for annual payments to two funds, one for Region II and the other for CONICYT. BN also sold the land for the Operations Support Facility (OSF), more than 2,000 m lower in elevation and 28 km away from the chosen array site, to RCL. The Ministry of the Environment approved the environmental impact study, which contained 91 commitments to be kept during construction and operation of ALMA; those commitments involved a number of other agencies and entities in Chile. It was also important to get the approval of the San Pedro de Atacama mayor, Sandra Berna. The governor of Chile's Region II, Jorge Molina Cárcamo gave his approval after the agreement was reached on annual payments by ALMA to a social development fund for the San Pedro region. CONICYT would administer annual payments to a fund for the development of astronomy in Chile. The Forestry Department authorized a right of way from the OSF to Route 23, the primary access, in exchange for a one-time payment. The

Figure 6.1 Left panel: President Ricardo Lagos greeting the local residents of the San Pedro community. Right panel: President Lagos giving his speech on astronomy. One of the attendees appears to have heard enough. Credit: Eduardo Hardy; NRAO/AUI/NSF, CC BY 3.0.

Agricultural Service gave its approval after ESO/AUI made a commitment to protect the flora and fauna. The Department of National Monuments granted its approval after ESO/AUI promised to protect historical sites. The agreement with GA that was discussed earlier was also one of the requirements for gaining legal access to build and operate ALMA. The signing of decrees was celebrated at two receptions. The first was on 25 July 2003, in San Pedro de Atacama. President Ricardo Lagos can be seen in Figure 6.1 greeting the assembly before he gave a speech on the wonders of astronomy. Eduardo Hardy also gave a speech in which he thanked President Lagos and Jaime Ravinet, the head of BN. Ravinet then signed the degree granting the right to build and operate ALMA, followed by Daniel Hofstadt and Eduardo Hardy for ESO and NRAO/AUI, respectively.

The second reception was held on 21 October 2003 at the Ministry of Foreign Affairs. An agreement allowing ESO to build and operate ALMA on the Chajnantor site was signed by Maria Soledad Alvear, Minister of Foreign Affairs, and Catherine Cesarsky, who had followed Giacconi as ESO Director General. The agreement added ALMA to ESO's existing Convenio with Chile for its optical telescopes. A photograph recording the signing of the agreement is shown in Figure 6.2.

On the Chilean side, several individuals stood out in the effort to make the land negotiation process successful, and deserve mention. Leo Bronfman and his colleagues at U. Chile were notably helpful, especially at the start when NRAO first came to Chile looking for an MMA site. Hernán Quintana, who

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Figure 6.2 Left to right: (unidentified), Catherine Cesarsky, ESO Director General, Maria Soledad Alvear, Foreign Minister of the Republic of Chile, (unidentified). Credit: ALMA/ESO/AUI, CC BY 4.0.

first pointed to the Chajnantor area as a possible MMA site, later became anxious that the agreement with the U. Chile would limit access to MMA time for him and his colleagues at U. Católica. His concern reinforced the position of the ALMA partners that CONICYT would have the responsibility for administering ALMA observing time on behalf of *all* Chilean astronomers. As already noted, Cristián Barros, Undersecretary of the Ministry of Foreign Affairs, was a key figure in the early negotiations. He took over when things appeared to be bogged down, demanding that all the parties come to an agreement, and putting Ambassador Luis Winter, his right-hand man, in charge. By a stroke of good fortune one of the authors (Dickman) was at the time a US Embassy Fellow at the American Embassy in Santiago, on temporary leave from NSF. At his request, the US Ambassador, William Brownfield, convinced the Governor of Region II that ALMA was not flush with money, like a mining company, but a scientific enterprise that could not afford the large payments that had originally been requested. The efforts of these people in particular, as well as the goodwill of all involved, led to a successful conclusion, however long it took to get there. The process leading to these agreements is shown as a flow chart in Figure 6.3 and a map of the land in question is shown in Figure 6.4.

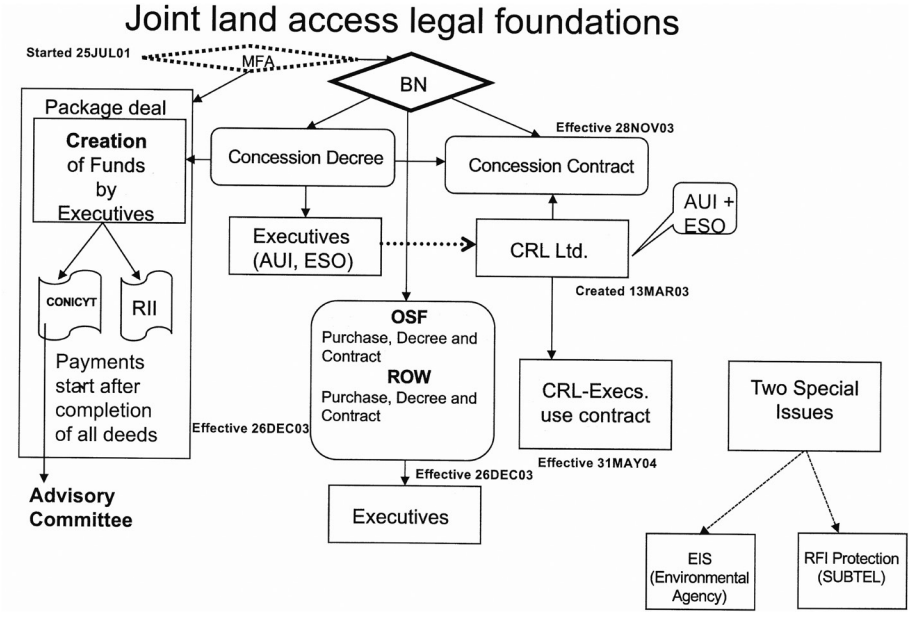

Figure 6.3 A flow chart showing the steps taken in acquiring the ALMA site. The label "CRL" should be "RCL" for Radioastronomía Chajnantor, Limitada. Credit: Eduardo Hardy, NRAO/AUI/NSF, CC BY 3.0.

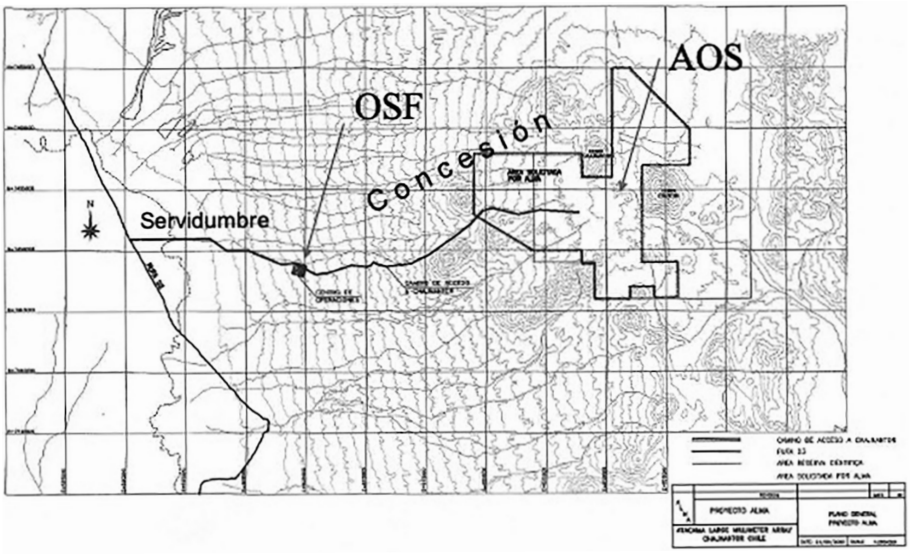

Figure 6.4 The land concession sought for the MMA and then ALMA, showing the large 17,000 hectare Array Operations Site (AOS), the right-of-way (labeled "Servidumbre") to the Operations Support Facility (OSF), and then to Highway 23 running from San Pedro de Atacama to the village of Toconao. The OSF occupies a 1 km × 1 km piece of land that was purchased outright. Elevation contours and runoff ravines are shown in gray. Credit: Adapted from a topographic map of the Instituto Geográfico Militar; NRAO/AUI/NSF, CC BY 3.0.

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Early Joint Activities

There were joint technical, science, and management working groups that began as early as 1997, but they were only "joint" in the sense that groups on both sides of the Atlantic kept each other informed of progress and, on occasion, attended each other's meetings. The only published reports of these working groups are those that appear in the LSA Feasibility Study, and those are of the European side. Bob Brown, Paul Vanden Bout, Peter Shaver, and Michael Grewing met in Munich to discuss management options, but they did not issue a report either. The highlight of their meeting seems to have been an evening concert featuring Daniel Barenboim conducting the orchestra while playing the piano.

Defining ALMA in the United States

A Revised Design and Development Plan – The long delay before design and development funds were finally (and only verbally) promised by NSF Director Neal Lane meant an updated plan was needed. By early 1997, too much had already changed. There also was a sense of urgency, now that NRAO and ESO had agreed to explore a merger of their projects. That updated plan[5] was submitted in January 1998, as the *MMA Program Plan – Design and Development, Volume 2*. It was similar to the first plan in structure, with updated discussions of the plan's elements. A very significant change revealed in this updated plan was the switch from forty 8 m antennas to thirty-six 10 m antennas. This array was regarded as the one that would meet the many enumerated scientific requirements, while also ensuring a scope that the United States could manage alone should the proposed merger fail. It came to be called the *US Reference Design for the MMA.* Another significant change was to specify the two sites that were then under consideration: Maunakea in Hawaii, and the Atacama Desert in Chile. No mention was made of the former three US continental sites. The revised plan included extensive material as attachments that documented the results of technical studies. The more detailed work breakdown structure (WBS) led to a budget of $26M for a design and development program, to be spread over four years of construction.

The Reference Design for the MMA – Increasing the collecting area of the MMA by 40 percent while only cutting the number of antennas by 10 percent had increased the construction cost well beyond the $120 million total in the MMA proposal. There was also inflation over the intervening years to take into account. Dickman, with strong support from Bob Eisenstein, the NSF Assistant Director for MPS, asked for a cost estimate of the expanded array.

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The documents were prepared and submitted to the NSF as requested. Not unexpectedly, the cost had escalated significantly. Taken aback by the magnitude of the increase, the NSF scheduled a so-called Lehman Review, named after Daniel Lehman, who had conducted in-depth reviews of science projects for the Department of Energy. Lehman Reviews were considered the gold standard for audits of large project feasibility and cost. This was a life and death moment for the MMA. Failing the review would possibly mean the end of the project, whereas a strong endorsement would mean renewed confidence at NSF for pushing forward.

The review took place 8–9 July 1999. The panel was chaired by John Peoples, who had just stepped down as director of Fermilab to take charge of the Sloan Digital Sky Survey. It included other experts in large project management, as well as leading scientists and engineers in radio astronomy. Sessions were attended by NSF officials, NRAO staff, and observers from other projects around the world. One attendee was AUI trustee Paul Gilbert, a leading expert on the construction of tunnels at the engineering firm Parsons Brinckerhoff, and a veteran of the Super Conducting Super Collider debacle. He kept a close eye on the MMA for AUI and gave sound advice to the project. Ultimately, a very complete report[6] was issued. The panel examined the cost estimates in detail, found them to be reasonable, and concluded that the US Reference Design for the MMA could be built for around $400 million. Beyond this overall finding, the panel made numerous recommendations for improvements in the management structure, in the WBS, and for actions in the areas of site development, electronics, and computing. The confidence of the panel in this cost estimate and the helpful criticism in the report provided exactly what was needed to advance the MMA within the NSF. The US Reference Design for the MMA evolved into the US contribution to ALMA. Backed by the Lehman Panel's report, the cost of the MMA was reset in NSF's thinking.

Further Steps in the Merger

Studies proceeded amicably but independently by the respective groups in both Europe and the United States in order to explore considerations to be addressed in a merger of the LSA and MMA. The US effort was led by a small cadre of NRAO staff members. The standing MMA advisory committees were composed of university-based astronomers and engineers. Receipt of funding for design and development would allow for the formation of a larger team at NRAO, as well as financing for support tasks by the university members of the Joint Development Group (JDG). The JDG was set up by NRAO to involve

university millimeter astronomy groups, principally at the Owens Valley Radio Observatory and the participants in the Berkeley-Illinois-Maryland Association, in the design of the MMA.

In Europe, on 17–18 December 1998 an MOU[7] was signed between ESO and the funding agencies in several of its member countries wishing to participate in LSA design and development to form the European Coordinating Committee (ECC). Initially, the interested countries forming the ECC were France, Germany, The Netherlands, and the United Kingdom. Later, Sweden and Spain joined. Each of the signatories pledged support in money and labor, with the goal to agree on specifications of an array that merged the MMA and LSA. There was a push toward matching the effort to be funded by NSF in the United States. The MOU also established the European Executive Committee (EEC) to manage the activities of the MOU, and the European Negotiating Team (ENT) to negotiate an MOU with the NSF for the design and development phase of the joint project. One of the first actions of the ECC was the appointment of Dick Kurz and Stephάne Guilloteau as European Project Manager and Project Scientist, respectively.

The developing partnership between Europe and the United States to build a merged array needed a joint management structure. In April 1999, an MOU[8] specifying all the design and development tasks required for an array of sixty-four 12 m antennas on the Chajnantor site was concluded between NSF and the principal parties to the ECC. It was signed by all the parties in June 1999. The MOU covered Phase 1 of the merged project, with the objective of completely defining the work to be carried out in Phase 2, including the definition of all the scientific and technical requirements and the management approaches, as well as a WBS, schedule, and costs. The MOU for Phase 2, which addressed actual construction, was to be negotiated and signed by 31 December 2000.

The Phase 1 MOU contained contractual language that was necessary, if tedious to read. However, along with the legalese there was an item of great significance, namely the appointment of the ACC, whose charge was to supervise all the activities under the MOU. Later, it would provide a model for the ALMA Board. The ACC was expected to meet at least twice per year, although in practice it met as often as monthly. It was to elect its own chair, with that position alternating between the United States and Europe, and had an initial membership[9] of 12, with six representatives from North America (NA) and six from ESO.

The work during Phase 1 was supervised for NA by the NRAO MMA Project Director, Bob Brown, and for ESO by ECC Project Manager, Dick Kurz. The Project Scientists were Al Wootten (NRAO) for the United States and Stephάne Guilloteau (CNRS) for Europe. This group together with the NRAO Director and ESO Director General formed the ALMA Executive Committee (AEC).

Defining ALMA in Europe

LSA/MMA Feasibility Study – The first formal step in Europe to define ALMA was a study of whether it was even feasible to combine the MMA and LSA. The feasibility study involved nine working groups, and was run by the LSA Board,[10] which had led the earlier development of the LSA. The working groups were largely composed of European scientists and engineers, although the antenna working group added Peter Napier of NRAO as an unofficial member to present the 10 m and 12 m antenna options that would be considered for the MMA. The report[11] entitled *LSA/MMA Feasibility Study* concluded that a combination of the MMA and LSA would indeed be a powerful facility for addressing ESO's larger science goals, and could be built within a reasonable budget. It formed the basis for the proposal that was later prepared for the ESO Council.

ESO ALMA Proposal – This massive document of 676 pages in six volumes is the most complete and detailed description of ALMA on record.[12] Dated December 2000, it was drafted at a sufficiently late date to have the benefit of over three years of planning. The science case for ALMA is superbly presented. Its six volumes represented the defining statement of the whole project at the time that it was submitted to the ESO Council for approval.[13]

Dividing the Effort

At the suggestion of Riccardo Giacconi, the ACC agreed that contributions to Phase 2 would be in the form of completed work packages, with the amounts of actual cash contributions kept to a minimum. That is, the project would be divided into deliverables: antennas, site development, receivers, signal correlator, etc. with each deliverable assigned an estimated value. The sum of the values was to be the same for Europe and NA. Moreover, once a party had agreed to provide a deliverable, they were obligated to do so, no matter what the final cost came to, although it was obvious that if things got out of hand there would be a renegotiation of value. This process required the construction of a detailed WBS. To get started, Brown and Kurz made rough estimates of the value of the major packages and, knowing the preferences of the respective partners, divided them as best they could to assure equity. The largest package was the antennas. Both sides wanted to provide the antennas, but it was unreasonable and unrealistic to expect that one partner would, for example, provide all the antennas and the other provide most of the rest of the array components. So, that work package was split, with each side agreeing to contribute half of the antennas. When it came to assigning the

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site construction, ESO argued that its long experience in Chile was an obvious reason for them to do all the site work. But NRAO was loath to have ESO be the single face of the project on the Chilean site. Again, the two sides agreed to split the package, with NRAO taking responsibility for the high site work at 5,000 m and ESO taking on the mid-level OSF. Negotiations about the other deliverables followed similar lines. For example, receiver inserts were divided between Europe and the United States, their cryogenic containers being built in England but the integration of the receiver inserts into the container carried out at NRAO. The final division of overall effort was hammered out in a retreat at Abingdon, England, in the spring of 2000. The chief participants were Massimo Tarenghi, Bob Brown, Dick Kurz, and Masato Ishiguro. It was ratified in the MOU for Phase 2.

It should be noted that the Japanese participated fully in these discussions even though Japan had not yet joined ALMA. The final WBS concluded at the Abingdon retreat, attended by Masato Ishiguro and Tetsuo Hasegawa, included all the contributions to ALMA expected from Japan, except for an additional compact array of 7 m antennas, an item left for further negotiation. Their participation made the final negotiation of the terms for their entrance into ALMA much easier than it would have been had they been excluded. It was another example of the collegial relations that characterized the global millimeter astronomy community at that time.

ALMA Coordinating Committee

The ACC met 25 times from March 1999 to December 2002. Thirteen of those meetings were in-person at locations around the world (London, Munich, Paris, Santiago, Tokyo, Venice, and Washington DC). Twelve were telecons, with audio/video technology that preceded Zoom® by many years and could prove frustrating to the participants. Besides the routine of reports, scheduling the next meeting, and approving the minutes of the last, there were key issues of concern to the ACC over which much effort was expended. These included: (1) monitoring the division of effort; (2) advising on the negotiations for the site, with special attention to the differing institutional requirements for ESO and AUI; (3) deciding who would employ the local workforce; (4) selecting a location for the ALMA headquarters in Chile; (5) negotiating the entrance of Japan into ALMA; and most importantly, (6) managing the negotiation of the ALMA Agreement between ESO and NSF. A full discussion of all the meeting agendas, discussions, conclusions, and minutes is beyond the scope of this book. In the following text, we give brief summaries of the more significant meetings.

30 March 1999, Garching – This meeting at ESO Headquarters was actually a meeting between NSF representatives and the ENT rather than an official ACC meeting. In fact, the attendees became the ACC at its first meeting the following June. A significant step at this meeting was the adoption of the name ALMA for Atacama Large Millimeter Array. Bob Brown reported the results of an informal poll in which he had requested votes for suggested names. ALMA came out on top, a joint suggestion from Paulo Cortes and Pablo Altamirano. The name ALMA got ringing endorsements from Catherine Cesarsky (ESO Director General designate), who liked the fact that "alma" means "soul" in Spanish, and Ian Corbett, who liked acronyms he could pronounce. Later, after Japan joined ALMA, the acronym stood for Atacama Large Millimeter/submillimeter Array. Another important topic was the draft MOU for Phase 1 of ALMA, discussed earlier. It was initialed by Bob Eisenstein for NSF and H. Grage for the ENT to indicate approval by both parties

How ALMA Got Its Name

The origin of the ALMA name came from a random encounter and a decision with unexpected consequences. I was a newly minted engineer looking for what to do in life but without a clear idea of where to go. I also happened to have a thing for physics and astronomy but had no clear idea about how to become a professional astronomer. You see, in Chile undergraduate education is different. You do not get a major/minor; you have to go into a career path that will lead you to a professional degree, so you can get hired by someone. Because I didn't know what to do, I did physics and computer engineering so I could get a job. One day about March 1998, I was in the Information Technology Office at Universidad de Chile Astronomy Department, where I was doing some programming for a radio astronomer, when a scientist, Eduardo Hardy, entered with some questions. I didn't know who he was, but because my friend was busy, I engaged him in conversation. After thirty minutes he knew who I was and my field of expertise, and he asked me, "*What are your plans for the future?*" I said, "*I have no idea, I am applying to a job at Entel*" (a local communication company). He said, "*Why don't you work for us?*" Long story short, I made a fast decision and ended up at NRAO/Socorro. There I programmed data reduction software at the time when the MMA North American project joined with the European LSA project. A new name was needed (MMA and LSA are not that glamorous). An email had been sent asking for names. I started playing with words and two names came out: (1) ARTE for Atacama

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Radio Telescope and (2) ALMA for Atacama Large Millimeter Array. Another Chilean engineer was there at the time, Pablo Altamirano. The two of us sent an email with the name suggestions. ALMA got chosen. Looking back, it was the right name, given the discoveries that ALMA has enabled. About a year later, I started graduate school to get a PhD in astronomy and ended up working as a scientist for the NRAO at the place that I named – ALMA – which is the unexpected consequence.

Paulo Cortes
Joint ALMA Observatory
Santiago, Chile

29 September 1999, Tokyo – The ACC first heard reports on progress in the United States, Europe, and Japan. A draft of an agreement making Japan a full and equal partner in ALMA was discussed. During a break in the agenda, a visit was paid to Monbusho, the Japanese science funding agency, by Catherine Cesarsky (by then ESO Director General), Ian Corbett, Bob Dickman, Riccardo Giacconi (by then AUI President), William Blanpied from the NSF office in Tokyo, Keiichi Kodaira, and Masato Ishiguro. Masayuki Inoue, the deputy director of Monbusho was not encouraging. Indeed, he complained about astronomers always asking for money. The visit was a classic example of differing perspectives and cultures: the ACC came with a viable two-party project to which they were willing and eager to add Japan. From their perspective, it would be a win-win for everyone. Inoue thought they simply wanted Japan's money. The ACC realized that funding constraints in Japan at the time would, in any case, preclude the signing of a tri-partite MOU. As an alternative, a resolution[14] was initialed that agreed to the establishment of a liaison between the ALMA and LMSA projects, with the goal of an eventual formal partnership in a millimeter/submillimeter array. To that end, the ACC formed the ALMA Liaison Group (ALG), chaired by Masato Ishiguro with Bob Brown as vice-chair. The ALG was charged with defining and evaluating the options for Japanese participation in ALMA that would be most scientifically and technically advantageous. Figure 6.5 shows a photograph taken of the ACC meeting participants.

12 November 1999, London – At this meeting, the resolution, initialed in Japan and signed there by Keiichi Kodaira, was also signed by Bob Eisenstein and Catherine Cesarsky. Reports were heard from the European and US project managers, including discussion of the purchase of prototype antennas. Bob Dickman reported the results of the Lehman Review. A report[15] on the first

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Figure 6.5 Participants in the ACC meeting of 29 September 1999 in Tokyo. Standing, left to right: Makoto Inoue, Norbert König, Ryohei Kawabe, Ian Corbett, Bob Dickman, Paul Vanden Bout, Masato Ishiguro, Satoshi Yamamoto, Naomasa Nakai; seated, left to right: Catherine Cesarsky, Riccardo Giacconi, Keiichi Kodaira. Courtesy of Masato Ishiguro, reproduced by permission.

joint ALMA science symposium, held 7–8 October 1999 in Washington DC at the Carnegie Institution, was also presented. The ACC noted that the ALMA Science Advisory Committee (ASAC) had held an organizational meeting at the conference. The ASAC was charged[16] with refining the scientific goals of ALMA, and subsequently, with advising on the impact to those goals of proposed changes in technical specifications that might arise in the course of the project. A surprising development was the announcement from Masato Ishiguro that Monbusho, the Japanese science funding agency, had approved a draft tri-partite MOU.

7 April 2000, Washington DC – The most interesting action at this meeting, held at NSF, was in executive session and took up half of the time. Motions were quickly approved granting Chile an *ex officio* seat on the ACC and enlarging Japan's membership in the ASAC from three to five. This was followed by a contentious discussion of progress, or rather the lack thereof, in negotiations with Chile for a concession of the land for ALMA. Each side accused the other of failing to take the required steps. In fact, both sides were guilty. A proposal

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to let AUI take charge was rejected in favor of the appointment of a working group that would only be advisory to the ACC. The working group included Ian Corbett, Norbert König, Bob Brown, and Bob Dickman. Vanden Bout worried that involving a committee would only serve further to slow progress. The discussion then turned to the basis on which Japan would enter ALMA: providing additional capability, or merely saving the present partners costs. The former was preferred, but how? The AEC, defined earlier as a subset of the ACC, was charged with defining an array that optimized the science for $552 million (FY2000). In addition, the AEC was to work with the ASAC and the ALG to define a scientifically optimal enhanced project that included Japan, and to estimate its cost. The entrance of Japan into ALMA was becoming more serious, but was still a long way off.

13 October 2000, Paris – This meeting at the Observatoire de Paris had several routine reports. Dick Kurz and Marc Rafal presented a scheme for managing Phase 2, the construction of ALMA. They proposed organizing the project around IPTs, which had members from each side participating in the management of the execution of each ALMA delivery package. The scheme was well-known at NASA, ESA, and multi-national organizations. It did become the ALMA project management structure, with the incorporation of some quibbles over the organization chart. Then the meeting turned to Japan where national budget difficulties again made funding for Japan's participation in ALMA construction uncertain. Takayoshi Seiki, Director of the Research Institute Division of Monbusho made a strong statement[17] affirming the intent of Japan to join ALMA as a full and equal partner. He was followed by Norio Kaifu, the Director of NAOJ, who presented two options for Japan joining ALMA. The first involved adding another thirty-two 12 m antennas equipped with four receiver bands and an enhanced correlator. The second would add only fourteen 12 m antennas plus ten 8 m antennas with six receiver bands. Kaifu asked that an effort be made to conclude a tri-partite agreement by the following spring and that there be official Japanese members, not observers, in all the working groups. The latter request was granted, but, unfortunately, Riccardo Giacconi was somewhat abrupt in stating that any official participation of Japan in ALMA needed to wait until their effort was actually funded by the government. Understandably, Kaifu was offended. Vanden Bout recalls assuring him during a stroll in the Luxembourg Gardens that all would be well and Japan merely needed to be patient. Neither of them had even an inkling that it would take another four years of patience before funds were available and an MOU on the terms for Japan joining ALMA was concluded.

6 April 2001, Tokyo – This meeting[18] of the ACC marked a seemingly high point in the path of Japan's joining ALMA. The meeting began with a decision to add six Japanese members to the ACC, forming an Extended ALMA Coordinating Committee (EACC). Masayuki Shibata of MEXT[19] expressed strong support for Japan joining ALMA. He also noted the financial difficulties facing the Japanese government, but promised to work toward a start of the project. Yet another resolution was signed by Bob Eisenstein, Catherine Cesarsky, and Norio Kaifu committing to cooperative efforts to construct an agreement to bring Japan into ALMA, conclude negotiations with Chile for access to the Chajnantor site, and make best efforts to obtain approval and funding for the project. The resolution listed the members of the EACC. Following reports from Marc Rafal and Dick Kurz on progress in Phase 1, Catherine Cesarsky noted the common intent to buy antennas of one design. Masato Ishiguro pointed out that their prototype antenna was being developed by a partnership between the government and Japanese industry, and that purchasing a final single design could be problematic. This concern was echoed by Norio Kaifu. It was an early signal of the difficulties that would arise in contracting for identical 12 m antennas. Jack Welch presented a lengthy report on the recent meeting of the ASAC in Florence, Italy, in February 2001. He stated that the Japanese delegation was well integrated into the ASAC. In their second of 17 recommendations, the ASAC strongly supported the addition of the compact array that Japan proposed to contribute to ALMA in the event of a three-way partnership. Following the meeting, NRAO and ESO issued press releases announcing the imminent entrance of Japan into ALMA.

30 October 2001, Washington DC – It was at this meeting at NSF that the ACC learned from Ishiguro that the Japanese Finance Ministry would not be providing funds for ALMA in 2002, although funds for the purchase of a prototype antenna would be made available. It was expected that the Finance Ministry and MEXT would provide funds in 2004, but at a level only two-thirds that of the other two partners. The delay prompted a long discussion of how to proceed in the interim. It was concluded that it was important to continue the existing arrangements, if only to keep Kaifu in good standing with his ministries. Further, it was regarded as important to continue to define a tri-partite ALMA at the original level of financial participation by Japan. In other developments, Bob Eisenstein told the ACC that he was confident that there would be $12.5 million in the FY2002 NSF budget to start ALMA construction. His confidence was based on language that Senator Domenici of New Mexico had placed in the Senate appropriations bill. ESO had been slow in obtaining Council approval for funding, thinking that the chances for immediate funding in the United

States were still uncertain. Catherine Cesarsky asked Eisenstein to speak to the ESO Council at their December meeting.

19 April 2002, Venice – The Italian radio astronomers outdid themselves in the arrangements for the meeting of the ACC in Venice. The meeting took place in the ornate rooms of the Academy of the Lynx, founded in 1603 and the oldest science academy in the world. Gianni Tofani, a radio astronomer at the University of Bologna, was well connected in the art world and was able to schedule a private tour of San Marco Cathedral at night. But the attractions of Venice did not distract the participants from the serious issues of the meeting. Phase 1 was coming to a close and preparations needed to be made to manage Phase 2, and the actual construction of ALMA. Bob Brown presented an ALMA construction plan. Dick Kurz and Marc Rafal presented reports on the activities already begun on Phase 2 tasks. Eduardo Hardy reported on the negotiations with Chile regarding the site. At this point in the meeting, Bob Eisenstein spoke up. He was adamant that ALMA needed to be organized as a real project, with a director and project manager, reporting to a board. He was not prepared to support the funding of anything less. A project the size of ALMA, he argued, could not be run by a committee. No one disagreed but there was palpable tension in the room.

Brown and Kurz, after a quick whispered conversation, volunteered themselves as director (Brown) and project manager (Kurz). The ACC went into an executive session to discuss their offer. Both Riccardo Giacconi and Catherine Cesarsky were supportive of their offer, but the NSF representatives wanted others. The executive session ended with offers to Vanden Bout and Massimo Tarenghi to be (interim) ALMA director and project manager, respectively. The full meeting concluded with a declaration of intent to execute the Bilateral ALMA Agreement that was being negotiated by the end of the year.

17 September 2002, Garching – In the last three of four meetings held via telecon since their Venice meeting the ACC had: (1) made official the appointments of Vanden Bout (interim ALMA Director), Tarenghi (ALMA Project Manager), and Guilloteau (ALMA Project Scientist) effective 1 June 2002; (2) written job descriptions for these positions; and (3) appointed a search committee for Director and Project Engineer chaired by Anneila Sargent. She reported on the progress the committee had made. The meeting was memorable for those who were present in the executive session requested by Massimo Tarenghi. He presented a project organization chart that showed his impression of the project staff by highlighting their names in red, yellow, and green. Green managers were competent, yellow meant that with guidance they could become competent, and red was for those who should be fired immediately. He had tactfully omitted a color for Vanden Bout. Cesarsky mused in a stage whisper about the

appropriate color for Tarenghi himself. No action was taken, but the ACC had been informed of his opinions as to where future trouble might lie.

29 October 2002, Santiago – Technically, this was not a meeting of the ACC, as the MOU establishing that body had expired. Nor was it the first meeting of the ALMA Board, as the Bilateral ALMA Agreement had yet to be approved and signed. But the group sensibly forged ahead with an "informal" meeting, which largely consisted of progress reports. Something significant to the future of the Joint ALMA Office (JAO) happened outside the meeting. After a few months on the job, Vanden Bout and Tarenghi decided they would only serve in their positions if they had full authority to exercise their responsibilities, with control of the budget, and without constantly checking with NRAO/AUI and ESO. This was conveyed to Cesarsky and Giacconi when the four met the evening before the meeting began, and there seemed to be agreement on the demand. But Giacconi and Cesarsky wanted to think on it, and the next morning they called Vanden Bout and Tarenghi's bluff. Institutional requirements trumped efficient management. The JAO would have responsibility, but little authority. Rather than quit, Vanden Bout and Tarenghi relented, the prospect of running the ALMA project trumped their management principles. From that point forward, JAO directors would not only need expertise in science and management, but would need whatever political and diplomatic skills it took to convince those holding the ALMA purse strings of the value of their plans. This arrangement may have been inevitable, however unfortunate. The JAO was not a legal entity. Only ESO and AUI could legally sign contracts and pay bills.

Following the execution of the Bilateral ALMA Agreement, the ACC simply morphed into the ALMA Board, changing from a committee into a board, and acquiring a new set of procedures that largely mimicked the old ones. The major change was that instead of a project run by a committee, ALMA had a well-defined management structure, exactly what Eisenstein had demanded. The ALMA organization chart for construction under the Bilateral ALMA Agreement is shown in Figure 6.6. The ALMA Parties, responsible for funding the project, were ESO and NSF/NRC for NA. The ALMA Executives, responsible for conducting the project, were ESO and AUI/NRAO. Project governance rested in the ALMA Board, advised by the ALMA Science (ASAC) and Management (AMAC) Advisory Committees. The JAO was responsible for execution of the ALMA Project Plan. Each area of the project was conducted by IPTs with memberships balanced between Europe and NA. In August/September 2004 ESO, NSF, and the National Institutes of Natural Sciences[20] (NINS) executed an agreement by which Japan officially joined ALMA, which added another arm to the central tree of the organization chart.

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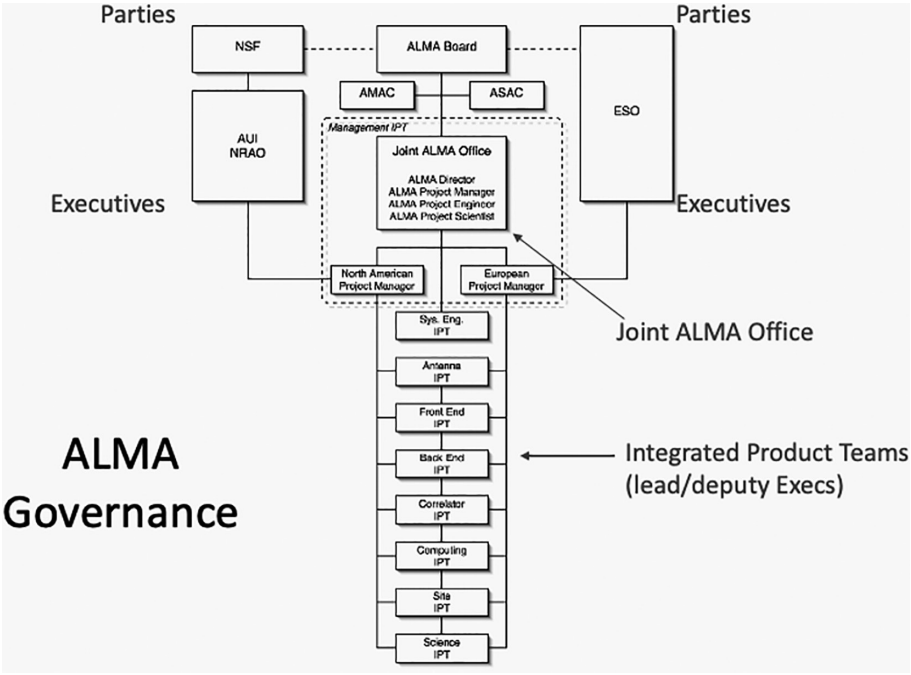

Figure 6.6 The organization chart for ALMA construction up to the point when Japan officially joined ALMA. Credit: NRAO/AUI/NSF, CC BY 3.0.

Musical Chairs

It might be expected that ALMA's long history would see changes in key personnel over the years. This was certainly the case. The most interesting change by far was the move Riccardo Giacconi made from being Director General of ESO to President of AUI. This happened in July 1999. He was succeeded at ESO by Catherine Cesarsky, a distinguished astronomer who had led the camera team for the European Space Agency's Infrared Space Observatory. This put the top position on each side in the hands of strong-willed management-savvy experienced hands. ALMA's success owes a great deal to their leadership. Giacconi's new associates at AUI and NRAO noticed his total, sudden switch in loyalty from Europe to the United States. It seemed as though it happened on his flight from Munich to Washington DC.

Up to the inauguration of ALMA in 2013, there were three ALMA directors – Paul Vanden Bout, followed by Massimo Tarenghi, and then Thijs de Graauw; three project managers – Massimo Tarenghi, followed by Tony Beasley, and then Dick Kurz; but only one project scientist – Richard Hills. John Credland served as the European project manager after Kurz. He was followed by Hans

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Rykochevsky and then Wolfgang Wild. On the US side, the project managers were Marc Rafal followed by Adrian Russell. The European project scientists were Stephάne Guilloteau followed by Leonardo Testi. Al Wootten was the only US project scientist. For Japan, the project directors were Masato Ishiguro followed by Tetsuo Hasegawa, Ken'ichi Tatematsu, and, again, Tetsuo Hasegawa; project managers were Tetsuo Hasegawa, followed by Satoru Iguchi; project scientists included Ryohei Kawabe, followed by Koh-Ichiro Morita and Daisuki Iono and others; Satoru Iguchi and others served as project engineers. Although these changes could be distracting to upper management, at the working level life went on as usual. The project had a life of its own.

Notes

1 In 2006, T. Beasley negotiated a redesign of the points where the antennas crossed the pipeline.
2 A second pipeline from Argentina to Chile was constructed by NorAndino. It did not cross the Chajnantor site but took a nearby route. In 2016, it began transporting natural gas in the opposite direction – from a liquified natural gas port in Chile to Argentina.
3 As an example of the difficulties at the start of negotiations, Paul Vanden Bout and Jorge Molina Cárcamo, the governor of Region II where the ALMA site is located, got off to a bad start. The governor's monetary expectations from ALMA outraged Vanden Bout. Much later, at the ALMA inauguration, the two shook hands and celebrated the day.
4 A press release on the 10th anniversary of this agreement can be found at www.eso.org/public/austria/news/eso0621/.
5 *The MMA Program Plan – Design and Development Volume 2* can be found at: NAA-NRAO, MMA, MMA Planning, Box 7. https://science.nrao.edu/about/publications/alma.
6 The report of the Lehman Review can be found at: NAA-NRAO, MMA, MMA Planning, Box 9. https://science.nrao.edu/about/publications/alma.
7 The MOU defining the European Coordinating Committee (ECC) is Annex 1 of the document cited in note 8.
8 *ALMA Design and Development MOU Between NSF and Europe* (signed), December 1998. NAA-NRAO, ALMA, ALMA Multi-Institutional Agreements, Box 1. https://science.nrao.edu/about/publications/alma.
9 The initial ACC membership for the United States was: Bob Eisenstein, Hugh van Horn, Bob Dickman, Martha Haynes, Paul Vanden Bout, and a member of the US astronomical community to be named; for Europe: Riccardo Giacconi, Jan Bezemer, Ian Corbett, Arno Freytag, J-F. Minster, and Franco Pacini.
10 The LSA Board members were: Roy Booth (chair) (OSO), Harvey Butcher (NFRA), Marcello Felli (Obs. Arcetri), Michael Grewing (IRAM), Richard Hills (U. Cambridge), Jens Knude (Ast. Obs. Copenhagen), M. Mayer (Obs. Genève), Karl Menton (MPIfR), Peter Shaver (ESO), Jean Surdej (Inst. Astrophys. and Geophys., Liege), François Viallefond (Obs. Paris), and John Whiteoak (ATNF).

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11 *The MMA/LSA Feasibility Study* can be found at NAA-NRAO, MMA, MMA Planning, Box 7. https://science.nrao.edu/about/publications/alma.
12 The ESO proposal can be found in NAA-NRAO, ALMA, ALMA Design and Construction, Box 2.
13 The JAO maintains a current technical description of ALMA for prospective users. For the version as of the writing of this book, see: https://almascience.nrao.edu/documents-and-tools/cycle10/alma-technical-handbook.
14 *Resolution between the ALMA* Coordination Committee and NAOJ Concerning Coordination between LMSA and ALMA (signed), 12 November 1999. NAA-NRAO, ALMA, ALMA Multi-Institutional Agreements, Box 1. https://science.nrao.edu/about/publications/alma.
15 The Washington DC conference in 1999 was the first of a series, to be followed by conferences held in Paris in 2004, Madrid in 2007, and Puerto Varas in 2012.
16 The fourteenth and final draft of the ASAC charter can be found at: www.cv.nrao.edu/~awootten/mmaimcal/asac/asac_charter.html.
17 The statement was included in the ALMA report of NRAO Newsletter #86, January 2001. https://library.nrao.edu/public/pubs/news/NRAO_NEWS_86.pdf.
18 The minutes of the ALMA Board meeting of 6 April 2001 in Tokyo can be found at: NAA-PVB, ALMA, ALMA: The Story of a Science Mega-Project. https://science.nrao.edu/about/publications/alma.
19 MEXT (the Ministry of Education, Culture, Sports, Science and Technology) was formed on 6 January 2001 from Monbusho (the Ministry of Education, Science, Sports and Culture) and the Science and Technology Agency.
20 The National Institutes of Natural Sciences (NINS) was formed in April 2004 as an inter-university research institute corporation consisting of five member institutes: the National Astronomical Observatory of Japan, the National Institute for Fusion Science, the National Institute for Basic Biology, the National Institute for Physiological Sciences, and the Institutes for Molecular Sciences.