System Design Review

Committee Report

2004 May 5

Members of the Committee: Bryan Butler (NRAO), Michel Guelin (IRAM), Stéphane Guilloteau (Observatoire de Bordeaux), Richard Hills (Cambridge University), Masato Ishiguro (NAOJ), Robert Laing (ESO), David Woody (CalTech, Owens Valley Radio Obs.), Alwyn Wootten (NRAO; Chair)

Scope

The Scope of the System Design Review was specified in the Charge to the Review Panel:

Charge to the Review Panel

Objective of this review is to ensure that for the ALMA telescope array and its sub-system a design exists, which is able to meet the ALMA scientific and the other top level requirements. The review panel shall review the design documentation and presentations and should prepare a recommendation report to the ALMA management IPT. The focus shall be on the completeness of the ALMA telescope technical specification and design. Attached is also a copy of the 'ALMA Design Review Definitions, Guidelines and Procedure' document. This should serve as guideline for the review panel to conduct the review.

Items to be covered

The design review shall concentrate on the telescope array design only and to ensure that the telescope and its sub-systems will meet the science, system and lower tier down requirements (L2 and L3 according to product tree). Following IPTs and groups will be involved: System, Antenna, Front End, Back End, Correlator, Computing and Local Oscillator.

The review took place 2004 March 1-3 at Schloss Elmau near Garmisch-Partenkirchen, Germany. All Review Panel members attended the review. The agenda for the review is attached as an Appendix to this report.

Documentation for the review was specified in a 2003 December 2 memo from the System Engineering IPT, also attached as an Appendix to this Report.

Presentations were made by various team leaders as listed in the agenda (these presentations are available in ALMAEDM).

Summary of Review Panel findings

In general the Panel found that viable designs which could meet the ALMA scientific and other top-level requirements existed for all elements of the system.

However, the project lacks comprehensive top-down and bottom-up error budgets. As a consequence, there is disagreement and confusion about a number of important specifications. A top-down error budget should be produced, starting from the key science requirements. This should be compared with a bottom-up analysis incorporating the results from prototyping. These budgets should be iterated to produce achievable and agreed specifications.

Error budgets should also be produced for component lifetime and mean time between failures.

We recommend that an overview of the complete system and a comprehensive error-budget analysis be produced and reviewed (not necessarily in a face-to-face meeting) at a delta-SDR.

The technical area which gave the committee the most serious cause for concern was the local oscillator, and specifically its photonic distribution system. The latter is a potential single-point failure. The project management is clearly aware of the problems in this area, but we reiterate the need to solve them rapidly.

We recommend that the LO reference distribution system should be reviewed and that the project should deploy appropriate resources to ensure success of the system.

In addition, the Panel made a number of detailed recommendations to the ALMA Management IPT for improvements of the system design. These are outlined below.

1. The Review Process

The Committee found the Process of placing documentation before it to be haphazard. It is not acceptable to have documents arriving late, without warning, and in a variety of formats. Committee members watched the document count rising daily until the very last day, finding themselves wondering exactly where to find the newer documents in the count among the more than one hundred in the final tally. Some documents were real, some were mere links; documents in a variety of formats were produced some of which were unreadable by any committee members. All committee members found downloading individual documents to be painful. One lacked access to any of the documents at all owing to restrictions on ALMAEDM. Links should be prohibited and all documents should be in pdf unless there is a very good reason specifically presented to the committee.

Among the over one hundred documents, it was not clear which documents were to be reviewed and which were for information. The system which has evolved for VISTA (which has ESO-style reviews) is to distribute a CD to reviewers with an index file (html) giving a list of documents for various subsystems by title, filename and status (for review/applicable/info only). The html file contains links to all of the documents. The provision of a CD including all documents at a preset interval in advance of the review should be Project policy (Even if no CD is made, the committee recommends the use of this structure or a similar one for the review files).

If the documents arrive in time, then it becomes reasonable to assume that the panel members have read at least those being reviewed. That allows the presentations to concentrate on problem areas and permits adequate time for discussion.

2. System Design Considerations

2.1. Overview

A *complete* system design (including antennas, software etc. in addition to what is in the SDD) is lacking. No complete system design was presented for review. The Systems Design Document explicitly excludes antennas and off-line software, and only the lowest levels of the monitor and control systems are described. As a consequence, it is extremely difficult to assess trade-offs in design and performance for the system as a whole. An overview of the entire ALMA system is essential as a top-level design document and should be provided.

There is no comprehensive error-budget analysis. Top-down error budgets should be produced starting from the key science requirements (e.g. sensitivity, image fidelity, polarization performance, spatial and spectral resolution). These should be elaborated to the point that they generate sub-system requirements and specifications. In turn, the sub-system designers should produce bottom-up estimates of performance for comparison with the specifications. There should also be an error budget assigned to components to allow the target calibration accuracy to be achieved. The work described in the System Design Document and System Level Technical Requirements (e.g. Table 2 of the latter) provides a good starting point, but needs to be extended to cover the whole system in a self-consistent way. There was evidence of disagreement on and misunderstanding of specifications throughout the SDR. Examples include:

(a) There are two sets of numbers for the gain stability requirement: D'Addario's specification in terms of Allan variance and the edict from the CCB (whose interpretation is ambiguous). These are inconsistent with each other and with the values that the FE and BE IPT's expect to be able to achieve.
(b) The specification of the performance of Band 3 below 86 GHz is unclear. There is a derogatory remark about this on p.3 of the SDD.
(c) The requirement for the frequency-switching time is unclear. The specification is given as 1.5s, but <0.1s is said to be desirable.

Although many of the systems and subsystems have precise specification, few of these have been compared with the performance achieved so far. A major difficulty comes from the fact that the prototyping phase (Phase 1) has not yet been completed for a number of the subsystems. In addition, the current error-budget allocations between subsystems often seem arbitrary and there is therefore a danger of overloading development teams with needlessly tight specifications. For complex systems that are to be constructed in various locations by various teams (e.g. the Front End sub-assemblies), standard procedures should be developed for measuring critical parameters such as the signal-path phase and the gain stability.

An error-budget analysis provides a systematic way to identify and resolve such conflicts and to allow trade-offs between sub-system requirements. It is overdue for ALMA.

We recommend that an overview of the complete system and a comprehensive error-budget analysis be produced and reviewed (not necessarily in a face-to-face meeting) at a delta-SDR.

There is no coherent design philosophy for infrastructure issues common to all IPTs. For example, the BE design includes good protection against RFI while the FE design appears to have little consideration for this issue. Guidelines for environmental constraints (temperature, air humidity, dust, lightning hazard, RFI), power supply specifications and earthing need to be discussed and standardized across the project.

The lifetime and mean time between failures of the different subsystems are another set of important specifications that lack a realistic error budget at the system level. In the case of MTBF, this budget should take into account the time needed for repairs. No procedures are given that would allow estimation of MTBFs for subsystems with components developed in laboratories.

It is unclear who is responsible for lifetime analysis and the determination of how many spares are needed. Is there a system policy on spares and reliability? This issue was raised specifically in discussion over correlator spares (see below).

The committee considered the specific issue of reliability in the low pressure environment of Chajnantor and suggested that it should be possible to do some tests in low pressure chamber to evaluate individual components.

The early availability of the AOS – OSF fiber link is a critical element for the integration and commissioning phases of ALMA and is therefore a key systems level issue deserving of attention.

2.2. Polarization

The system group should consider the polarization science case and carry it through the system design to ensure that it can be carried out as specified. There are two possible approaches to high polarization accuracy: using a quarter-wave plate to generate circular polarization over a limited frequency range (currently possible for one band only, Band 7) or using linearly-polarized feeds with a tight specification on relative complex gain stability between the two channels on timescales ~ a few minutes (phase stability is a particular concern). At present, the gain stability requirements appear to be inconsistent between the science requirements, systems design documents and front end specifications and the proposed requirements seemed technically difficult to meet. This issue must be resolved. No design was presented for a Band 7 quarter-wave plate and its status was unclear to the committee. It was also unclear what work has been done to optimize Band 7 for polarization and whether any tests are planned to demonstrate its performance. Other arrays with linearly-polarized feeds (e.g. ATCA) monitor the relative complex gains of the two polarization channels by injecting a pilot tone into the feed horn and monitoring the outputs. A similar approach was considered for ALMA (with injection into the front-end) but appears to have been discarded.

2.3. Total power requirements

If all total power continuum work is done on the Compact Array, what are the consequences for the rest of the system, including on calibration? There seems a lack of clarity on which requirements apply just to total-power continuum (or total-power line, for that matter). Four antennas have special requirements for total power operation: is it reasonable to extend these requirements to all 64 antennas?

With some form of Japanese participation evident, the presumption must now be that total-power work is done exclusively by ACA 12m's (and the issue of gain stability was indeed brought out in the ACA presentation), but the design issues are in a sense independent of this, as US and European groups are still responsible for their assigned front ends. A design approach is recommended whereby the front ends for the total-power antennas are allowed to be different from those used purely for interferometry, possibly with a modified compromise between noise and gain stability (GaAs amplifiers, for instance). While this suggestion interferes with a desire for uniformity of system design, the ACA breaks the symmetry and offers an opportunity to optimize the main array and the ACA somewhat independently of each other for manifestly different scientific applications. Later delivery of the total-power systems could be considered, but the first ACA antenna is expected to be on-site for Early Science: is total power continuum a mode which the project supports at this point and, if not, when?

2.4. VLBI

VLBI capability should be supportable at least to 350 GHz. The ability eventually to phase the entire array should be specified. Note that for VLBI, the WVR phase corrections can be applied in near real time from one second measurement to the data obtained at the next second. This mode should be supported.

2.5. Observations of the Sun

Observations of the Sun were foreseen in the Science case. These ought to be done with the help of a removable solar filter located in the widget space. To our knowledge, there is no design or detailed specifications for this solar filter.

3. Individual Sub-systems

3.1. Front Ends

The committee commends the FE group for presenting a clear compliance matrix - this did highlight the problem areas, a task which would have been difficult for the committee given the number and variety of documents before it.

The process of orchestrating Front End cartridge design across many groups in many locations has resulted in a certain lack of design symmetry. For example, the number of IFs in bands 3 and 7 is planned to be four (the bandwidth is 4 GHz per polarization thus presenting the requisite 16 GHz of bandwidth to the correlator). However for the wider bandwidth (8 GHz per polarization) band 6 only two IFs are implemented in the design. This choice of 8GHz bandwidth and two IFs has certain undesirable scientific drawbacks: because of the choice of 2 IFs in Band 6, only one isotopic variant of the important CO molecule, $^{12}C^{17}O$, may be observed simultaneously with the more abundant $^{12}C^{16}O$ variant. However, if four IFs were available for Band 6, both the main isotopic line and 3 variants could be observed simultaneously (this cannot be done in Band 3 because of the relatively narrow bandwidth). This is true for many other lines also—flexibility is increased immensely. Therefore we recommend that all four IFs be available for Band 6. This modification should not delay the project; it could be introduced in cartridges built subsequent to the first prototypes.

The front end lifetime was presented as fifteen years and the mean time between failures (MTBF) specified to 20 years. Are these figures realistic and are they consistent with the lifetime estimates for other elements of the system? No method is given for evaluating the lifetime and MTBF for these complex systems. They use parts and/or design solutions with few or no reliability statistics, and certainly nowhere close to industrial standards.

It was not clear whether the warm multiplier assembly is 'hot swappable'—the committee believes that it should be.

A very accurate amplitude calibration device is foreseen, but the committee did not see its design, construction schedule or operational plan.

Filters will be needed to meet specifications on out of band radiation but the specifications for this appear to be lacking.

Heat dissipation outside the dewar has not been addressed properly. There are many YIG-tuned oscillators and amplifiers in this region which will generate heat but the plan for dissipation of this heat load was not presented.

It was unclear to the Panel whether the specified dewar cooling time could be achieved for realistic cartridge masses: this should be checked.

There should be system guidelines on how cooling should be accomplished and the FE IPT should address how these guidelines have been met.

The power output of the Band 9 multipliers is currently too low. This is a concern, although there appears to be a plan to enable sufficient power to be generated.

Several documentation errors were noted:

1. The time to tune within a band (Spec 590) has a misprint— the frequency switch specification is incorrectly given as 5s.
2. The specification on Band 9 (section 5.1) is given improperly—there should be a realistic SSB specification for each sideband.
3. The mismatch between sideband gains for DSB receivers is specified as <3dB; this is unacceptably high and needs revision.

The passband shape specification was not agreed between front-end and systems groups. The committee felt that the specification proposed in the System Design Document was probably too stringent, for reasons covered in detail in Section 3.2.

3.2. Back End

Many of the specification issues the committee encountered with the requirements for the front end resurfaced during the back-end discussions.

The mixture of prototypes and pre-prototypes among backend elements was alarming, especially as CDR is in May and there is a requirement to produce something for integration tests and, subsequently, the prototype interferometer. The compliance matrix for the back end was so terse as to be very confusing. Provision of prototype modules for systems integration is currently 3 months behind schedule and cannot be allowed to slip further—integration using temporary prototypes should not be allowed lest the situation worsen.

The Backend IPT described problems with fiber management (which is late). Nevertheless, it was proposed to replace what we presume to be a working optical transmitter unit with a new design. In this specific case, adopting the EVLA design reduces risk, saves 20% of the costs (~ 1M$) and moves more towards COTS. The committee sees the advantage in this approach but cautions against continued tinkering with the design. Primary emphasis should be put upon providing components for lab integration and prototype interferometer tests. On the sampler and demux the same criteria hold—make sure that components are delivered on time for the system integration tests as they are also critical and late In general the backend plan gave the appearance of a lack of control: a sequence of prototypes with insufficient direction.

The committee is particularly concerned about the lateness of the digitizer, for which no complete demonstration results have yet been shown.

The total power backend involves detectors at both 8 GHz and 2 GHz bandwidth. We recommend using the only the 2GHz detectors for science. There are a number of interrelated issues concerning the use of these detectors, which are also relevant to the front-end bandpass specification (cf. Section 3.1).

1. The proposed bandpass specification appears to refer primarily to the total-power detectors, which are useful only for single-dish continuum observations. The sensitivity of these detectors will be limited by gain fluctuations and the effective sensitivity loss due to bandpass errors needs to be compared with the sensitivity in the presence of such fluctuations rather than the theoretical value.

2. If the correlator is used (in cross- or autocorrelation mode), then a bandpass correction can be applied prior to deriving an estimate of the continuum. This relaxes the specification on passband flatness (for autocorrelation) or mismatch between antennas (cross-correlation). The appropriate specification is then on the excess noise produced because the bandpass is not flat, and in particular if there are large dips in gain anywhere in the band.

3. There remains the issue of the use of the continuum detectors for calibration (i.e to set the scale for the correlator input). We were concerned that the proposed design might not provide the required calibration accuracy, for several reasons:

   a. There is no specification on the accuracy and stability of the thresholds in the 4GSample/sec digitizer and one is needed if this method of calibration is to be used. The system calibration accuracy will depend upon the details of the calibration procedure and in particular on the use of the 2-4GHz analog square law detector and the threshold counts from the digitizer
   b. Th bandpass of the inputs to the digitizers may not be well matched in shape to that presented to the continuum detectors, resulting in a loss of accuracy
   c. Similarly, the flatness of both the square law detector and digitizer frequency responses may affect passband accuracy (depending upon the calibration algorithm). Specifications are also required here.

4. Use of the 2GHz total-power detectors for calibration may not be necessary if the sampler system is sufficiently stable, in which case the specification on the bandpass mismatch between continuum detector and sampler can be relaxed.

We recommend a careful study of these issues, with the aims of defining an accurate calibration scheme for the correlator input and of relaxing the specifications on the front-end bandpasses.

For the Band 9 receiver, the sideband gain ratio is undetermined until interferometry is analyzed.

We cannot make a strong science case for increasing the frequency of total power sampling beyond the planned 2 millisecond time.

3.3. Local Oscillator

The LO reference distribution is probably the most worrisome area in that there is no clear picture of whether the error budget can be met. The master laser is an especially worrying component owing to its high cost—what is its lifetime? This design urgently needs a schedule ending in PDR: the system integration tests depend critically upon LO availability and performance. The LO system design must include verification over the full frequency range covered by ALMA and system integration tests should be performed at the highest frequency attainable in order to test the phase stability of the LO system as rigorously as possible. Line Length Correction poses another worry for the committee. There are potentially serious problems in several areas, including the laser synthesizer's tuning speed and phase noise, correction of polarization misalignment effects in the LLC, the master laser, and uncorrected phase shifts in optical amplifiers. [Shillue gave an excellent and honest summary of these difficulties]. Attention should also be paid to the role of LO amplitude stability as part of the overall gain stability.

To summarize: the committee is seriously concerned by the risk and uncertainty posed by the photonic LO distribution system in general and the master laser in particular. It recommends that the LO reference distribution system should be reviewed and that the project should deploy appropriate resources to ensure success of the system

3.4. Correlator

The panel found it puzzling that the optical crossbar switch vanished as a feature of the correlator system but apparently remained in the system design. In the opinion of this committee, the requirement for the extra factor of four in resolution is insufficiently compelling to justify construction of the optical crossbar switch at this time.

The committee strongly endorses the tunable filter concept, which it believes has considerable scientific advantages, for example in line searches. It recommends, however, that there should be a delta CDR following adoption of the tunable filter CRE to address issues such as stitching together of bands, data rates and integration constraints. . Stitching overlap and level of errors need to be specified by system engineering in consultation with the relevant IPTs. Questions about phase ambiguity need to be understood and fine delay correction must be properly implemented.

There should be a specification on the gain accuracy between FIR sub-bands as well as between the 8 and 2GHz IF bands. Is the basic 1% calibration accuracy we are trying to carry through for absolute calibration sufficient for the band-to-band gain accuracy or does the science require a more stringent specification? What portion of the overall calibration error budget is assigned to the correlator? (The assignment will determine one component of the stitching requirement). The requirement should be considered separately for both interferometric and single dish observations.

The committee noted that implementation of the tunable filter imposes integration constraints—even without Walsh 90d switching, the minimum dump time is 512 ms (except in bypass mode). The data can be stored internally and dumped more frequently, however.

The panel strongly supports implementation of 90 degree phase switching, for which there is strong science demand, as demonstrated in the DRSP and summarized in the CRE.. The extra sensitivity achieved when doing DSB measurements on continuum sources is the strongest argument for implementing 90 degree phase switching; there is also an increase in efficiency of calibration. The length of the switching cycle will mean that some experiments will suffer from phase variations during the switch

The reliability study of the correlator yields an MTBF for the correlator boards of less than two weeks. Although the replacement time for these boards is only a few minutes, this raises the question of how many spares should be bought (15 spares are foreseen for 512 in operation) and whether the supply of chips, which may not be available a few years after construction, is large enough (+10%). It was not clear who was responsible for answering this question.

3.5. Antennas

The committee discussed the 2" rms specification on absolute antenna pointing and was unable to deduce the reasoning leading to this number. The specification should be based upon the size of the primary beam at the highest frequency, half of which is ~4", suggesting that with this accuracy a pointing source would be found within the beam. The committee suggests that some relaxation of the *absolute*, but **not** the offset pointing requirement could be allowed during contract negotiations should it lead to significant cost reductions.

The requirements on the time to settle to within 3 and 0.6 arcsec of the target positions are given in different places in the antenna specification. This confused the committee, and the Project should make sure that bidders understand this point.

There is a specification for the ability to support a nutator on all antennas; is this requirement relevant for an ALMA which includes the ACA [see section on Total Power observations]?

The size of the cone on the secondary may not be large enough: a 30% increase in size gives a substantial improvement in ripple for a negligible loss in antenna gain. Systems Engineering should follow up this point.

What is the status of the weather stations near the antennas given the need for an accurate refraction correction to ensure adequate pointing? How many are planned and where are they? The Project needs to provide a plan for the implementation of weather stations.

A proper servo simulation of antenna performance for OTF mapping is needed. This should be a deliverable from the antenna contractor. The Panel was concerned at the increase in the allowed tracking rms in OTF mosaic mode to 2 arcsec (from 1 arcsec). The implications of this change for imaging performance must be evaluated. At the moment, OTF performance is strictly only specified below 60 deg elevation; however optimum utilization of the submillimeter spectral windows requires good utilization of time when sources are at high elevation. The extent to which the encoders are rigidly enough coupled to follow fast (primarily wind-induced) pointing fluctuations is unclear. The use of this information in software for OTF path reconstruction and pointing self-calibration needs to be analyzed to determine whether the available bandwidth is adequate.

3.6. Software

The Panel was concerned that the Computing IPT was still overly concerned with peripheral software such as the pipeline and dynamic scheduling and insufficiently focused on essentials – the basic control and operation of ALMA. Although verbal assurances were made that this was not the case (and these were to some extent reflected in the SSR priorities), the balance of emphasis in presentations and documentation suggested that the Panel's concerns were justified. On the specific issue of the pipeline, the plan for appears to be to phase it in about 18 months after Early Science. The Panel's view was that this is the earliest reasonable date.

As systems integration, commissioning, science verification, operations and engineering maintenance become clarified, the software requirements for these tasks need to be better defined

The Panel was concerned about several issues of schedule. Firstly, ALMA control software must operate at the ATF in Q3 2004; this is a necessary high-level milestone. . Secondly, software commissioning must precede Early Science by a comfortable margin if the latter is to succeed, and there is very little margin for delay.

The SDD has various remarks about the "philosophy" of distributing intelligence to local controllers. This varies for different parts of the project. D'Addario asserts that intelligence should be centrally concentrated and the local controllers should be as dumb as possible. The Computing IPT is more tolerant of variations in design, provided that they can, if necessary, command the controllers at a low level. Members of the committee tend to agree with the Computing plan. There should, however, be a comprehensive low-level (engineering/manual) interface to the sub-systems.

It was not clear to the Panel whether the ALMA software had been analyzed to discover single point failure modes. It was also unclear whether a clean restart was possible after a power outage (it should be). Issues of spares and the ability to replace obsolete components over the lifetime of the project need to be considered.

A number of changes are planned for elements of the software infrastructure in the near future. These include the replacement of VxWorks by real-time Linux and a change from Glish to Python for the aips++ scripting language. These changes seem sensible, but the committee was concerned to ensure that the manpower is equal to the task and can be deployed at the appropriate time.

The committee's understanding was that correlator data processing barely (if actually) fits within the baseline Beowulf configuration. If this is correct the project should consider the implications of reliance on Moore's Law to ensure adequate capacity.

Concern was expressed about the inflexibility introduced by use of XML in the archive database.

3.7. The Atacama Compact Array

The committee supports the idea of compatibility of specifications and ICDs between the elements of the ACA and other elements of the project. The Japanese proposal for the coexistence of the "Photonic hybrid" LO with the baseline "Photonic Reference" design is distasteful from a system point of view, but the committee finds appealing the simplification of the warm multiplier assembly the former permits. RFI emission and heat dissipation from the Japanese system also promises to be low. For the construction project, a principle requiring compatibility of systems promises to simplify the construction tasks.

The issue of optimum scanning strategies for OTF versus fast switching capability needs further research. The relationship between the ACA and the main array needs further definition—will elements of the ACA be substituted in the main array and under what conditions for what purposes—cross calibration, supplying intermediate baselines for opportunistic targets? What is the role of total power polarization measurements with the ACA?

Agenda ALMA week in …..
1 March to 5 March

1 March
8:30 Welcome by ALMA JAO Director and Organizing Committee

Time	Topic	Responsible
9:00	System Design Review Introduction	Christoph Haupt
9:15	ALMA System Design	Larry D'Adario
11:45	ALMA Reliability	Jeff Zivick
12:15	Lunch Break	
13:30	Antenna Design	Stefano Stanghellini
14:30	Front End Design	Charles Cunningham, Gie Han Tan
17:30	End of the day	

2 March

Time	Topic	Responsible
8:00	Back End Design	Clint Janes, Alain Baudry
10:00	Coffee Break	
10:30	Local Oscillator Design	Clint Janes, Bill Shillue
12:30	Lunch Break	
13:30	Correlator Design (including tunable filter proposal)	John Webber, Alain Baudry
15:00	Coffee Break	
15:30	Computing	Brian Glendenning, Gianni Raffi
17:30	End of the day	

3 March

Time	Topic	**Responsible**
8:00-9:00	First Feed back from review panel	Review Panel

ALMA System Design Review
Date: early 2004 (Beginning of March) for 2d during Mini ALMA week
Location: tbd
Author: Ch. Haupt, 1 December 2003

Items to be covered

The design review shall concentrate on the telescope array design only and to ensure that the telescope and its sub-systems will meet the science, system and lower tier down requirements (L2 and L3 according to product tree). Following IPTs and groups will be involved: System, Antenna, Front End, Back End, Correlator, Computing and Local Oscillator.

Deliverable Documentation

For this review each IPT and group need to deliver the following documentation:

1. Design description which covers the corresponding sub-system design down to Level 2 or Level 3 (if appropriate) item according to the product tree. This design description includes block diagrams, system budgets, a description about the actual design (including a design justification), interface design and a presentation of the achieved performance. All this is to ensure that the chosen design is able to meet the requirements and interfaces correctly with the adjacent hardware.
2. Compliance matrix. This compliance matrix shall provide a compliance statement to all requirements; Performance, ICDs, Engineering and Product Assurance requirements.
3. A configuration item data list CIDL (As designed or as build) down to L2. (The CIDL is a list of all documents describing the current design or build status)
4. List of critical items. The list should comprise items critical for meeting the performance, schedule, or funding requirements. Please provide also a long lead items list.

The documentation shall be delivered 2 weeks prior to the System Design Review. Due to the fact that all sub-system are at least in a design phase between PDR and CDR the documentation preparation should be possible based on the existing technical / engineering documentation. In addition only a reduced set of documentation is asked for compared to the approved ALMA document 'ALMA Design Reviews Definitions, Guidelines and Procedure'.

Presentations

The presentations shall cover the same items as listed under deliverable documentation.

Participants

All IPT leads as listed above plus one senior design engineer for each IPT and group.

Review Panel

TBD. External reviewers are envisaged.

Schedule

System Design Review Meeting	Beginning of March 2004
All documentation posted on ALMA EDM System Design Review Folder and IPT review complete.	13 February
Presentation posted on ALMAEDM	25 February