

## WHITEPAPER

### Transition of ALMA Development Projects to JAO Operations

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**References:** 1) *Principles for ALMA Development Program, AEDM 2011-02300, Rev 2.0; T. de Grauw, et.al; 2011-08-09*  
2) *ALMA Development Steering Committee - Terms of Reference, AEDM 2012-010-O, Rev 1.0; L. Ball, P. Bocaz; 2012-03-12*

#### 1.0 PURPOSE

The purpose of this Whitepaper is to focus the attention of ALMA Project Senior Management upon pressing issues affecting the implementation of initial ALMA Development Projects, and to provide context for needed discussion of these issues. The authors do not presume to prescribe solutions for each issue. Rather, we attempt to present the issues in an unbiased manner, offer practical recommendations, and thereby facilitate prompt resolution of the issues.

#### 2.0 THE PROBLEM

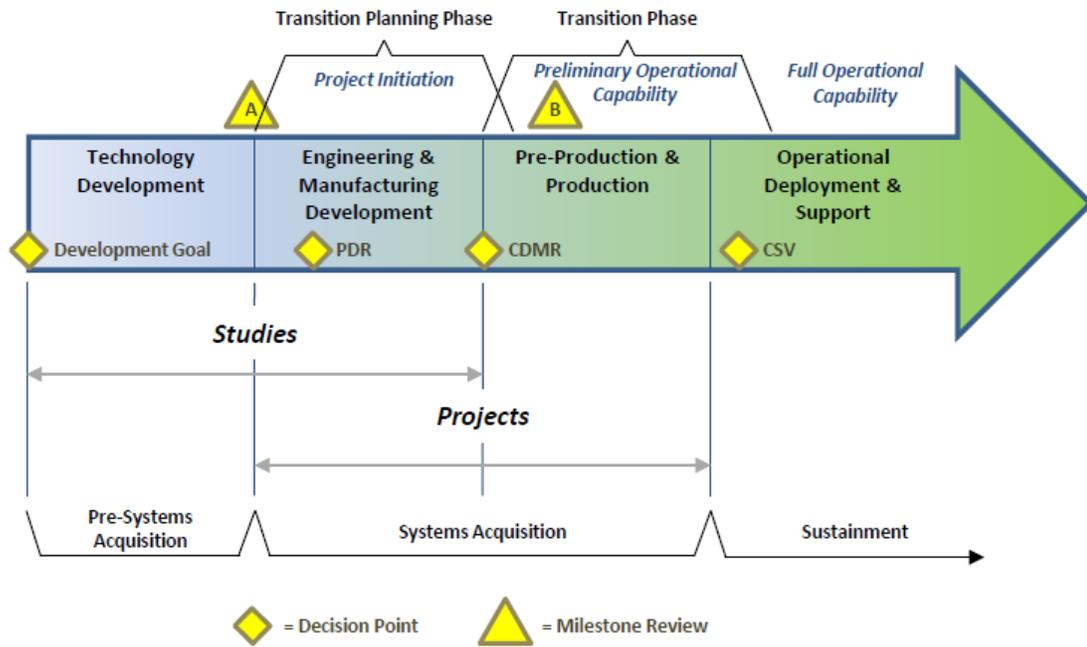
No official policy, practices or procedures are available to guide the transition of ALMA Development Projects to Joint ALMA Observatory Operations. Three Projects (the European Band 5 Project, the North American Fiber Optic Project, and the North American ALMA Phasing Project) are in early transition to JAO Operations; meanwhile, the Project Teams are writing the rules as they go. The risk of discord and setting undesirable precedents is high.

#### 3.0 PRINCIPLES OF OPERATION

The authors assert that the following Principles constitute a logical construct within which the issues (set forth in the following Section of this Whitepaper) can be deliberated, discussed and resolved.

**Principle 1: Transition is a process.** Though it is common to think of the transition from Development to Operations as an event, “transition” is actually a process that occurs over time. In the context of the ALMA Development Program, the transition process is a set of activities that progress through four successive stages, and correspond to increasing levels of technical maturity. The transition stages are (reference **Figure 1**, on following page):

- a. **Technology Development** (a conceptual Study which includes a scientific justification, specification, and outline costing),
- b. **Engineering and Manufacturing Development** (an extended Study or early-stage Project which includes final engineering design and manufacturing process development),
- c. **Pre-production and Production** (typically a multi-year Project which includes preparations for operational deployment), and
- d. **Operational Deployment and Support** (a collaboration of Project and JAO personnel).



**Figure 1** The ALMA Development transition process.

Milestone Review “A” typically occurs at the conclusion of a Development Study and the ALMA Development Steering Committee (ADSC) judges whether or not the initiative should be sustained (by encouraging, or discouraging, the Principal Investigator to submit a follow-on Study or Project Proposal). Milestone Review “B” occurs soon after the Critical Design and Manufacturing Readiness Review (CDMR) and the ADSC judges whether or not the initiative should carry forward to Operational Deployment.

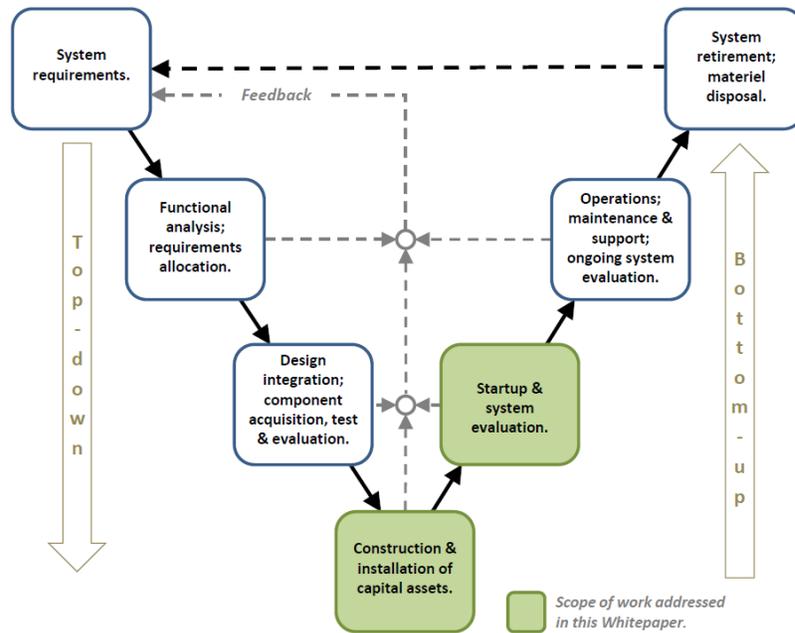
This Whitepaper focuses upon the activities comprising the *Transition Phase* (Stage c /d) and emphasizes the coordination required for a smooth hand-off from the sponsoring Executive to Joint ALMA Observatory Operations. It is noteworthy that the nature of the ALMA Development (sponsoring Executive Operations) to JAO Operations transition differs from the ALMA Construction to ALMA Operations transition in terms of participants, funding sources, and timing.

**Principle 2: A systematic approach improves the odds of success.** The root cause of most planning errors can be traced to one, or more, dysfunctional interfaces between organizational elements. ALMA’s Integrated Product Teams (IPTs) do a good job of minimizing inter-element confusion. They could do a better job if provided with a business process model (specific to ALMA Development) that prescribes a systematic approach to ...

- identification of necessary tasks,
- allocation of responsibility for each task,
- organization of the tasks,
- estimation of requisite resources, and
- prioritization of performance, risk, cost, and schedule requirements.

Decomposition of the *Transition Phase* (reference **Figure 1**, above) into a hierarchy of sub-phases, deliverables and work packages provides a framework for the development of a comprehensive transition plan. This “Work Breakdown Structure” (WBS) also serves as a basis for organizing tasks into definable increments from which Statements of Work (SOWs) can be derived. A SOW, acceptance criteria, and acceptance procedures are necessary for construction/production close-

out, and commissioning science and verification. Acceptance criteria are performance-oriented and based upon system-level requirements (reference **Figure 2**, below). The aforementioned Work Breakdown Structure is also useful for requirements mapping from one level of system specification to another; for example, a requirements cross-reference matrix mapping functional requirements to high-level or low-level design documents.



**Figure 2** The system development approach.

While beyond the scope of this Whitepaper, early consideration of operations planning, maintenance and support planning, and system retirement planning is encouraged.

**Principle 3: Metrics ensure an orderly progression through the transition process.** Well-defined criteria (“metrics”) enable objective determination of readiness for the next step in the transition process. The **Technology Readiness Level (TRL)** method is applicable to this purpose and provides a convenient rubric for communicating technical status (reference **Table 1**, below). Transition from TRL 8 to TRL 9 corresponds to the transition of an ALMA Development Project, to scale-up and implementation.

**Table 1** Technology Readiness Levels and Objectives.

TRL No.	Objective
1	Idea conceived; technology gap analysis performed.
2	Technology concept and application formulated.
3	Proof of concept successfully demonstrated; manufacturing process requirements identified.
4	Component and/or breadboard validated in laboratory environment; lab-scale evaluations of manufacturing process(es) complete.
5	Component and/or breadboard validated in a relevant environment; laboratory/vendor prototype available.
6	System/subsystem or prototype demonstrated in a relevant environment; manufacturing process development complete.
7	Prototype demonstrated in a simulated operational environment; ready for low-rate initial production.
8	Complete system functionality fully demonstrated in an operational unit; ready for full-rate production.
9	System proven through successful deployment in JAO Operations.

Exit criteria for TRL 8 (i.e., readiness criteria for TRL 9) are:

**TRL 8.0 Exit criteria for hardware** - components are form, fit, and function compatible with operational system. Form, fit, and function demonstrated in the targeted system. User documentation complete and under configuration control. TRL 9.0 (implementation) funding source(s) established.

**TRL 8.0 Exit criteria for software** - released code thoroughly debugged and performs reliably in the operating environment. User documentation complete and under configuration control. Implementation authorized by ALMA Operations.

**Principle 4: The nature of the work ordains organizational structure.** Concurrent implementation of multiple Projects is likely to occur during the course of routine JAO Operations (reference **Figure 3**, below) and the level of implementation effort will vary from one Project to another. The net effect of varied schedule and varied effort will probably be an irregular work load over time. Further complicating matters, the mix of requisite skills will also vary from one Project to another and these personnel will be drawn from both the sponsoring Executive and the JAO. Altogether, this makes workforce organization and staffing challenging. Definition of an upper limit (implementation capacity within a planning period; e.g., seven percent of base labor during a calendar quarter) will be useful. An *ad hoc*, flexible approach to organization structure (such as a *matrix* structure) seems appropriate.

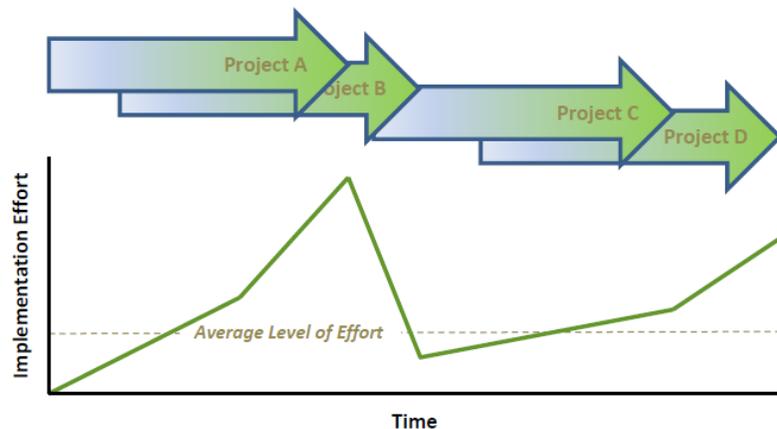


Figure 3 Time-phased Projects and relative level of effort.

#### 4.0 ISSUES

**4.1. Insufficient governance.** The *Principles for ALMA Development Program (AEDM 2011-02300, Rev2)* defines a process workflow whereby a Project is developed into an “Upgrade Work Package”, but stops short of defining how an Upgrade Work Package will be implemented (reference **Figure 5**, on following page).



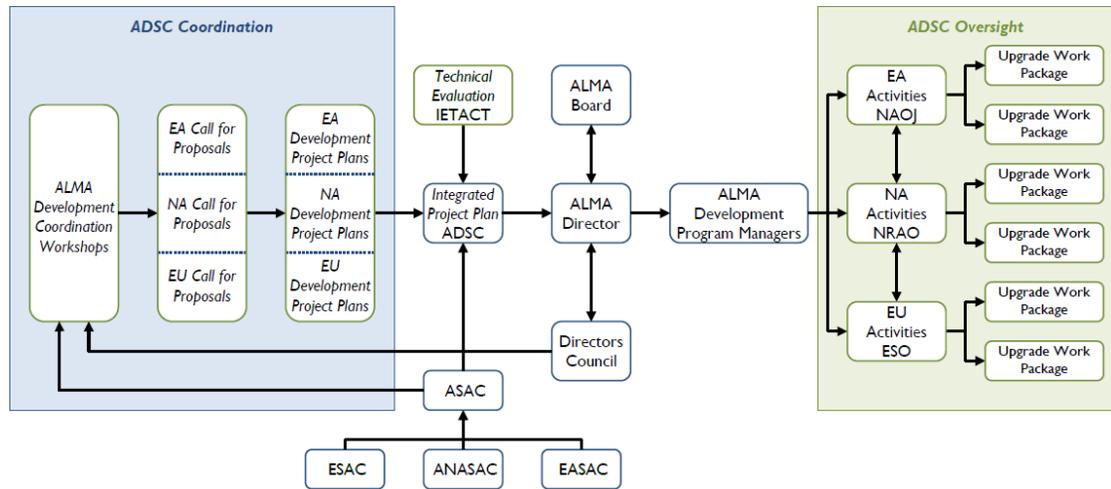


Figure 5 Development process workflow.

The model needs to be extended to include the Transition Phase (highlighted by the blue ellipse in Figure 6, below). This will likely be an iteration of preceding steps “book ended” by a cost/benefit analysis at the beginning and an acceptance review at the end.

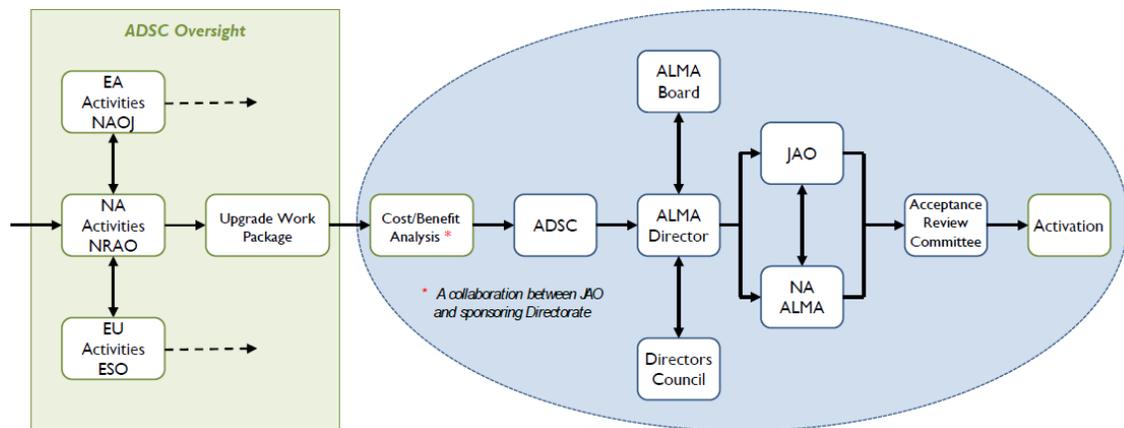


Figure 6 Development process workflow - extended.

- 4.2. **Lack of standards for Upgrade Work Packages.** The components and structure of an Upgrade Work Package (UWP) need to be standardized across Executives so JAO personnel can operate with uniformity and efficiency. At a minimum, the UWP should address schedule, budget, staffing, safety, product assurance, training, integration, commissioning and science verification, operating procedures, maintenance, and spare parts provisioning. This information should be presented in a consistent order and common format to facilitate the combination of Upgrade Work Packages into an overall quarterly, and/or annual, implementation plan.
- 4.3. **Lack of standards for cost/benefit analysis.** “... each Executive will be free to spend money in their own region according to their own culture, to apply their own contract and procurement and oversight practices, and to manage expenditures as required by their own rules.” (reference Principles for ALMA Development Program, Rev 1; Section 2, Defining the Program: Scope, Contribution and Share). While this *modus operandi* is suitable for early Transition Phase work conducted within a sponsoring Executive’s region, it may become

problematic if each Executive calculates project cost/benefit differently from the others. The ADSC may find it difficult to judge the relative value of Projects emanating from different Executives. A common (“normalized”) basis of estimate for costs and benefits is necessary to fairly compare one Project to another. Schedule prioritization of favorable projects could be facilitated by use of a common method to determine a Project’s “break even” point in time. Variable fuel/energy costs and currency exchange rates could adversely affect the financial viability of a project; a common model for assessing sensitivity to these variables would also be useful.

**4.4. No established criteria for implementation decisions.** Every transition-phase project has a compelling science case. Every transition-phase project must also make a compelling business case, and this should be made by the end of the Transition Planning Phase (reference **Figure 1**, page 2). The business case should be re-assessed (in context of the Upgrade Work Package) before making the final decision to proceed with implementation. Each type of project (be it a new addition to the Array, an extension of existing capabilities, an improvement to an existing system, or an improvement to infrastructure) may require different implementation decision criteria. Essentially, the following questions must be posed and answered:

- Does the Project still align with ALMA’s strategic development goals and objectives?
- Is there any synergy with other Projects in the development “pipeline”?
- Is the Project still affordable?
- Are the needed resources available in time to support the implementation schedule?
- Are the funding sources clearly identified and are the funds committed?
- Are Project expenditures in line with the current balance of Regional contributions?
- Is the Upgrade Work Package acceptable?

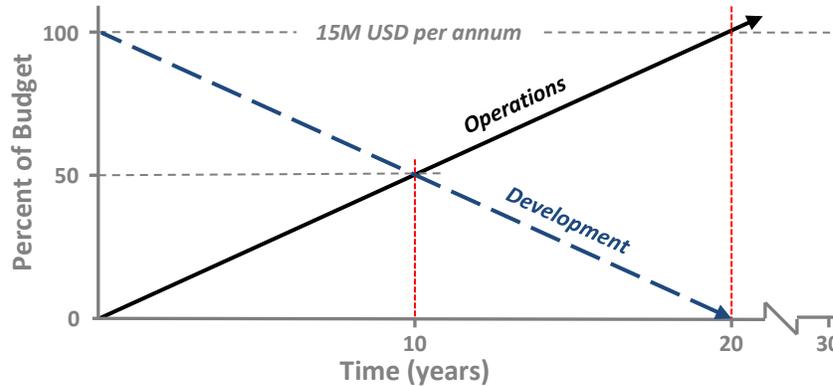
Decision criteria and check lists are needed for each of these questions in order to assign an appropriate position in the implementation queue and to ensure implementation success.

**4.5. No established protocol for implementation team operations.** *“To carry out oversight on behalf of the partnership (technical scope and schedule) the ALMA Director will assign an ALMA Development Program Manager, who will work with the Executives’ Project Managers to ensure compliance with the ALMA construction and safety standards, interfaces and scientific objectives and also **to coordinate implementation in the array ...**”* (reference Principles for ALMA Development Program, Rev 1; Section 3, Governance). To date, no one has been appointed to this position and, consequently, interactions between development project personnel and JAO personnel have been conducted without benefit of a unifying business process. Functional points of contact need to be identified. Common approaches to labor charging, procurement, change control, and on-site management need to be established.

**4.6. No budget for JAO Transition Phase work.** Installation, system start-up, and evaluation are non-recurring tasks in which the sponsoring Executive and the JAO share cost (proportions may vary from Project to Project). The Executive sponsoring a Project provides its share of Transition Phase cost through the Project budget. Thus far, the JAO’s share of Transition Phase cost has been negotiated on a case-by-case basis. Going forward, this approach becomes increasingly problematic. Assuming ten percent (10%) of the \$15M annual ALMA Development Program budget is required to pay for Transition Phase costs, and further assuming that the JAO’s average share of these Transition Phase costs is twenty percent (20%), the annual cost to the JAO is \$0.3M ( $\$15\text{M}/\text{yr} \times 0.10 \times 0.2 = \$0.3\text{M}/\text{yr}$ ). This is

predominantly a cost of labor and as such, will fall heavily upon the JAO ADE budget (approximately \$9.8M/yr). This three percent “hit” ( $0.3M/9.8M \times 100 = 3.06$ ) will be difficult to absorb without supplemental funds. The source of such funds is yet to be determined.

**4.7. No budget for operation and maintenance of Array enhancements.** Assuming annually recurring operating and maintenance costs for Array enhancements are equivalent to five percent (5%) of the \$15M annual ALMA Development Program budget, and further assuming that these costs are borne by the ALMA Development Program budget alone, and the \$15M/year level of funding remains constant ... the ALMA Development Program budget will be exhausted in approximately twenty years (reference **Figure 7**, below).



**Figure 7** Declining capacity to invest in Development Studies and Projects.

Conversely, if annually recurring operating and maintenance costs for Array enhancements are borne by the JAO Operations-Site budget alone, the cost to operate and maintain these enhancements will exceed that required to operate and maintain the baseline Array within approximately twelve years. The source of such funds is yet to be determined.

## 5.0 CONCLUSION

The ALMA Development Program is in the start-up phase and is going through its “growing pains”. No irreparable harm has been done and there is no need for emergency remedial action. However, the longer the Program continues without addressing the foregoing issues, the greater the risk that one or more Projects may go awry due to an increasing workload and inadequate planning.

## 6.0 RECOMMENDATION

Appoint a working committee (reporting to the ALMA Development Steering Committee), comprised of the Regional Development Program Managers and at least one JAO representative, to develop solutions to each of the issues. It is further recommended that the working committee should complete this task no later than 01 January 2014.