Report of the ALMA Scientific Advisory Committee: March 2002 Meeting

April 8, 2002

ALMA Scientific Advisory Committee

R. Bachiller (Spain), A. Benz (Switzerland)*, G. Blake (USA, Chair), R. Booth (Sweden), L. Bronfman (Chile), P. Cox (France, Vice Chair), R. Crutcher (USA)*, N. Evans (USA), Y. Fukui (Japan, Lead Observer), M. Gurwell (USA)*, T. Hasegawa (Japan), D. Mardones (Chile), H. Matsuo (Japan), N. Nakai (Japan), J. Richer (UK), S. Sakamoto (Japan), P. Schilke (Germany), L. Mundy (USA)*, K. Tatematsu (Japan), M. Tsuboi (Japan), E. van Dishoeck (Netherlands), M. Walmsley (Italy), D. Wilner* (USA), C. Wilson (Canada)*, S. Yamamoto (Japan), M. Yun (USA)

Ex-officio members

S. Guilloteau (ESO), R. Kawabe (Japan), J. Mangum (NRAO), P. Shaver (ESO), A. Wootten (NRAO)

Other participants

R. Brown (NRAO), K. Chiba (NAOJ), Y. Chikada (NAOJ), T. Cornwell (NRAO), C. Cunningham (NRC), P. Gray (NRAO), K. Kohno (NAOJ), M. Ishiguro (NAOJ), N. Kaifu (NAOJ), R. Kurz (ESO), S. Miyama (NAOJ), K. Morita (NAOJ), T. Noguchi (NAOJ), M. Rafal (NRAO), Y. Sekimoto (NAOJ), W. Wild (NOVA/SRON)

* Not present at Mitaka meeting, but provided input to ASAC report.

1. Executive Summary

This report covers the developments in the ALMA project between September 2001 and March 2002, an important transitional period as ALMA moves into its construction phase. Overall, the ASAC notes the excellent progress being made in many areas that relate directly to the scientific capabilities of the array. The impending completion of the Vertex prototype and its relocation to the Antenna Test Facility at the VLA site marks a pivotal milestone in the Project, and the ASAC eagerly looks forward to our next face-to-face meeting in Socorro, NM. The very tight schedules that must be maintained for the European and Japanese prototypes are a cause for concern, however, since any delays will jeapordize the rigorous testing necessary to select a single design for the ALMA production antennas. The ASAC also emphasizes that the enhancements to the Project resulting from the participation of Japan in ALMA are so valuable from a scientific point of view that all efforts should be made to allow Japan to become a founding partner in a future 3-way ALMA Project.

The moment is fast approaching when final decisions have to be taken on the design of the production receivers, and impressive progress continues to be made in the prototype receivers, multiplier chains, and laser LO system. Still, a number of parallel efforts, including the possible fabrication of ‘commissioning receivers’, remain ongoing despite the fact that the selection of a single option for each band is needed by the end of 2002. Production plans, while moving forward, are far from complete. The ASAC requests to be involved in any necessary trade-offs between performance, reliability, schedule, and cost, especially in cases where they directly affect the scientific capabilities.

In the view of the ASAC, system engineering in general and calibration in particular remains an area needing more investment by the Project. The establishment of a Calibration Team is a welcome step forward, but we reiterate our recommendation that a single leader for this Team should be appointed along with a single member whose responsibility is evaluating the polarization behavior of the array. The scientific capabilities of ALMA are greatly impacted by work in this area, particularly on the phase correction schemes using the WVR receivers.

Concerning software, the progress with the AIPS++ test using Plateau de Bure millimeter-wave data appears to going well, though the final report will not be available until after the upcoming ACC meeting in Venice. The ASAC again suggests that the Software working group defines a core program to test both the pipeline and offline analysis software and obtain early user feedback; and requests the Project present a detailed management plan for the ALMA software effort, including a detailed timeline including milestones covering the construction phase through 2011, at our Fall 2002 face-to-face meeting.

Following up on earlier ACC requests, the continued discussions of scientific operations formed the core of the ASAC face-to-face meeting. The concept of the Regional Support Centers (RSCs) was further defined, and an initial examination of possible roles for the community in evaluating ALMA observing proposals was conducted. No specific recommendations on how the review process might occur are made, but this report does outline the pros and cons of various possible options, which we hope will be helpful to the ACC. As a result of these deliberations and the unique reliance of ALMA on a dynamic scheduler, the ASAC does recommend in general that time accounting and the establishment of partner parity be separated from the proposal review process, and that the ALMA agreement adopt some flexibility in the precision within which and the timescale over which the allocation to any partner must balance. No matter the mechanism used, the concept of stringency is clearly important to ALMA, and so the ASAC recommends that the Project work with it using existing site data to begin to assess the statistics of stringency on various timescales.

2. Introduction

This document reports on the fifth face-to-face meeting of the ASAC, held on the peaceful grounds of the National Optical Observatory of Japan (NAOJ) campus in Mitaka, Japan on March 19–20, 2002. The meeting started with the happy news that the 10m Atacama Submillimeter Telescope Experiment (ASTE) antenna had safely arrived at Pampa La Bola. Telescope shakedown is set to begin shortly, and the ASAC looks forward to the detailed submillimeter astronomical measurements that will soon become possible in Chile. We are grateful for the exceptional hospitality of the NAOJ throughout our visit, and for the chance to learn more about the exciting ALMA-related technology development efforts underway in Japan.

In addition to the regular project updates, the program on the first day centered on likely community interactions with ALMA, specifically with a discussion of various facets of proposal preparation and review. The ASAC has a great deal of expertise in these areas, and the substance of our deliberations is presented in §12 and §13. We hope these discussions are helpful to the ACC as the design of the observatory progresses during the transition into the construction phase.

The program on the second day centered on a deliberation of the plans for the fabrication of the production receivers (see §6). The reports outlining our discussions and the resulting issues are given below, with the overall recommendations summarized in §14. The September 2001 ASAC report is quite extensive, and so in many sections dealing with individual aspects of the project we refer the interested reader to this more detailed discussion. As to our future meetings, Pierre Cox will become Chair and Chris Wilson was elected the new Vice Chair from North America, while Satoshi Yamamoto is now the Lead Japanese Observer. Given the impending completion of the Vertex prototype antenna, the ASAC would like to hold its fall 2002 meeting in Socorro.

On March 21, an ALMA science day event was held at the recently completed (and wondrous) Museum of Emerging Science and Technology in Tokyo harbor. Talks at this well attended public forum were given by Drs. Fukui, Blake, and Cox. Following the presentations, there was a lively question and answer session for which nearly all of the audience remained. Talks from this day, and from the previous ALMA science day in Chile, will be posted on various ALMA web sites for access by the Project and by the public.

3. Project Status and Management

The meeting started with a number of presentations on the status of ALMA. M. Rafal first presented the bilateral Project status in North America and Europe, concentrating on the differences in anticipated funding profiles and the likely ramifications for the organization of the Project. The upcoming ALMA Week starting April 22 was described, and the ASAC concurs that it may well offer a more efficient means of sharing information in this widely distributed undertaking. R. Kurz then outlined the baseline Project scope and schedule, with an anticipated completion date of 2011. A brief discussion of the commissioning and interim science followed. The ASAC requests guidance from the ACC in how it might be helpful in establishing the early science to be performed with ALMA, in particular whether programs such as a collaborative "first look survey" might be of interest in highlighting the observatory capabilities to the astronomical community.

M. Ishiguro described the funding situation and on-going developments in Japan. As discussed in the September 2001 report, the R & D effort in Japan is going well, but the main construction budget is not likely to commence until FY2004. Important dates in the Japanese budget process were highlighted along with the time frames over which the assistance of the ACC and the ASAC would be most helpful.

R. Brown then surveyed the Project status in Chile, concentrating on possible locations for the Operations Support Facility (OSF) and the nature of the Science Preserve and exclusive use areas. As part of this discussion, L. Bronfman informed the ASAC that the Chilean government intends to grant a *Direct Concession* within the Science Preserve presently administered by CONICYT (the Chilean Consejo Nacional de Ciencia y Tecnología) to a consortium that should be formed in Chile by the ALMA project partners. The law allows a maximum concession period of 50 years. The conditions for such a concession will be established by a *Concessional Committee* that includes at least representation from the Ministry of National Assets, the Ministry of Foreign Affairs, the Region of Antofagasta Government and town authorities from San Pedro de Atacama; and CONICYT. The land within the *Concession* will undergo a process of *zonification*, under which a fraction of the area will be for exclusive ALMA use, and the rest will be shared with other eventual astronomical projects evaluated by CONICYT. The creation of an additional protection zone, mostly to the west of the actual preserve, will be sought. A question that must be settled soon by the project is the possible location of antennas on or near the OSF access road for the largest configurations, in particular the size of the exclusive use areas around each of these pads (as further discussed in §11).

4. Toward a three-way Project

The enhancements to the ALMA Project resulting from the participation of Japan in the Project are so valuable from a scientific point of view that all efforts should be made to allow Japan to become a founding partner in a future 3-way ALMA Project. These enhancements include the Atacama Compact Array (ACA), some of the missing six receiver bands, and the Second Generation Correlator. In addition, the experience of the Japanese community, in particular with ASTE, will be a valuable asset to ALMA. During the meeting, M. Ishiguro presented areas of Japanese interest in ALMA, which include: antennae, receivers for Bands 10 and 4, the photonic LO system, a high speed sampler, and the Second Generation Correlator together with a contribution to the infrastructure and computing.

The ASAC notes that in order to make an extension to a three-way partnership possible, a certain flexibility needs to be kept in the Project, since Japan cannot be counted on to provide all the enhancements. Receiver Band 1, for example, which was highly ranked by the ASAC, would utilize HEMT amplifiers for which there is no real expertise in Japan, while the Second Generation Correlator has been envisioned as a European-Japanese collaboration. All decisions which are not time critical, i.e. which do not lead to a delay in the two-way project, should be deferred as much as possible until the situation of Japan is clear.

In particular, a single antenna type is of prime importance for the overall performance of the array, and we emphasize that the selection process should be based on the evaluation of all three prototypes, provided the current schedule is kept. We refer to the recommendation for a single antenna type in the antenna section of this document (§5).

5. ALMA Antennas

The ASAC heard detailed reports both on the progress of the prototype antennae under construction as well as on the plans for their testing in Socorro, NM. In particular, it was gratifying to hear that the North American antenna is expected to be assembled and ready for testing this summer. The program for evaluation of antenna performance seems satisfactory although it is regrettable that interferometric holography will probably not be possible in practice. The ASAC is worried by the tight schedule for testing the European and Japanese prototypes which are each scheduled to arrive in Socorro in April 2003. It seems extremely important that the delivery schedule be adhered to in order to allow testing for all three prototypes to be concluded by the end of 2003. The ASAC would also like to underline the importance to the project of the choice of a single antenna design subsequent to an objective comparison of all three prototypes. This presumably would allow cost savings and increase ease of maintenance which, in the end, will increase the productivity of ALMA. The ASAC also notes that the choice of a single antenna type is particularly required to guarantee good performance for polarization measurements.

6. Receivers

The receiver presentations and discussion at the ASAC meeting consisted of two parts: (i) a status report on the prototype receiver development efforts; and (ii) plans for series production. Related receiver issues such as polarization and calibration were not discussed, and the recommendations of the previous ASAC reports on these topics still hold. Hardware progress on the WVR receivers is also good; the major issues here are likely related to calibration and data correction issues, as discussed in §8.

Frequency Bands. The discussions on prototype and production receivers focussed on the initial complement of four receiver bands in the bilateral project (in order of increasing frequency): Band 3 (84-116 GHz), Band 6 (211-275 GHz), Band 7 (275-370 GHz), and Band 9 (602-720 GHz). The ASAC reiterates that the goal for ALMA should be complete coverage of the atmospheric windows across the millimeter and submillimeter spectrum leading to exciting new science (see the September 2001 report on 'Scientific Justification for the ALMA Enhancements'). Designs for the cryostat, LO and IF systems should therefore remain capable of supporting the full receiver suite. Continued receiver development funding in the operational phase of ALMA will be essential for implementing new bands and performing upgrades. The ASAC requests continued involvement in any prioritization for implementation or addition of new receiver bands.

Prototype receivers. The ASAC was pleased to hear of good progress in many areas, including the cryostat and optics design, the mirror and lenses fabrication and the IF amplifiers. The LO power multiplier/amplifier devices have improved to the point that they now form the baseline LO system for ALMA. Encouraging results on the photonic LO option from various groups were reported as well, and the ASAC supports the decision by the Project and JRDG to extend this research for an additional two years because of the potential long-term savings in cost and complexity. The mixer noise temperatures, where reported, are promising and well within the ALMA specifications, but they refer in several cases to DSB systems with $\leq$4 GHz IF bandwidth. The ASAC stresses that the ALMA baseline specifications are SSB below 370 GHz and DSB at higher frequencies with a bandwidth of 8 GHz per polarization (4-12 GHz IF), and that efforts should be made to retain these specifications. For 2SB sideband separating receivers, the ASAC recognizes that the maximum output that can be processed is only 4-8 GHz IF, and recommends adopting this as the baseline for further development work because it leads to only a minor loss in flexibility.

In spite of the good progress, the ASAC is concerned that a number of parallel developments continue to be carried out. The receiver development and production schedules are now on the critical path, and final decisions for a single option for each band for production are needed by the end of 2002. The ASAC requests to be involved in the trade-offs between performance, reliability, schedule, and cost, especially in cases where they directly affect the scientific capabilities. The ASAC also heard of plans to implement 'commissioning' receivers containing fewer frequency bands on the initial telescopes at Chajnantor for early testing of the array. While the ASAC strongly supports end-to-end testing and science commissioning as soon as possible, it recommends that the effort involved for constructing any such ‘commissioning’ receivers is limited to a minimum and does not lead to a major distraction from the main receiver production. It also notes the importance of Band 3 for testing and commissioning, and urges the JRDG to speed up the development of this band.

Total Power Stability. No detailed work has yet been carried out to investigate whether the specification of $\Delta P/P \sim 10^{-4}$ in 1 second can be achieved, largely due to a lack of manpower in the systems engineering area. As noted in previous ASAC reports (see Appendix D of the March 2000 ASAC Report and p. 8 of the February 2001 ASAC Report), such high stability would enable total power on-the-fly maps to be generated without the need for a nutating subreflector. The excellent temperature stability of the Japanese prototype test cryostat reported at the meeting is encouraging in this respect. With the appointment of a new front-end systems engineer, the ASAC urges the JRDG to carefully consider this important issue as soon as possible and report back at the next meeting.

Series production and integration. The ASAC obtained oral reports of the plans for the organization of the series production of cartridges and receivers in the European, North-American and Japanese front-end groups. Product trees down to the subsystem level were presented. The need for simple and standard designs which are easy to assemble with strict quality and process control was stressed by all groups, and is strongly endorsed by the ASAC. Automatic testing at the cartridge production sites and receiver integration centers will be essential, and such facilities need to be developed as soon as possible. In general, the ASAC is concerned that while the organization of the receiver production is now being clarified, realistic schedules and manpower requirements need further work. The ASAC urges an updated report by the time of its next meeting. The ASAC also advises the Project to include critical spares in the planning.

Summary. The ASAC was pleased to hear of the progress on various components of the prototype receivers for the initial frequency Bands 3, 6, 7, and 9, but expressed concern a number of parallel developments that continue to be carried out. It re-iterates that 2SB is the baseline specification for the receivers below 370 GHz, but accepts that the IF frequency bandwidth can be limited to 4-8 GHz in this case. The ASAC urges that final decisions of the various options be taken by late 2002, and requests to be involved in the process. The ASAC notes the importance of early end-to-end testing of the receivers and antennas on the Chajnantor site, but recommends that the effort for producing any ‘commissioning’ receivers is kept at a minimum and does not distract from the main receiver production. Finally, the ASAC looks forward to a report on the total power stability and an updated plan for the production, integration, testing and implementation of the ALMA production receivers at its next meeting.

Recommendations:

1. *The Project baseline specification should be 2SB receivers below 370 GHz, but given that only a small loss of flexibility results, the IF bandwidth could be limited to 4-8 GHz. The baseline specifications remain DSB with a 4-12 GHz IF bandwidth for band 9.*
2. *The ASAC recommends that final decisions on the various options be taken by late 2002, and requests to be involved in the process.*
3. *The fabrication of ‘commissioning’ receivers, while important for testing, should not distract the Project from the critically important main receiver production.*
4. *The ASAC requests at our next face-to-face meeting a report from the Project on total power stability along with an updated plan for the production, integration, testing, and implementation of the production receiver bands.*

7. Correlator(s)

7.1. Baseline Correlator

The ASAC heard a presentation by Peter Gray on the activities concerning the ALMA backend and the baseline correlator. The backend subsystem includes hardware located at the antennae (downconverters, digitizers, fiber optic transmitters, LO reference receiver and second LO synthesizer), as well as at the observatory central building (fiber optic receivers, central reference generator, maser, and LO laser synthesizers). Most of the tasks involved in the backend developments are assigned to North America; exceptions are the digitizers which are assigned to Europe and the fiber optic transmitters and receivers which are shared by both partners. The developments in this area seem to be proceeding well; bench prototypes of the backend subsystem will be completed by next fall, and the pre-production prototype models will be ready at the end of 2003. A Preliminary Design Review on the backend will take place April 24-25 during the upcoming ALMA week in Granada.

The ALMA baseline correlator has been discussed in previous ASAC meetings and is described in Chapter 10 of the ALMA Project Book. The correlator is made up of seven different kinds of cards (correlator card, FIR filters, long term accumulator, front panel data port, station, station control, and station motherboard). Except for the station motherboard, prototypes of all cards are either in test or in fabrication. The correlator card includes the correlator chip and several thousands of power and signal connections. The custom correlator chip is currently at foundry, and its delivery is expected this spring. The prototype of a first quadrant of this correlator is now foreseen for October 2003, and should be delivered to the VLA site in case interferometric tests can be carried out with the prototype antennae (such tests are not envisaged before January 2004). The first quadrant of the baseline correlator will be completed by October 2004 and additional quadrants will be completed one per year until the final completion by October 2007. The ASAC has no further remarks on the baseline correlator developments which appear to be progressing well, and reiterates that it will be a very valuable instrument for the first years of the interferometer.

7.2. Second Generation Correlator

A Second Generation (2G) Correlator should provide a considerably greater number of channels, higher sensitivity, and higher flexibility than the baseline correlator. The scientific capabilities of such a correlator have been previously summarized by the ASAC in the document "Scientific Justification for the ALMA Enhancements." A set of guidelines about the minimum performances to be met by this 2G Correlator were provided in the September 2001 ASAC report. The ASAC recommended that the ALMA project scientists should take these guidelines as starting point to establish the actual technical specifications and goals of the 2G Correlator, ensuring at the same time that these are consistent with the requirements coming from other areas of the project (namely the specifications on LO, calibration, and software).

The Committee was pleased to hear from M. Ishiguro that a prototype of the FX Japanese design for the 2G Correlator has been built and successfully tested at Nobeyama very recently. This prototype includes a 2-bit high-speed sampler and provides 14.6 kHz resolution over the 2 GHz band (i.e.: about 131000 channels).

An updated version of the possibilities of the European concept of the 2G Correlator and a straw-man schedule have been recently included in the ALMA Project Book, Chapter 10. A meeting of the 2G Correlator Working Group is to be held March 26-27 in Garching. The Committee was glad that, following its previous recommendations, the 2G Correlator Working Group is now taking into consideration the EVLA/WIDAR concept, and that the Garching meeting includes a discussion on the EVLA/WIDAR architecture.

The ASAC continues to encourage the collaborative efforts of the European, Japanese, and North American teams to identify the optimal 'Unified Design' for the 2G Correlator. Following discussions at this and at previous meetings, the Committee reminds the teams that a detailed design, a precise cost estimate, and a production plan for the 2G Correlator should be made available not later than fall 2002.

Recommendation: The ASAC enourages the 2G Correlator group to continue its work involving European, Japanese, and North American teams toward the selection of an optimal "Unified Design" architecture, and suggests that the detailed design, precise cost estimate, and production plan for the 2G correlator be available to the Project before the end of 2002.

8. Calibration

Little new work on calibration was presented to the ASAC; however, plans for setting up a Calibration Group at the forthcoming ALMA week in Granada were disclosed, and the ASAC looks forward to developments from this group. It appears that the Project Scientists will lead this group: some ASAC members felt it would be useful to identify a separate leader if possible, to alleviate the burden on the Project Scientists. The ASAC reiterates their view that although there is a great deal of work going into several areas of calibration, it appears somewhat disorganized: a well defined calibration team, with strong leadership, pursuing a definite strategy would be a major step forward. This seems especially true of the WVR system and real time phase correction. The existing schemes are promising, but none work over the range of conditions expected for ALMA, nor to the high degree of precision and accuracy required at the superb Chajnantor site. Further attention in this critical area is now imperative.

9. Polarization

Polarization has been extensively discussed at the previous two ASAC meetings; details can be found in our previous reports from the September 2000 and February 2001 ASAC reports. No further discussion is presented here, except to note that the very solid progress on the submillimeter photonic source means that it should be possible to calibrate the polarization properties of the receivers and electronics systems easily and frequently. Here we reiterate our recommendation that a dedicated person, probably within the Calibration group, be identified to concentrate on polarization issues.

Recommendation: The ASAC recommends that a well-defined leader for the Calibration Group be identified, as well as a dedicated person to lead studies on polarization issues.

10. Software

The ASAC heard two very useful presentations regarding data handling and analysis software developments. The first of these was a status report on the AIPS++ evaluation being made collaboratively by IRAM, the AIPS++ group of NRAO and ALMA-ESO. The goals of this re-use analysis are to evaluate:

1. Does AIPS++ meet the ALMA requirements for off-line data reduction?

2. How long does an expert developer of millimeter data reduction software need to learn AIPS++ development?

3. Can we perform a complete end-to-end reduction of actual millimeter line data with AIPS++ and achieve similar results to existing packages?

In general, it appears that the test is going well, but the work is incomplete. The committee therefore looks forward to receiving the final report, which is due at the end of April 2002. The committee was informed of the current status of the AIPS++ test:

1. The ALMA Test Interferometer (now called the ALMA Test Facility) FITS data format was chosen as the export format.

2. Representative IRAM interferometric data including HCO^+(1–0) and ^{13}CO(2–1) data for the circumstellar disk around GG Tau were chosen as the data set for the test.

3. Some new tasks (selection of radiometrically corrected or uncorrected data, etc.) and functions (polynomial fitting for bandpass, phase, and amplitude, etc) were implemented in AIPS++.

4. No major change in AIPS++ has been necessary so far.

5. Mutual visits are being held between NRAO and IRAM in this re-use test.

6. First maps of the data from AIPS++ have just been obtained, and are being compared in detail with the original IRAM maps.

The second report was made by Tim Cornwell, and concerned the NRAO data management plan, called the 'e2e (end-to-end) project' (hereafter NRAO e2e). NRAO e2e aims to facilitate easier access to radio data and archives for NRAO observers and archival researchers. The plan will cover all the NRAO facilities (VLA/VLBA, GBT, EVLA, ALMA), including proposal preparation and management, observing scripts, scheduling, calibration and imaging, interactive observing, pipeline, archive, and quality assessment. The project kicked off in July 2001. NRAO e2e is obviously of great interest to ALMA, as many of the needs of the data reduction pipeline and archive requirements for EVLA are similar if not identical to ALMA's. In particular, NRAO e2e will use AIPS++ as its data reduction pipeline engine, and will develop its own radio interface to the Virtual Observatory (VO). The concept at this stage is to isolate the VO requests from the details of the radio data storage.

The development of the NRAO e2e will be 'spiral', with 9 month cycles of requirements capture, analysis, design and implementation. The project duration is five years. The ASAC felt this development model was potentially of great interest to ALMA, and is somewhat at odds with the rather monolithic requirements capture that is currently underway for ALMA. The committee urges the software IPT to maximize their interaction with the NRAO e2e project and other similar on-going management projects in other institutions (e.g., ESO) to share development experience and code; the ASAC also looks forward at a subsequent meeting to seeing a report on the detailed planning underway for the ALMA archive and pipeline.

More generally, software issues remain pivotal to the performance and easy use of ALMA, especially for the non-expert observer. For our next meeting, we therefore reiterate our request for a more detailed management plan for the ALMA software effort, including a detailed timeline including milestones covering the construction phase through 2011; and our recommendation that the Software working group define a core program that begins user feedback as early as practical.

Recommendations:

1. *The ASAC recognizes the need of a better understanding of the resources of the Software team and the current management plan of the entire data analysis project, and requests a presentation on these issues at our next face-to-face meeting.*
2. *The formal results of the "audit" of AIPS++ with PdBI data (due in April 2002) should be carefully examined for their scalability to ALMA, and should be used to review the entire software effort for ALMA in 2002.*
3. *The ASAC reiterates that the Software working group should define a core program for both the pipeline and offline analysis. Such a core program would be a significant milestone and would allow a first user feedback.*
4. *The Committee urges the software IPT to maximize their interaction with the NRAO e2e project and other similar on-going management projects at other places (e.g., ESO) to share development experience and code.*

11. Configuration Issues

A. Wootten reported the results of the ALMA Configuration CDR held in Socorro, NM, on 24-25 January 2002. The PDR review committee made recommendations on several specific action items and a list of deliverables. The ASAC supports their recommendation to: (1) appoint a leader of the configuration design process; (2) to contract with a consulting engineer to provide an estimate of the construction costs and input on road and utility conduit design; (3) to obtain high resolution imagery and maps; and (4) to report on configuration progress at the upcoming "ALMA Week".

The ASAC welcomes the new leader of the Configuration team, John Conway, and notes with satisfaction that the configuration working group can now concentrate their efforts into finalizing the configuration designs and addressing the practical issues such as the road and conduit design in collaboration with the site development group.

The design of the largest configuration is one area where a broader design study is still needed, particularly for the new idea of utilizing the proposed OSF access road in the direct link option. The configuration CDR review team did not recommend a separate review for this work, but the largest configuration has a critical scientific impact and thus deserves a full report and a review by the ASAC. Although we understand that this may take some time, we note that there are legal repercussions on the design of the largest array in that it could extend into the regions beyond what has been granted as the ALMA exclusive use zone. Therefore a report on the design of the largest configuration is requested to the project scientists and the configuration working group in conjunction with the appropriate report from the site development group, probably around the next site development review.

12. Science Operations: Proposal Review and Time Accounting

Following the E-ACC and E-AEC meetings in June 2001, the ASAC was asked to consider ALMA operations from an astronomer's point of view. As a result, an ASAC Operations Study Group was formed chaired by N. Evans, C. Wilson and Y. Fukui. The Study Group did not address technical operations issues, such as the siting of the OSF, the work schedules, etc. Instead it focused on the operational issues that might affect the scientific productivity and vitality of ALMA, looking at the questions from the point of view of the future ALMA observer.

In the initial report from the Study Group, the major recommendations on the ALMA operations centered on the role of the Regional Support Centers (RSCs) in assisting observers from the preparation of proposals through the analysis of ALMA data. During our Santiago face-to-face meeting, it became clear that certain aspects of ALMA made it rather different than other observatories, and that further deliberations by the study group and discussions by the ASAC were warranted. Here we present a summary of our March 2002 discussions on possible modes of proposal review for ALMA. In § 13, we report on our further thoughts on the roles of the RSCs. For background information, please consult the September 2001 ASAC report.

The ASAC Operations Study Group made a study of how proposal review and time allocation is done at other multi-partner observatories. They further considered the unique characteristics of ALMA, in which all observing is scheduled by a dynamic scheduler. Time cannot be "allocated" in the usual sense because the dynamic scheduler actually decides what project will be observed at a given time, based on the current weather conditions and array status. The outcome of the proposal review process is then a **scientific ranking** and a **maximum** time. In this situation, the only possible place to account for and adjust time going to different partners is in the dynamic scheduler. These considerations were agreed to by the entire ASAC, leading to our first recommendation to the ACC:

1. The ASAC recommends that time accounting and establishment of parity among the partners be separated from the proposal review process.

The distribution of requested observations over the range of weather conditions and array status conditions (encapsulated into the concept of *stringency* in our last report) may be very uneven for a given partner. In addition, the fraction of time during a given semester that a certain stringency will be achieved is unpredictable because of long-term weather variations. Imagine a partner that produced almost all projects with high stringency (e.g., requiring the very lowest water vapor) in a semester with bad weather (e.g., an El Niño event). A rigid requirement that the observing time for a partner adds up to a fixed fraction would lead to observations being done under inappropriate conditions, resulting in bad data and possible embarrassment for the observatory. This problem leads to our second and third recommendations:

2. The ASAC recommends that the ALMA Agreement adopt some flexibility in the precision within which and the timescale over which the time accounted to any partner must balance.

3. Alternatively, we recommend that the time accounting be weighted by the stringency so that observations under rarely-achieved conditions count more.

Between these two alternatives, the ASAC was more comfortable with the first, but if the flexibility implied by the first suggestion is not feasible, the second alternative is almost certainly needed. It would require further study to define the optimum weighting factors, which would depend on the statistics of stringency at the site. Such a study needs to be done, leading to another recommendation to the ALMA Project:

4. The ASAC recommends that the Project use existing site data and projections of performance under various conditions to assess the statistics of stringency on a range of timescales.

Stringency is defined in our previous report as t_a/t_p, where t_a is the total available observing time and t_p is the observing time during which the particular observation can be done. However, one should also think of stringency as a function that depends on opacity, seeing, pointing, etc. The value of this function, including all the dependencies, would yield the first definition.

Once we realize that time accounting is logically separate from the proposal review process, we can consider the methods for proposal review free of the need to balance time shares. That function is done by the dynamic scheduler. Thus we use the term Proposal Review Committee (PRC) rather than a Time Allocation Committee (TAC). The Study Group developed a set of principles, assumptions, and hypothetical projects and two alternative models for Proposal Review Committees, using features of existing committees, adapted to the ALMA situation. These are **subject-based PRCs** (with multi-partner panels), similar to the HST and ESO systems, and **partner-based PRCs** (with an overall International PRC), similar to the JCMT and CFHT systems. We explicitly attempted to mitigate the negative features of each of these, leading to models that would satisfy the largest possible group. Many members of the ASAC started out with strong preferences for one or the other but realized that either model could be made to work.

These models are presented in Appendices § A and § B in some detail only to reveal the issues that they raise. They are strictly "straw-person" models for the sake of discussion. The main issues that our considerations raised for the ACC to consider are these:

5. The ASAC recommends that some time (6–10%) be set aside for Director's discretionary time, international (non-partner) proposals, and special programs such as Key or Legacy programs.

6. We recommend that policies be adopted that encourage collaborative proposals with members from different partners.

A number of the hypothetical projects involved time-critical or target-of-opportunity observations that could be handled easily only with discretionary time. In addition, we hope that some project with an impact like that of the Hubble Deep Field will be done with ALMA. The role of Director's discretionary time in obtaining such paradigm-shifting results was recognized. We also believe that worthy projects from outside the ALMA partners should have a chance to be executed. Finally, we believe that Key or Legacy (no proprietary time) programs are important to demonstrate the power of ALMA to the larger community. We expect that such programs will combine the expertise in the different partner communities, helping to encourage collaborative proposals. Taking the time for such proposals "off the top" makes these a joint effort by the partners. However, we also seek to encourage smaller, more typical projects with members from different partners. This can be difficult in the partner-based PRC model in particular, where there may be a bias against them. While opinion was divided, we considered the idea that the time accounting method be adjusted to lower the barriers to such "mixed proposals." If the time accounting goes partially to the partner of the co-Is, rather than all being assigned to the partner of the PI, mixed proposals can compete more fairly in a partner-based PRC. However, this means that one partner could favor a proposal that led to time being counted for another partner. In any case, the method of time accounting should be considered by the ACC; if possible, it would be good to leave some flexibility in the agreement on this point.

13. Science Operations: Regional Support Centers

In the September 2001 ASAC report, the roles of the 'Science Operations Center' (SOC) and the Regional Support Centers (RSCs) were discussed. It was recommended that there should be "a single SOC, operated by the ALMA observatory, where the pipeline produces and stores the official archive" and that the RSCs "should be responsible for the support of the observer, from proposal preparation through data reduction and analysis." Further study and discussion were recommended on the core functionality of the RSCs and on the number of RSCs that are needed. The ASAC has considered the issues of the RSCs further and we report here on the conclusions based on the various discussions which were held in the partner communities.

The need for a RSC has been recognized as being a critical aspect in the success of ALMA as a means to support the the larger astronomical community and so enhance the scientific return of the project. The main problem is that interferometry represents a 'cultural change' for most astronomers, so that assistance is essential for any new user. Astronomers therefore need support in their own time zone, and new users need physical access to a Center. There should thus be one ALMA supported RSC for each partner community. Even experienced observers need to top-up their knowledge and talk to a team of people who are expert users of the instrument. The interaction of 'ALMA-qualified' astronomers with the ALMA users will also be essential to develop tools and strategies for the best use of ALMA. Therefore it is important that such a Center has close interactions with the instrument and the Operations Support Facility in Chile. The RSC should also provide easy access to the Data Archive.

These are the core functions that each RSC should have and which are under the control of the ALMA project, to be distinguished from additional functions that different partners may add. It is the functions themselves, rather than the particular means to realize them, that we discuss here; the means may differ among the partners. The core functions that we have identified, in order of importance, are:

1. Providing user support for observing proposals, data reduction beyond the pipeline products, and archival research;
2. Providing feedback from the user to the project on performance;
3. Ensuring rapid access to the ALMA Archive, either via a local copy or a fast link.

We note that the role in supporting archival research overlaps to some degree with the role of Virtual Observatories and the interaction between the RSCs and these VOs needs to be defined. Whether each RSC has a physical copy of the archive or merely provides a link is a matter of local implementation. Various communities have considered other functions to be important (e.g., financial support for the US community, software development for the Canadian community), but the core functions listed above are agreed to be the common denominator.

Other aspects, which could be supported by the communities' own resources outside the ALMA project, (and which may even be distributed among the individual institutes) include, e.g.:

- Software development & maintenance beyond the nominal operations
- Interferometric data handling & new techniques
- Support for special projects such as public surveys with limited time-priority, legacy programs or projects which cannot be handled with the pipeline

- Organization of post-docs (ALMA Fellowship), training program & interferometry schools
- Financial support to observers to help with student support, data analysis, and publication of results

These non-core functions or development activities will depend on the community. Finally, the ASAC reiterates that it is crucial that the RSCs are operated with an international and collaborative spirit leading to close interactions between the RSCs for the benefit of the astronomical community at large.

Recommendation: The core functions identified above for the RSCs should be adopted by the Project.

14. Summary

The major ASAC recommendations are summarized below. These are in the order discussed in the text and not in any priority order. More detailed recommendations can be found in the section referenced by the major recommendations.

1. The ASAC has the following recommendations concerning receivers (see §6):

   – The Project baseline specification should be 2SB receivers below 370 GHz, but given that only a small loss of flexibility results, the IF bandwidth could be limited to 4-8 GHz. The baseline specifications remain DSB with a 4-12 GHz IF bandwidth for band 9.

   – The ASAC recommends that final decisions on the various options be taken by late 2002, and requests to be involved in the process.

   – The fabrication of 'commissioning' receivers, while important for testing, should not distract the Project from the critically important main receiver production.

   – The ASAC requests at our next face-to-face meeting a report from the Project on total power stability along with an updated plan for the production, integration, testing, and implementation of the production receiver bands.

2. The ASAC gladly notes that the 2G Correlator group is now considering alternative designs, per our recommendations. We encourage the group to continue its work involving European, Japanese, and North American teams toward the selection of an optimal "Unified Design" architecture, and suggests that the detailed design, precise cost estimate, and production plan for the 2G correlator be available to the Project before the end of 2002.

3. The ASAC applauds the formation of a Calibration group within the Project, but recommends that a well-defined leader and a dedicated person for polarization issues be identified to lead this process (see §8 and 6).

4. The ASAC has the following recommendations on Software issues (see §10):

   – A better understanding of the resources of the Software team and the current management plan of the entire data analysis project is needed, and the ASAC requests a presentation on these issues at our next face-to-face meeting.

   – The formal results of the "audit" of AIPS++ with PdBI data (due in April 2002) should be carefully examined for their scalability to ALMA, and should be used to review the entire software effort for ALMA in 2002.

   – We reiterate that the Software working group should define a core program for both the pipeline and offline analysis. Such a core program would be a significant milestone and would allow a first user feedback.

   – The committee urges the software IPT to maximize their interaction with the NRAO e2e project and other similar on-going management projects at other places (e.g., ESO) to share development experience and code.

5. The ASAC supports the decisions of the Configuration CDR and welcomes the new leader of the Configuration team, John Conway.

6. The ASAC continues to consider Science Operations in detail, particularly the likely interfaces between the observing community and the observatory, and has the following major recommendations for the submission and review of proposals (see §12):

   – The ASAC recommends that time accounting and establishment of parity among the partners be separated from the proposal review process, and that

   – The ALMA agreement adopt some flexibility in the precision within which and the timescale over which the allocation to any partner must balance. Alternatively, time accounting could be weighted by the stringency of the proposed observations.

   – Accordingly, the ASAC recommends that the Project work (with the ASAC) to use existing site data along with projections of array performance under various conditions to assess the statistics of stringency. The latter analysis should consider a wide range of timescales.

   – The ASAC recommends that some time (6–10%) be set aside for Director's discretionary time, international (non-partner) proposals, and special programs such as Key or legacy programs. We also recommend that policies be adopted that encourage collaborative proposals with members from different partners.

7. The ASAC reiterates our earlier recommendation that the Regional Support Centers (RSC) should be responsible for support of the observer, from proposal preparation through data reduction and analysis. They may also provide data portal and software development. They should be operated with an international and collaborative spirit. The ASAC recommends that the following be the core functions that are provided by each Regional Support Center (RSC):

   (a) Providing user support for observing proposals, data reduction beyond the pipeline products, and archival research;

   (b) Providing feedback from the user to the project on performance;

   (c) Ensuring rapid access to the ALMA Archive, either via a local copy or a fast link.

8. The ASAC applauds the successful arrival of ASTE at its observing site in Pampa La Bola, and recommends that testing of the ALMA prototype receiver cartridges under the realistic conditions offered by this telescope begin as soon as is feasible.

APPENDIX

A. Model for Subject-Based PRCs

General Structure: This is a model for a Subject-Based or unified ALMA Proposal Review Committee (PRC). It is based on the systems used at HST and ESO and adapted to the circumstances of ALMA. It is assumed below that Japan is an equal partner in ALMA, but the adaptation to a bilateral ALMA is straightforward. We also assume that the host nation, Chile, chooses to participate in this PRC.

We assume that there is an overall committee, the APC or ALMA Program Committee, and Subject-Based Panels. The Panels would provide a ranking of proposals within their subject area. The APC would merge these into a single set of rankings and make recommendations regarding balance between general proposals and special programs (Key or Legacy proposals, etc.). We also assume that the ALMA Director has some discretionary time. We propose that the panels and the APC meet in a location that rotates among the partners.

A.1. Composition of the Panels and the APC

We assume 4 panels, divided into subject areas (for an example, see below). Each panel would have 7 members. Four panel members should be chosen by the partners and host nation as *representatives* of their regions (Europe, Japan, N. America, Chile). Three members (one from each of the partners) would be added by the ALMA Director. The reason for *partner representatives* is to reassure the regional communities that they are fairly treated. The three additional members would ensure that all specialities are covered in a given panel. The Panel chairpersons would be members of the PRC and would be distributed among the partners and host country evenly (1 Europe, 1 North America, 1 Japan, 1 Chile). We propose 3 year terms for each panelist to balance experience with the need for new ideas and to avoid overly stressing individuals. The Panel chairpersons would rotate every year.

The APC would consist of the chairpersons of each Panel and additional members chosen by the partners (one for each partner or host nation) and additional members chosen by the ALMA Director. These extra members should have an equal say to the Panel Chairs. The members of the APC would serve 3 year terms. The final composition of the APC would then be 3 Europeans, 3 North Americans, 3 Japanese, and 2 Chileans (11 in all).

A.2. Proposed Panel Structure

We suggest for ALMA 4 panels. Based on the assumed proposal pressure (up to 500 proposals per semester seem plausible based on ALMA's throughput and the experience with HST), each panel would review 125 proposals, close to the *pain barrier* for proposal review. At any one time, there would be 28 people (8 Europe, 8 N.America, 8 Japan, 4 Chile) on the ALMA panels.

The Panels could be distributed as follows:

1. Stellar Astronomy including the Sun, circumstellar envelopes, planetary nebulae.

2. Interstellar Medium, Star and Planet Formation, Solar System including planets and comets.
3. Nearby Galaxies including the Magellanic clouds and AGNs with $z < 0.1$.
4. Galaxies and Cosmology including high-redshift objects, the S-Z effect.

The idea behind this breakdown is to have roughly equal numbers of proposals coming to the different Panels. The subject areas should be redefined periodically based on proposal pressure.

A.3. Charge to the Panels

The Panels are charged with producing a rank-ordered list of all proposals assigned to them along with any adjustments deemed necessary to the maximum time for a project. International (no proposer from a partner) and ALMA staff proposals are assigned to the Panels in the same way as any other proposal. The Panels should not explicitly consider partner balance, but they may consider partner priorities for style of science (e.g., continuum versus line, survey versus case study, ...) as expressed by the partner representative. They may also consider balance between sub-areas within their large subject area. While they do not assign time, they may consider time requirements in their ranking and decrease the maximum time from that requested. They also consider stringency, as determined by the simulator in the proposal process.

A.4. Charge to the APC

The APC is charged with review of special programs and merging the panel rankings into a final rank-ordered list. Special programs include proposals for large blocks of time with no proprietary period (Legacy proposals), Key projects, and anything else that requires an overall view. They may ask the subject-based panels for scientific evaluation of such proposals, but responsibility for their placement in the overall ranking rests with the APC. They should also consider whether international proposals have been fairly dealt with on the panels. The APC is also responsible for deciding the fraction of time going to the different subject areas using the proposal pressure as a guide. They may recommend to the ALMA Director a redefinition of the areas in order to equalize proposal pressure. Finally, they are responsible for advice to the ALMA Director regarding the proposal evaluation process.

A.5. Charge to the Director

The APC reports its rankings to the ALMA Director. The Director exercises discretionary time by inserting programs into the rank-ordered list. The Director must also monitor partner parity and, if necessary, adjust the parameters of the Dynamic Scheduler in such a manner as to redress any imbalance outside the allowed range on the appropriate time scale.

A.6. Pros and Cons of a Subject-Based PRC

- **Pros**
  1. More expertise on subject-based panels

2. Can favor multi-partner collaborations including large programs or surveys.
3. Competition leads to better proposals.

- **Cons**

1. Issues of partner parity and style of science can arise. The above model tries to deal with this problem partly by having a fair representation of the partners on the panels and APC and partly by empowering ALMA management to take partner parity into account in the Dynamic Scheduler.
2. The APC has to consider balance among subjects when producing its rankings and this will always be somewhat arbitrary. In the above model, the Panel Chairpersons have the responsibility of defending their area. Over and above this, we recommend periodic redefinition of areas in order to obtain roughly equal proposal pressure in all panels.

B. Model for Partner-Based PRCs

General Structure A partner-based time-allocation system is successfully used at several multi-national observatories (the JCMT and CFHT being examples). We assume that North America, Europe, Japan, and Chile have separate PRCs, which would report to an International PRC (IPRC). The composition of the IPRC is not specified in this model, but it could be similar to that of the APC in the subject-based model.

In this system, the partners can choose the style of science they prefer. For example, one partner may have invested heavily in another telescope (e.g., a deep submm space survey telescope), and its community may wish to capitalize on this investment by spending a large fraction of their ALMA time following up the sources they have detected. Or they may choose to give special priority to graduate student projects, survey work, or public outreach work. These issues of scientific *style* have proved important in previous multi-partner observatories.

We assume the following for Partner PRCs:

1. Each partner has its own Proposal Review Committee (PRC) that weighs the scientific merits of the proposals with PI's from that partner.

2. ALMA will utilize dynamic scheduling that uses a weighted combination of science ranking, stringency, execution status, and aggregate partner share to ascertain which project in the dynamic pool will be observed under current conditions.

   Usually, but not always, this will be at the project with the highest scientific ranking that has a stringency range consistent with the current stringency. The science ranking is the only input from the PRC to the dynamic scheduler.

3. The International Proposal Review Committee is needed to provide a single point of contact between the time allocation process and the ALMA Director, and to resolve conflicts between identical or similar proposals from different partners. In addition, it could handle proposals from applicants without partner affiliation, and any calls from the Director for Legacy/Key projects.

B.1. Suggested Organization

1. Well before each semester, the Director makes an estimate of expected integration time available in different stringency ranges. Director's time, engineering time and an estimate of International time are top-sliced before partner and host country allocations are made. The partners are then given an indicative figure of how much time they are likely to receive in the coming semester, in the given stringency ranges.

2. Each partner solicits proposals from their science community, at roughly common deadlines.

3. The Partner PRCs rank scientifically all the proposals from their community. Each Partner can choose how it wishes to handle such things as Long Term proposals or student theses.

4. Ranked proposals are then forwarded to the IPRC. The IPRC attempts to identify and resolve conflicts between partners (see later), and allocates international time and Legacy time if appropriate. The IPRC then sends on recommendations to the Director, who deals with Director's discretionary time.

5. On a slower cycle (perhaps 2-3 years) the Director will solicit Legacy/Key Project proposals from the entire community. These proposals will be ranked scientifically by the IPRC, and a certain fraction will be accepted into the project queue.

B.2. Issues still to be resolved

1. There are various natural ways of handling large Key or Legacy proposals in this scheme. Each partner could individually allocate its own large programmes depending on its own priorities. Alternatively, an agreed amount of time could be top-sliced from the ALMA time, and a special call for proposals issued by the Director periodically, with assessment done by the IPRC.

2. The mechanism by which a proposal is matched to the correct PRC is usually the PI's affiliation. If the PI is not affiliated to a partner, any partner co-Is' affiliations are used. Alternatively, the PI and co-I's could be given different weights, and the PRC chosen according to this weighted share.

3. At some point, it must be decided whether mixed projects count as time from a single partner (the PI) or if time is counted against all the co-I's partners in some way. The latter method could have the result that the European PRC could allocate some "North American" time. On the other hand, it would remove barriers to inter-partner collaborations in partner-based PRCs. In addition, it must be decided if multi-partner proposals can apply simultaneously to several PRCs, or must go to only one PRC.

4. There are several possible ways that the Director could act on the recommendations from the IPRC. For example,

   (a) Model A: A sequential list of the Partners is created, with the number of entries for each Partner approximating the fraction of time each Partner is expected to receive. Each entry corresponds to a set amount of time. The top proposal from Partner A is given a rank of 1, and the expected amount of time to complete the project is used to determine how many entries for Partner A in the sequential list are "skipped" until another proposal from Partner A is ranked. Priority is then allocated sequentially by running through this list for all partners.

   (b) Model B: No merging of ranked lists is done. When a observation block needs queuing up, the scheduler looks at the four lists and chooses an appropriate block, using the usual criteria of ranking, completion, stringency and also partner share to date.

5. The task of resolving overlapping observing proposals from different partners has been left to the IPRC. Where proposals are **identical** (i.e., observe the same galaxy with the same sensitivity and resolution), the proposal with the higher scientific ranking could simply be chosen. However, note that even if the two proposals are exactly the same, the winning proposal would be the one ranked higher by the PRC that reviewed it. This will be dependent upon the number of good proposals each PRC reviews as well as the style of science priorities that each Partner may have. This will work, but could seem quite arbitrary to the losing proposers.

   Where proposals are only **similar** (i.e., deep continuum imaging of different blank fields) the case becomes trickier. This type of overlap may also not be allowed for very well matched proposals, but could shade to allowable if, say, one group had mid-IR and VLA data to match while another had optical and X-ray data (although experts might well say one group had a better data set for comparison than the other). This type of overlap will require some human intervention to identify. Perhaps once they are identified they could again be dealt with on the basis of scientific ranking from the PRCs. The more labor intensive but perhaps more satisfying alternative is to use the IPRC to review and rank such conflicting proposals.

B.3. Pros and Cons of Partner-Based PRCs

- **Pros**

  1. Different partners can choose different scientific priorities.

- **Cons**

  1. Multi-partner collaborations require special handling. One suggestion to mitigate this is to count some of the time to the partner of the co-Is.
  2. In some implementations of the system, duplicate observations and science may be allowed to happen. One suggestion to mitigate this problem is to give the IPRC considerable authority to decide which proposals have too much overlap. Both these mitigations tend to decrease the main advantage of this system, the freedom of partners to choose their own priorities.