Use Cases

Software Analysis and SSR Groups

December 15, 2000

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1 ObserveWithAlma

Use Case: ObserveWithAlma

This Use Case outlines the basic process of astronomical observations with Alma.

Role(s)/Actor(s):
Primary: Observer
Secondary: The Operator, the Staff Astronomer, the Reviewer

Priority: Critical

Performance: hours to months

Frequency: hours

Preconditions:

1. The Alma System has reached at least partial operational state and accepts observing proposals from astronomers.

Basic Course:

1. The Observer plans his/her observations, preparing an Phase 1 Observing Proposal (UC *Create Observing Programme*). This includes two phases of submission, between which the proposal is subject to peer review, and technical validation.
   Exception Course: The proposal is rejected by the reviewers.
   Postcondition: The Phase 2 Observing Programme is stored as one or more Scheduling Blocks in the Scheduling Blocks Repository. Its SBs are ready to be queued for observing.
2. The Programme's SBs are dynamically scheduled for observing, whenever the optimal conditions apply for best efficiency of the ALMA System. Observations are scheduled in units of Scheduling Blocks. Further scheduling for a programme is halted when a BreakPoint is reached. (UC *ScheduleSB*).
   Alternate Course: The programme may be observed interactively.
3. The ALMA Observing System executes Scheduling Blocks (UC *ExecuteSB*): if necessary the system allocates requested resources and initiates pipeline data reduction, or releases those resources after execution.
   Postcondition: The raw data goes into the archive.
4. The data pipeline reduces observing scans as they are written into the archive. It writes calibration data and reduced science data into the archive, optionally displays results, and makes relevant results and data quality evaluation available to the scheduling and observing processes (UC *ProcessData*).
5. At any time, the Observer can update the SBs of his/her observing programme in the frame set by the reviewers. This affects the content of the SBs that have not yet been executed and their relative priorities (UC *CreateSchedulingBlocks*).
6. At any time, the Observer or the Staff Astronomer may inspect the archived raw or science data, and initiate an off-line pipeline data reduction. (UC *RetrieveArchivedData*)

Postconditions:

1. The science goals are reached so that the results may be published for the improvement of human knowledge.

Issues to be Determined or Resolved: ...

Notes:...

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2 CreateObservingProgramme

2.1 CreateObservingProgramme

Use Case: Create Observing Programme

This use case describes the creation of a validated Observing Programme. The goal of the Observer is to create an approved Phase 1 Observing Programme, and to deliver the complete technical specifications of the Observing Programme to the Phase 2 Scheduling Block Repository. The Observing Programme consists of one or more Scheduling Blocks.

Role(s)/Actor(s):
Primary: Observer
Secondary: Reviewer, ALMA Propasal Repository, Scheduling Block Repository, ALMA Archive

Priority: critical

Performance:
Depending on the actual submission policies, the process will take a couple of weeks to a couple of months between Phase 1 Proposal Submission and delivery of the Phase 2 Scheduling Blocks.

Frequency:
The system must be able to cope with one or more Phase 1 submission periods and with around 2000 proposals on a yearly basis. Most of these proposals will be submitted within 24 hours before the submission deadline. Similarly, the system must be able to cope with one or two Phase 2 Proposal submission periods (see Notes). In the case of Phase 2, the amount of interaction with the system is lower. It is assumed that proposals can also be submitted outside the regular proposal period.

Preconditions:

1. The most recent version of the Proposal Preparation Tool should be available, either locally installed, or via the network.
2. Catalogues needed by the tool should be available, either locally (limited scope) or via the network.
3. For actually submitting the Phase 1 Proposals and Phase 2 Scheduling Blocks, the Observer must have network access to the ALMA system
4. Optionally, the Observer has access to the ALMA Users's Manuals, simulator and Archive.
5. On-line access to databases and additional catalogues (those not required to run the tool) is desirable, not mandatory.

Basic Course:

1. Observer starts up the ALMA Proposal Preparation Tool
2. Observer creates a new Phase 1 Observing Proposal
   Alternate Course: Observer retrieves a previously locally stored Phase 1 proposal
3. Until the Observer completes the Phase 1 Proposal
   - Observer enters or modifies the Phase 1 information, including the scientific justification with figures and graphs (see *Create Phase 1 Proposal* use case)
   - Observer saves completed Phase 1 Proposal
   - Observer locally validates Phase 1 Observing Proposal (see *Validate Phase 1 Proposal* use case)
4. Observer submits Phase 1 Observing Proposal (see *Submit Phase 1 Proposal* use case)
   Exception Course: Phase 1 proposal cannot be submitted now (for whatever reason)
5. System validates Proposal (see *Validate Phase 1 Proposal* use case) and stores it in the ALMA Proposals Repository.
   Exception Course: Phase 1 Observing Proposal validation fails

6. Reviewer evaluates (incl. feasibility) and OPC approves Phase 1 Proposal (see *Review Phase 1 Proposal* use case). The proposal becomes an ALMA Observing Programme.
   Exception Course: OPC rejects Phase 1 Proposal
7. The Observer is informed about the outcome of the review
8. Until the Observer completes all Phase 2 Information
   - The Observer enters/modifies the Phase 2 technical specs. The tool creates a Phase 2 Scheduling Blocks, and optionally defines breakpoints (see *Create Scheduling Blocks* use case)
   - Observer saves completed Phase 2 Scheduling Blocks
   - Observer validates Phase 2 Scheduling Blocks (see *Validate Scheduling Blocks* use case)
9. Observer submits Phase 2 Scheduling Blocks (see *Submit Scheduling Blocks* use case)
10. Staff Astronomer/Operator validates and approves Phase 2 Scheduling Blocks
    Exception Course: Validation of Phase 2 Scheduling Blocks fails
11. System stores validated Phase 2 Scheduling Blocks in the Phase 2 SB Repository

Postconditions:

1. The Observing Programme is granted observing time on ALMA.
2. Phase 2 Scheduling Blocks are stored in the Phase 2 Scheduling Block Repository.
3. The Observer is informed that the Phase 2 Scheduling Blocks were successfully validated and stored, ready for scheduling/execution.

***Issues to be Determined or Resolved*:**

- Policies concerning Phase 1/2 submission review procedures and deadlines are to be defined.
- Basically, ALMA will garantee an minimum data quality which depend on the amount of observing granted. Additional policies concerning the products to be delivered needs to be defined.
- There will be one Proposal preparation tool for Phase 1 and Phase 2. A decision has to be taken concerning validation tool and if there are distinct versions for Observer and System validation. Validation of the Phase 1 and 2 Proposal is considered to be part of the Proposal Tool.

Notes:

- The actual implementation of the proposal preparation tools is uncertain/unclear. However, in addition to on-line access, it is thought that the tool should be available locally as well. In the use cases for the Proposal Preparation the latter situation is assumed. In the case completely WWW based tools (Proposal Tool, Simulator, Correlator Tool, etc) are available, locally installed tools can still be useful for off-line Phase 1 and Phase 2 preparation work.
- At any time during the Phase 1 or Phase 2 submission process, the Observer can consult the on-line ALMA simulators, ALMA User Manuals, ALMA Observing Catalogues, and other foreign data bases to retrieve technical of scientific information needed for creating validated Phase 1 and Phase 2 Observing Proposals. However, the Observer should be able, using the tool off-line, to create Phase 1/2 Proposals without these on-line services.
- It is assumed that the Phase 1 validation is reasonably light and only checks the most basic instrument settings. However the information should be sufficient to check feasibility. The emphasis is on the scientific justification. Phase 2 submission and validation should focus on instrument settings only. Passing the validation means that the Scheduling Blocks can be executed at ALMA without problems.
- The observer shall be informed after Phase 1 and Phase 2 submission and after his submission passed the system validation successfully. (S)he shall also be informed about the result of Phase 1 Observing Proposals review.
- After a Phase 1 Proposal has been validated and accepted, the Observer shall be able to cancel it (not modify). Scheduling Blocks can be revised until they are scheduled (check-out, modify, check-in). Only in exceptional cases may a block be modified after it has been scheduled.

- It is suggested to create separate tools (incl. the Proposal Preparation Tool) and to package these together (Simulator, Correlator setup, Validator). There should be ways to pass data from the Proposal Tool to the other tools.
- It is assumed that ToO or DDT proposals will be evaluated by teh Director or his/her delelegate. Phase 2 preparation will go through the normal channels.

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2.2 CreateP1Proposal

Use Case: Create/Edit Phase 1 Observing Proposal

The goal of this use case is to create an optionally validated Phase 1 Proposal. The Observer can either create a new or retrieve a locally existing Phase 1 Proposal. The submitting observer works off-line. Network access is required for consulting the on-line ALMA Observer manuals, catalogues, as well as for simulation. The proposal will be stored on a local storage device of the observer.

Role(s)/Actor(s):
Primary: Observer

Priority:
critical

Performance:
Creation of (template) proposals should take of the order of seconds. Filling in /modifying the template can take several hours, depending on the experience of the the observer. The Proposal tool shall react in real time on the Observer's input.

Frequency:
On average, observers will create more than one proposal per proposal submission period. It should be possible to prepare proposals over the whole year, independent from any proposal submission policies. ToO and DDT proposals shall be possible during the whole year.

Preconditions:

1. On the Observer's system the most recent version of Proposal Tool is available.
2. In case the Observer retrieves a Phase 1 Proposal, this proposal should be available locally.
3. The Observer should be able to store proposal technical specifications and scientific justification.
4. Access to the ALMA archive is desirable.
5. On-line access to Observer User Manuals and Observing Catalogues is available/desirable.

Basic Course:

1. Start the Proposal Tool
2. Request creation of a new Phase 1 Proposal. An empty/template form for the Phase 1 Proposal is created.
   Alternate Course: Observer retrieves previously saved Phase I Proposal

3. Observer specifies User Mode (novice/experienced/expert)
4. Observer specifies personal and institutional information.
5. Observer specifies Observing Mode and tool fills in the default specs for this mode
6. Observer enters/modifies a minimal amount (to be defined) of Phase 1 technical data
   1. Observer enters Phase 1 data:
      - For single sources, specifies source co-ordinates, optionally using source catalogue(s)
        Alternate course: Specify multiple source co-ordinates for mosaic
        For snapshots selection criteria can be sufficient; area covered for mosaics.

      - Specify line name/central velocity/frequency, velocity/frequency resolutions and spacings
      - Specify angular resolution
      - Specify polarization information
      - Specify source flux and S/N, or RMS
      - Specify minimal image dynamic range
   2. Translate novice/experienced input data into expert data
7. If User Mode is expert Observer enters/modifies expert mode parameters

- Specify Array configurations
- Specify Observing time
- Specify Correlator setup (Optionally, use separate Correlator setup tool)
- ...

8. Create a file containing scientific justification and all additional information (e.g. figures); Specify information about related projects (i.e. if proposal is continuation)
9. Enter the list of all local documents to be included in the Proposal Tool
10. Optionally, the Observer validates specifications (see *Validate Phase 1 Proposal* use case)
11. Save Phase 1 Proposal locally.

Postconditions:

1. Phase 1 Proposal is saved on local storage with/without status **validated.**
2. In case of successful validation the proposal is ready for submission.

***Issues to be Determined or Resolved*:**

- The Proposal Tool should provide several levels of users, e.g. novice, experienced or expert. Depending on the user level less or more detailed information about the observational requirements can be filled in.
- At several instances the Tool could do checks on the feasibility and or provide feedback to the Observer (e.g. corrector setup, array configuration, calibrators). This user can set this check to done on the fly or on request only (see *Validate Phase 1 Proposal* use case).
- The Proposal tool should have the possibility to enter information concerning the scientific justifications attachments. This could allow a complete validation, including a check that all documents are available.

Notes:

- Proposal may contain more than one configuration (e.g. more than one object/frequency). Hence there can be more than one set of observing parameter
- At any time the Observing can consult the on-line ALMA User Manuals, ALMA Observing Catalogues, and other catalogues to retrieve technical of scientific information needed for the Observing Proposal. Similarly, it is desirable that a simulator is available., either locally or on-line.
- A Graphical interface for selecting mapping areas can be useful
- The Observer's validation of the Phase I Proposals is not mandatory during the creation and editing of the Proposal. However, the ALMA Proposal Handling system will only accept Observer validated Phase 1 proposals.

- At any time during the editing process the Observer can saved his proposal session locally.
- It has to be decided which format the scientific justification and additional attachments are supported. Most obvious formats are: Postscript, Adobe PDF, MS Word,
- I suggest that the files names of the scientific justification and additional attachments are entered in the Proposal tool. This allows: a) validation can be done on the complete Phase 1 Proposal and get it ready for submission; b) ensures that the user does not forget any relevant files.
- It is assumed that the scientific justification is a separate document that can be created by any standard WYSIWIG or ASCII editor. The format and content of this document is subject to a minimal set of requirements (language, max. length, etc.)

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2.3 ValidateP1Proposal

Use Case: Validate Phase 1 Proposal

In this use case the Observer or the ALMA Phase 1 Proposal Handling System validates the Phase 1 Proposal. The Phase 1 proposals is checked on technical specification. The Validator also checks if all addtitional documents relevant for the Proposal are received and can be handled.

Role(s)/Actor(s):
Primary: Observer
Secondary: Proposal Validator, ALMA Phase 1 Proposal Handling System

Priority: Critical

Performance: Minutes

Frequency: Locally , the Observer can validate the Phase 1 Proposal several times before its final submission. The validation by the ALMA will be done for every Proposal that is received. A total of about 2000 proposals are expected for each submission period. At peak submission times the frequency can be minutes.

Preconditions:

1. If the validation by the ALMA validator is requested, a network connection should be available.
2. If the validation is request by the Observer:
   - a Phase 1 Proposal is available
3. If the validation requested by the ALMA Proposal Handling System
   - The system has received a new Phase 1 proposal

Basic Course:

1. The Observer or the Phase 1 Proposal Handling System requests validation. In case the Observer request validation this can be locally or via the net. In the latter case the latest version of the ALMA validator is used.
2. The validator determines the type of validation request (Observer/PHS)
3. If the validation request comes from the Observer:
   - System starts validation (see *Phase 1 Validation* subflow)
   - System notifies the Observer that the proposal is successfully validated
     Exception Course: validation fails
   - Optionally, Observer saves the Phase 1 Information
4. If the validation request comes from the System:
   - The system checks version of the Proposal Tool
   - The system checks the observer validation flag
   - System starts validation (see *Phase 1 Validation* subflow)
   - System notifies the Observer that the proposal is successfully validated
     Exception Course: The validation fails. The Observer receives a complete validation report. The Proposal is rejected by the system (not included in the Proposal Repository)
   - The System stores the Proposal in the Proposal Repository

Subflow: Phase 1 Validation

1. The validator checks the following Phase 1 specifications:

- TBD
- ...

2. In case the validation is done by the ALMA Proposal Handling System the validator checks the ALMA archive for objects that have already been observed (or proposed) with e.g. same observing mode, frequency, array configuration, ...
3. In case of overlap with previously observed objects, notify observer and flag the proposal
4. In case of overlap with other proposals, enter note for reviewer (do not inform observer)
5. The validator checks for the completeness of the Phase 1 Proposal
   - Scientific Justification attached in a recognizable format
   - Graphs and figures included
6. If validation is successful, the validator sets validation flag

Postconditions:

- The Proposal is locally validated.
  or
- The Proposal is validated, and stored in the Proposal Repository ready to be reviewed (see *Review Phase1 Proposal* use case).
- The Observer is given the validation results.

Issues to be Determined or Resolved:

1. Is there a time cycle for submitting proposals or will we have continuous submission? This affects the validator requirements (deadline to be checked).
2. In case of an overlapping with other submitted programmes it is suggested to flags the proposal and to draw it to the attention to the Reviewer(s). Should the Observer be informed at this point?
3. In case of overlap with other executed or completed programmes (proprietary data) the proposal should be flagged as well and draw it to the attention of the reviewers. Should the Observer be informed at this point already?
4. In case of overlap with publicly available data the observer shall received a summary of the available observation. Should the submission process proceed anyway or should submission be confirmed by the Observer?

Notes:

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2.4 SubmitP1Proposal

Use Case: Submit Phase 1 Proposal

This use case concerns the submission of a user-validated proposal to the ALMA Proposal Handling System (APHS), which will check the proposal for completeness and integrity, and if validation is successful stores it in a database for reviewing.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: ALMA Proposal Repository

***Priority*:** Critical

***Performance*:** Minutes

***Frequency*:** Submission can occur up to several times per minute

***Preconditions*:**

1. The system is available to receive Phase 1 Proposals
2. The Observer is connected to the network.
3. The Observer has a validated Phase 1 Proposal

***Basic Course*:**

1. In the Proposal Tool the Observer performs an action to submit the Phase 1 proposal
2. Tool checks if Proposal is locally validated
   Exception Course: Proposal is not sent if not locally validated

3. Proposal Tool sends Phase 1 specs, scientific justification and documents to the ALMA PHS

4. ALMA Proposal Handling System puts the Proposal in the queue for validation.
   Exception Course: Phase 1 Proposal is not validated by the Observer.

5. The ALMA PHS validates the Proposal (see *Validate Phase 1 Proposal* use case)
6. The System stores the Phase 1 Proposal in the Proposal Repository and the Observer received a confirmation message (incl. validation report, number, etc.)
   Exception Course: The ALMA validation of the Proposal failed; the Observer receives validation report. Proposal is not stored in the Proposal repository.

Postconditions:

1. The Phase 1 proposal is received by the APHS and validated
2. The Observer receives an acknowlegment of reception and validation.
3. In case of successful validation, the Proposal is stored in the Proposal repository..

***Issues to be Determined or Resolved*:**

1. Is there a deadline for submitting proposals or continuous submission?
2. Are proposals reviewed continously or will there be deadlines?

Notes:

1. It is assumed that all Phase 1 Proposal information is sent and stored in the ALMA Proposal Repository.

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2.5 ReviewP1Proposal

Use Case: Review Phase 1 Proposal

This use case describes the Phase 1 Review Process. After a Phase 1 Proposal is submitted it will be reviewed. The Proposal will either be accepted, and given a priority, or rejected. The Observer is informed of the review outcome and receives a Phase 1 Review Report.

***Role(s)/Actor(s)*:**
Primary: Reviewer(s) , Observing Program Committee (OPC)
Secondary: Observer

***Priority*:** Critical

***Performance*:** The review process may take a couple of days or longer, depending on review procedures. Reviews of proposals that apply for special observing time allocation (e.g. Director's time, Target of Opportunity) may take less time and may not go through the standard review process.

***Frequency*:** The frequency heavily depends on policies and procedures. It can be short (when the review process runs the whole year) or longer (when a review process takes place once or twice a year). Review of a Phase 1 Proposal by the reviewer shall take up to one hour, on average less than 0.5 hours.

***Preconditions*:**

1. A submitted and validated Phase 1 proposal is available
2. Reviewer assigned for proposal review
3. Validate and simulator tools are desirable

***Basic Course*:**

1. Reviewer receives a validated Phase 1 Proposal for review
2. Reviewer makes judgement of scientific value of the Proposal
3. Reviewer checks possibly overlap with other observing programmes
4. Reviewer makes judgement of the technical feasibility of the Proposal
   Alternate Course: Reviewer runs validator and/or simulator to get better view of technical feasibility and scientific output
5. Reviewer rates scientific value and feasibility of Phase 1 Proposal
   Alternate Course: Review requests additional information from Observer and/or from ALMA Staff
6. OPC meets (face-to-face or electronically) to assign ratings to all programmes taking into account policies and procedures.
7. Phase 1 Proposal is accepted and gets assigned observing priority
   Alternate Course: Proposal is accepted subject to modification(s) of technical specification(s).
   Alternate Course: Proposal is rejected
8. Observer is informed and receives Phase 1 Review Report

Postconditions:

1. Proposal is accepted (with/without certain conditions) or rejected
2. The Observer is informed.

***Issues to be Determined or Resolved*:**

- Most, if not all, review procedures and policies are to be defined. Does the Time Allocation Committee meet face-to-face?

- It is assumes that there will be technical reviewers (feasibility) and scientific reviewers.
- OPC should take into account the percentage of time available for excellent, good, average and poor observing conditions and accept proposals accordingly.

Notes:

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2.6 CreateObservingBlocks

Use Case: Create/Edit Observing Blocks

In Phase 2 the technical specs of the Observing Programme are defined, consisting of at least one Observing Block. The goal of this use case is to create an optionally validated Observing Block or Blocks. The Observer can either create new or retrieve a locally existing Phase 2 Observing Block(s). The observer works either on- or off-line. On-line access to ALMA Observer manuals is desirable as well as tools for observing simulation. The Observing Blocks will be stored on a local storage device of the observer.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: Validator

***Priority*:**
critical

***Performance*:**
Creation of a (template) Observing Block should take of the order of seconds. Filling in /modifying the template can take several hours, depending on the experience of the the observer. The Proposal tool shall react in real time to the Observer's input

***Frequency*:**
On average, 2000 proposals per year will be submitted. A limited number will make it to Phase 2. It should be possible to prepare Phase 2 Observing Blocks over the whole year, independent from any Phase 2 submission policies.

***Preconditions*:**

1. On the Observer's system the most recent version of the Phase 1/2 tool is available

***Basic Course*:**

1. Start the Phase 1/2 Tool
2. The Observer retrieves the saved Phase 1 Proposal for which (s)he is granted observing time.
3. Observer specifies the Phase 2 User Mode (novice/experienced/expert). In User Mode novice the Tool provides preconfigured templates. In expert mode the Observer has full control over parameters. Observer can start with preconfigured templates and modify these in expert mode.
4. Observer defines one or more Observing Blocks. For each OB the following parameters are to be defined (for more details see http://www....):
    1. Observing mode (e.g. Interferometric, Total Power, etc.)
    2. Array configuration
    3. Correlator setup (using a correlator setup tool)
    4. Receiver setup (central velocity/frequency, velocity/frequency spacing, resolution, polarisation, ...)
    5. Calibrators/scientific target(s)
    6. time sequence of calibrator and target sources to be observed
    7. Additional requirements (e.g. data reduction requirements, environmental conditions (e.g., water vapor))
5. Optinally, in the case of special, non-standard observing requirements, the Observer may create a seperate preamble OB
6. Optionally, the Observer validates the Observing Block (see *Validate Observing Blocks* use case)
7. Observer indicates any dependencies between/among OBs
8. If required, the Observer defines breakpoints between OBs and action to be taken (online data pipeline results, environmental data, consultation of the observer)

9. *Alternate Course:* the Observer checks out an OB(s) from the ALMA database and makes modifications in one or more *(see above)*

10. Optionally, validate the Observing Blocks (see *Validate Observing Blocks* use case)
11. Optionally, run the simulation tool to check the scientific output
12. Optionally, save one or more Observing Sessions

Postconditions:

1. The Observing Block is saved on local storage with/without status **validated.**
2. In case of succesful validation the Observing Block is ready for Phase 2 submission.

***Issues to be Determined or Resolved*:**

- Phase 2 submission policies are to be determined
- It is assumed that the collection of all Observing Blocks defines the complete Phase 2 Programme.
- Which limitation do OBs have (E.g. no change of Observing Mode within a OB; maximum limit in time; e.g. max. angular distance between targets within a OB; ...).
- Observing Blocks that have been submitted should not be read-only. Instead the Observer should be able to check-out the Observing Block from the ALMA OB database (on-line access required), and then make the modifications. New or modified OBs will only be scheduled after successful validation (together with all OBs with which they have relationships)
- At several instances the tool could do checks on the feasibility and or provide feedback to the Observer (e.g. correlator setup, array configuration, calibrators). This functionality can be provided on the fly or on request (see *Validate Observing Blocks* use case).
- What kind of input does the simulator expect (a single block, or all blocks that are inter-related)?
- In Steve Scott's Feature List for GUIs, the term Sequence is mentioned. What is the relationship between Blocks and Sequences and how are sequences executed (particularly when the Scheduler can switch observing programmes between OBs)?

Notes:

- At any time the Observer can consult the on-line ALMA User Manuals, ALMA Observing Catalogues, and other catalogues to retrieve technical or scientific information needed for the Observing Programme. Similarly, it is desirable that a simulator is available..
- The Observer's validation of the Observing Block(s) is not mandatory during the creation and editing of the Block(s). However, it is mandatory at submission of the Observing Blocks.

- At any time during the editing process the Observer can save the Observing Block(s) locally.
- An enhancement could be that the Tool's output can be used as input for the Observing Tool to produce the observing scripts or object sequences.

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2.7 ValidateObservingBlocks

Use Case: Validate Observing Blocks

In this use case the Observer or the ALMA system validates one or more Observing Blocks

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: Phase 2 OB repository

***Priority*:** Critical

***Performance*:** Minutes

***Frequency*:** Locally , the Observer can validate the Observing Block(s) several times before its final submission. The validation by the System will be executed after receiving an Observing Block(s) or its/their modification.

***Preconditions*:**

1. If the validation request comes from the Observer:
   - an Observing Block is available
2. If the validation request comes from the Phase 2 receiving system
   - an new (modified) Observing Block has been (re-)submitted

***Basic Course*:**

1. The Observer or the system requests the validation
2. The validator determines the type of validation request (Observer/ALMA)
3. If the validation request comes from the Observer
   - System starts validation (see *Block Validation* subflow)
   - System notifies the Observer that the Observing Block(s) is/are successfully validated
4. If the validation is to be done by the ALMA System
   - The system checks version number of the Phase 1/2 Tool
   - Systems starts validation (see *Block Validation* subflow)
   - System notifies the Observer that the Observing Block(s) is/are successfully validated
     Exception Course: The Observing Blocks is/are rejected, the Observer is notified, and the Observing Block(s) is/are flagged as not-validated and left in checked out state.
   - The System flags the OBs as validated and checked in.

***Subflow*:** Block Validation

1. Validator checks consistency between Observing Blocks and Phase 1 information
   Exception Course: Observing Block does not match Phase 1 information. Block is left is checked out status.
2. The validator checks the Observing Block (see also *Create Observing Blocks* use case). For each Observing Block the following specifications are checked:
   - Observing mode(s) (e.g. Frequency Switching, OTF mosaic, etc.)
   - Array configuration
   - Receiver setup (central velocity/frequency, velocity/frequency spacing, resolution, polarisation, ..)
   - Correlator setup
   - Calibrators/scientific target(s)

- Time sequence of science and calibrator sources
- ...

3. The validator checks the relationships between the OBs and the positions breakpoints

Postconditions:

- The Observing Blocks are locally validated and the Observer is given the results
  or
- The Observing Blocks are validated and checked-in in the ALMA OB repository.

***Issues to be Determined or Resolved*:**

1. How strongly should we insist on having the Observing Block specs match the Phase 1 data?
2. Will each Observing Block be reviewed before it goes to the scheduler?
3. Does the System accept input given to the Phase 2 GUI and the actual Observing script?. If script can be accepted how is this validated?

Notes:

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2.8 SubmitObservingBlocks

Use Case: Submit Observing Blocks

This use case concerns the submission of one or more user-validated Phase 2 Observing Blocks to the System. The submitted OBs are validated. If validation is succesful the OBs are stored in the Phase 2 repository.

Role(s)/Actor(s):
Primary: Observer
Secondary: ALMA Phase 2 Repository

Priority: Critical

Performance: Minutes

Frequency: Submission can occur up to several times per minute

Preconditions:

1. The system is available to receive Phase 2 data
2. The Observer is connected to the network.
3. The Observing Block(s) has been validated by the Observer

Basic Course:

1. The Observer enters <submit Observing Block>
2. Proposal Tool connects to the system
   Exception Course: The Observing Block is not validated by the Observer.
3. Observing Block is validated (*Validate Observing Block*s use case) and stored in the ALMA Phase 2 repository
   Exception Course: The validation of the Observing Block fails and the Observer is informed. the Observing Block is left in the checked out state

4. The OBs are checked in and ready to be executed

Postconditions:

1. The OBs are received by the system, validated and checked into the Phase 2 repository
2. The Observer receives an acknowlegment of reception and validation.

Issues to be Determined or Resolved:

1. This use case assumes that Phase 2 submission is done on a Observing Block basis. In case of more than one OB that are inter-related, they should be submitted in one go. Is this a reasonable assumption?
2. Is there a time cycle for submitting Phase 2 data or continuous submission?
3. What about special proposals (targets of opportunity, discretionary time)?
4. The Scheduler should not schedule OBs that have a dependency relationship with a currently checked-out OB.

Notes:

- The Observer should be to checkout one or more OBs, make changes to them, and check them in again (after which the Observing Blocks are validated again).

Last modified: July 26, 2000/Rein Warmels

3 ScheduleOB

Use Case: ScheduleOB

Retrieve OBs from phase II programme data base, assign priorities to Observing Programme OBs and pass OB with highest priority to the Array Observing System.

The phase II data base for a given programme contains OBs as well as preamble OBs and postamble OBs. Each OB is linked to both a preamble OB and a postamble OB. That preamble OB must have been executed prior to execution of that OB in any time-contiguous execution of OBs in that programme (=session ?), which has also to be concluded by the postamble OB.

A persistent data base of the status of each OB must be kept and updated after each OB execution.

The programme may contain relational links between OB, in the sense that a given OB may only be scheduled if specified other OBs have been previously executed, and if some condition on their results (as available in the status data base) is fulfilled.

The programme may contain breakpoints, i.e. conditions to be fullfilled by the status data base contents to allow further scheduling of any OB in the programme.

***Role(s)/Actor(s)*:**
Primary: Operator
Secondary: Phase II programme data base, Array Observing System

***Priority*:** major
***Performance*:** order of seconds

***Frequency*:** order of minutes

***Preconditions*:**

1. A data base of active programmes from Phase II

***Basic Course*:**

1. Phase II data programmes are loaded in observing queue (UC *UploadOBQueue*)
   Alternate Course: A single OB, revised by the observer, is loaded in the observing queue and replaces the previous version in subsequent priority calculations and executions.
   Alternate Course: A breakpoint condition is released by the observer, after examination of available data, and head scratching as needed.
   Alternate Course: The Operator or the Observer my put the programme in hold condition, forbidding the scheduling of the programme OBs until further notice.
2. System calculates OB priorities in the queue (UC *CalculateOBPriorities*). These priorities are calculated based on rules involving:
   1. Initial rating prom science reviewers.
   2. Environmental parameters (weather, LST, UT, ...)
   3. System parameters (is the programme started, is it currently in execution, antenna resources availability ...)
   4. Pipeline results (current phase rms if available from calibrators, possibly science results, ...)
   5. Fulfillment of conditions imposed in the programme (relational links between OBs).
   6. Fulfillment of breakpoint conditions.
3. System displays the OB queue (UC *DisplayOBQueue*).
4. Optional step: Operator alters priorities (UC *AlterOBPriorities*)
5. System passes the top priority OB to the Array Observing System for execution (UC *PassTopOB*).
   Alternate Course: If the top OB belongs to a programme different from the one being executed: Postamble(s) needed by the current programme are passed to the AOS for execution, appended with Preamble needed by the new OB, appended with the OB itself.

6. System (AOS) updates status of executed OB queue after OB execution (UC *UpdateOBQueue*). This status contains e.g. the number of executions of that OB, the theoretical noise fluctuation obtained on the data, the actual signal-to-noise ratio, ... items that may be needed in the breakpoint rules and OB condition rules.
   Alternate Course:...
   Exception Course: ...
   Postcondition: ...
7. ...

***Alternate Course*:**

1. Operator removes OBs from the queue (UC RemoveOB)

Postconditions:

1. OBs are passed to the AOS and the queue is filled with new OBs on a regular basis.

***Issues to be Determined or Resolved*:**

1. The actual set of rules to calculate priorities.

Notes:

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4 ExecuteSB

Use Case: Execute Scheduling Block

The goal of this use case is to execute scheduling blocks that have been scheduled by the Dynamic Scheduler.

***Role(s)/Actor(s)*:**
Primary: Dynamic Scheduler
Secondary:

***Priority*:** Critical

***Performance*:** Seconds to hours

***Frequency*:** Several times per minute/hour/day; One at a time per sub-array

***Preconditions*:**

1. Need to have either scheduling blocks from the Dynamic Scheduler or directly from the Observing Tool

***Basic Course*:**

1. Dynamic Scheduler or Observing Tool sends SB
2. If this is a preamble SB
    - Allocate resources
    - Initialize resources (receiver & correlator setup, etc.)
    - Perform necessary system initializations and/or calibrations like bandpass calibration
3. Execute standard scans by interpreting the corresponding Observing Descriptors with the given user parameters and controlling the antennas accordingly
   Alternate course 1: For non-standard scan modes interpret the user supplied Observing Descriptors
   Alternate course 2: Alternatively, in manual mode, the user would type in commands to be executed directly via a CLI.
   Exception course: The execution of an observation fails
4. Archive data with time and project tags continuously, i.e. while an observation is being executed (see *Archive Data* use case)
5. For standard observations send standard Reduction Script to Data Pipeline (see *ProcessData* use case)
6. Optionally send user Reduction Script to Data Pipeline
7. Update persistent SB / OP (Observation Procedure/Program) parameters and save SB/OP status
8. Send feedback to Dynamic Scheduler
9. If this is a postamble SB:
    - Release resources

***Subflow*:**

***Alternate Course*:**

***Exception Course*:** The execution of an observation fails

1. Stop SB execution
2. Notify operator / observer; save status of OP
   Postcondition: Execution of SB halted; operator / observer notified; status saved

Postconditions:

1. SB has been successfully executed

***Issues to be Determined or Resolved*:**

- What are the system services needed in the preamble SB case ?
- The system must know about the possible default scan modes and the necessary Observing Descriptors. The *default modes* are described in the *ALMA Software Science Requirements Report*. The detailed Observing Descriptors for those modes are TBD. Use Cases for setup, observation and reduction of each of those observing modes are currently being developed.
- The system must have access to the SBs / OPs persistent parameters. Where will the persistent parameters be stored ? There should be a structure above the level of SBs (e.g. an OP (Observation Procedure)) because it is required to have feedback spanning more than one SB. This issue is currently (11/2000) being discussed in the SSR, UC and HLA groups.
- Should interactive observing be setup via SBs and go through the scheduler or rather use a CLI / GUIto directly talk to the AOS ?

Notes:

- Must have access to persistent program parameters
- Feedback to scheduler could be via OP parameters / archive, i.e. maybe no direct connection

Last modified: November 11, 2000, D. Muders

5 ProcessScienceData

5.1 ProcessData

Use Case: ProcessData

The pipeline reduces data in quasi-real time, in an automatic way, taking input data from the raw data archive, and putting results into the Science archive.

Some results (calibration) are made available to the AOS and/or to the Scheduler. The pipeline reduction should not be a bottleneck for the array operation.

Action may have to be taken after each observation to recompute e.g. system temperatures, and/or update incremental displays; or after a scan to reduce e.g. pointing scans, focus scans with a feedback to the AOS, or phase calibration scans with a feedback to the Scheduler (computed phase noise). Science data processing will more likely take place after an SB to calibrate the amplitudes and phases, and eventually perform imaging and deconvolution.

Role(s)/Actor(s):
Primary: Array Observing System
Secondary: Operator, Staff Astronomer, Observer

Priority: Major

Performance: from seconds (array calibration such as pointing) to tens of minutes for imaging.

Frequency: minutes

Preconditions:

1. Correlator data is available
2. Programme dependent reduction scripts available, as defined in the observing programme.

Basic Course:

1. the AOS initiates pipeline when the first OB of a new observing session is executed (UC *InitOnLinePipeline*)
   *Alternate Course:*off-line execution
2. the pipeline executes reduction script commands whenever scans are written into the archive (UC *ExecuteReductionScript).* These commands retrieve data for the raw data archive, manipulate data, optionally display results, store results in science archive.
   Exception Course: the operator is notified if the script fails
3. the pipeline makes results available to the AOS, (UC *ResultsToAOS*)
4. the pipeline makes quality check results available to the scheduler (UC *ResultsToScheduler*)

Alternate Course: off-line execution

1. the observer initiates the pipeline off line
2. the pipeline executes script commands sequentially

Postconditions:

1. Parameters are fed back to either the AOS or the Scheduler;
2. Science data (images) are written into the Science Archive
3. Data reduction scripts and logs are written into the Science Archive

***Issues to be Determined or Resolved*:**

1. How the ACS and the Scheduler retrieve pipeline results.

Notes:

1. The pipeline shall be run either at or near the telescope, or at the places where the archives are kept.
2. If the pipeline of a previous session is still active, the pipeline of the current observing session has priority for allocation of computing resources.
3. There may be actually two pipelines for a given observing session: one to process pointing and phase calibrations, one for imaging.
4. An observer must be able to look at the pipeline results of recently observed programmes without downgrading the pipeline performance on the currently observed programme.

Created: July 28, 2000/Robert Lucas
Last modified: December 6, 2000/Rein Warmels

6 ManageArchive

6.1 ArchiveData

Use Case: Archive Data

The goal of this use case is to store given data into the ALMA data archive / database. The archive will contain a variety of time tagged data streams such as:

- Proposals
- Observation Projects with their Observation Block data and scripts (observation and reduction) and their persistent data (program data and program related system data)
- Program related observational data:
  - Source name, coordinates and velocity
  - Line name and frequency
  - Continuum frequency (band) and bandwidth
  - Correlator bandwidth and resolution
  - Phase corrected and uncorrected raw uv data
- Environmental data:
  - Water vapor content
  - Weather data
- Monitoring data:
  - Instrument status
  - Telescope status
- Logs:
  - Observation log
  - Operator log
  - Automatic logs from subsystems
- Errors
- Warnings
- Online Data Pipeline products:
  - Pointing and focus corrections
  - Calibration Data
  - Images
  - Data quality parameters
- Data base related information:
  - Archive access / request logs

***Role(s)/Actor(s)*:**
Primary: ALMA System (role of Proposal Handling System, Dynamic Scheduler, SB Execution System, Array Observing System)
Secondary:

***Priority*:** Critical

***Performance*:** Faster than the time it takes to perform an observation, typically seconds to minutes; Archive system must be able to cope with data rates (currently expected to be as high as 30 MB/s)

***Frequency*:** Continuously

***Preconditions*: *Basic Course*:**

1. ALMA System sends data to Archive System
2. Archive System saves data stream in archive
   Exception course: Saving the data fails

   1. Notify ALMA System

   Postconditions:

   1. Data not saved
   2. ALMA System is notified
3. Archive System maintains indexes of the various archived data streams

Subflow*: *Alternate Course*: *Exception Course*: *Postconditions:

1. Data stored

***Issues to be Determined or Resolved*:**

- Will offline data reduction products also be stored in the ALMA archive ?
- How long will intermediate data pipeline results be stored in the archive ?

Notes:

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6.2 RetrieveData

Use Case: RetrieveArchivedData

The goal of this use case is to retrieve selected data from the ALMA archive and optionally reduce it using the ALMA Data Pipeline

Role(s)/Actor(s):

Primary: ALMA User (Role of Operator, Observer, Technician, Data Pipeline)
Secondary:

Priority: Critical

Performance: Seconds to minutes

Frequency: Seconds to hours

Preconditions: ***Basic Course***:

1. ALMAUser identifies him-/herself to the ALMAArchive System
2. ALMA User defines criteria for data selection (using a GUI for human user access):
    - Project name(s) / number(s)
    - Source name(s)
    - Coordinates
    - Line names / frequency ranges
    - Date(s)
    - Proposals
    - OPs
    - OBs
3. ALMA User requests data under given constraints from archive
   Exception Course: Data is not available or is not accessible to the user
4. Data set is made available to ALMA User
5. Optionally reduce the data set using the ALMA Data Pipeline
6. Save access / request log in archive

Subflow: ***Alternate Course***: ***Exception Course***: Data is not available or is not accessible to the user.

1. System notifies ALMA User
   Postcondition: No data delivered

Postconditions:

1. Requested data is made available to ALMA User

Issues to be Determined or Resolved:

- The access to the ALMA archive is supposed to be easy and fast. What exactly does that mean ?
- What are the policies concerning data access for reviewers, ALMA staff and general users ?
- Are there any restrictions concerning the usage of the Offline Data Pipeline or is anybody allowed to use as much computing power / time as they want ?
- Will products of the Offline Data Pipeline be stored in the ALMA archive ?

Notes:

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7 Main Observing Modes

7.1 Single Field

7.1.1 SetupSingleField

Use Case: SetupSingleField

Starting from user's scientific input, determine all parameters necessary to perform single field interferometric observations.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: Line Catalog, Source Catalog, Array Configuration Catalog

***Priority*:** Major

***Performance*:** seconds.

***Frequency*:** 100/hour

***Preconditions*:**

1. ...

***Basic Course*:**

1. User specifies
   - field name.
   - coordinate system.
   - field center coordinates (either by absolute coordinates or offsets from a direction specified by its absolute coordinates).
2. System checks the declination.
   Exception Course: The source is not observable from the ALMA site.
3. User specifies
   - desired synthesized beam size
   - field width
4. User specifies
   - number of IF bands
   - Line names; the frequencies are obtained from the line catalog
     Alternate Course: User enters line name and line frequencies
     Alternate Course: User enters continuum frequency
5. For line observations, the user specifies
   - center velocities
   - velocity reference systems
   - velocity bandwidths
   - velocity resolutions

   Alternate Course: for continuum, the user specifies
   - frequency bandwidths
   - frequency resolutions
6. User specifies phase calibrator choice policy (closest with given minimum flux, strongest with maximum distance, calibrator named explicitly from the instrument catalog)

7. User specifies phase calibration observing frequency and phase rms goal on calibrators at target observing frequency, and whether the radiometric phase correction is to be used
8. User specifies that the integration times of the phase calibration cycle are optimally determined at run time from measured phase rms
   Alternate Course: the integration times are given explicitly
9. User specifies the parameters of bandpass calibration:
   1. the calibrator is to be chosen at observing time
      Alternate Course: the calibrator is explicitly specified
   2. the goal in rms phase is specified
10. User specifies the performance goals: total integration time and/or final rms
11. The system evaluates the proposed setup:
    1. The field size is compared to the primary beamwidth at the observing frequency.
       Alternate Course: if larger a mosaic observation is suggested
    2. beam information is computed (ellipticity, actual size)
    3. the system computes maximum and minimum baseline lengths needed, and makes some comments about configuration availability (TBD).
    4. map cell size and number of pixels are computed.
    5. the correlator setup is explicitly computed from the spectral information. Warnings are given if the spectral coverage is affected by Doppler effect variations.
    6. proposes splitting into SBs based on observatory policy (max. SB length)
12. The User may either refine its input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

Notes: Coordinates may be also graphically determined from a user provided map or image.

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7.1.2 ObserveSingleField

Use Case: ObserveSingleField

Describe the actual observing actions needed to obtain data in the single field interferometric mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Major

Performance: real-time; overhead should be minimal and dominated by hardware.

Frequency: this mode is likely to be the most frequently used.

Preconditions: all the user parameters have been properly entered and checked (UC *SetupSingleField.html*)

Basic Course:

1. The preamble block is executed (only once in the session).
   1. Doppler effect is calculated for the target source and current time.
   2. The receivers are set up and tuned.
   3. The correlator is setup.
   4. The pipeline is started.
   5. The bandpass calibration is executed, after automatic selection if so specified. This includes observing this source at both the target frequency and the calibration frequency.
   6. The phase calibrator is selected if necessary by observing a few candidates in the source vicinity, according to the selection policy as specified.
   7. If the phase calibrator is not suitable (too weak) as a pointing reference, a pointing calibrator is selected.
2. For each scheduled SB:
   1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures.
   2. Update the pointing and focus corrections using feed back from the pipeline.
   3. Record correlator output on the phase calibrator at the calibration frequency then at the observing frequency (TBD) for a specified or calculated time.
   4. Record correlator output on the target source at the observing frequency for a specified or calculated time. This calculation is based on the current phase rms or phase structure function (TBD).
   5. Repeat steps 3 and 4 until the SB time is exhausted or the goals are achieved (e.g. minimum rms reached).

   Exception Course: If the phase rms increases over a specified limit, the SB is terminated (keep the data observed so far, with appropriate flag).
3. The system executes the associated postamble SB: the phase calibrator is reobserved one last time.
4. Optionally (if specified by the astronomer or if automatically determined) the pipeline is instructed to make the final image and is closed.

Postconditions:

1. ...
2. ...

Issues to be Determined or Resolved:

- An amplitude calibrator may need to be observed at some rate if the phase calibrator is not strong enough.

- That calibrator may also be used to monitor the relative phases at the observing and the calibration frequency
- The policy to choose the bandpass calibrator is to be defined.
- The algorithm to determine the dwell time for phase calibration is TBD.
- Measuring the sideband gain ratios could be needed in the preamble if both sidebands can be measured.
- This use case might be extended to deal with more than one target source.
- This use case might be extended to include a calibrator as a test source at regular intervals, for quality evaluation.

Notes:...

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7.1.3 ReduceSingleField

Use Case: ReduceSingleField

This Use Case describes the on-line data reduction operations for the Single Field interferometry mapping mode.

Role(s)/Actor(s)
Primary: The AOS, or the observer
Secondary:

Priority: Major

Performance: Need to feed back data nearly in real time.

Frequency: At least once per program, possibly after breakpoints, after a session or for every scan.

Preconditions: The user input parameters have been input and have been made available to the pipeline, preferably in the data headers

Basic Course:

1. For each available observation, the current system temperatures are computed using total power on sky and ambient load (previously measured).
2. When the bandpass scan is available, the bandpass calibration is computed (UC ReduceBandPass)
3. Whenever a new phase calibrator scan is available, the phase rms is computed, the antenna based amplitudes are checked against the known calibrator flux.
4. At the end of the session:
    1. the phase calibration is computed and applied to all target scans by interpolation.
       Alternate Course: the phase calibration is computed and applied on the fly, as soon a sufficient number of calibration scans are available
    2. the amplitude calibration is computed and applied to all target scans by interpolation.
       Alternate Course: the amplitude calibration is computed and applied on the fly, as soon a sufficient number of calibration scans are available
5. Optionally, the UV data is
    - gridded
    - Fourier transformed into a dirty map
    - deconvolved
6. Optionally the data cube is archived

Postconditions:

1. ...

Issues to be Determined or Resolved: ...

Notes:

1. we assume that the pointing and focus scans reduction is described in another Use Case
2. we assume that online displays to be regularly updated are described in another Use Case.
3. if resources allow maps may be computed and displayed at more frequent intervals, for diagnostic purposes.
4. Interim results are probably not stored in the archive or at least they should be flagged as being only intermediate results.

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7.2 Multi Field

7.2.1 SetupMultiField

Use Case: SetupMultiField

A Multi-Field interferometric observation is a scan consisting of a sequence of Single-Field interferometric observations.

Starting from the User's scientific input, determine all parameters necessary to perform multi-field interferometric observations by using the ObservingTool. This is a required part of the Phase II process. The most common use of multi-field interferometric observations is to create a mosaic, but in the most general case it can create an arbitrary sequence of different pointing centers with different nominal noise levels. This setup usually creates multiple SBs.

Role(s)/Actor(s):
Primary: The User (Observer, Staff Scientist, Array Operator), the ObservingTool
Secondary: Line Catalog, Source Catalog, Array Configuration Catalog

Priority: Major

Performance: Seconds.

Frequency: 100/hour

Preconditions:None

Basic Course:

1. User specifies the nominal field centers and a noise level for all fields. User fully specifies mosaic by choosing:
   - Noise level in final mosaic
   - A coordinate system and a center position for the mosaic
   - A pattern or area from the following:
     - Spiral pattern
     - Circular pattern
     - Rectangular area
     - Oval area
     - Region defined by mouse on a sky overlay

   ← Leaf "Other"

   The ObservingTool (OT) selects an angular spacing between field centers based on the frequency and then generates the list of field centers. The OT generates a nominal noise level for each field based on the specified noise level in the final mosaic. The OT generates a default name for each field based on the sequential order of the field and the source name assigned to the center position.
   Alternate Course: User specifies that a mosaic is not the scan goal and enters an array of field centers and noise levels. The field centers may be specified either by absolute coordinates or offsets from a position specified by absolute coordinates.
2. User optionally edits the sequence of field names, field center coordinates, and noise levels.
3. System checks the declination for all fields.
   Exception Course: The source is not observable from the ALMA site.
4. User specifies the desired synthesized beam size.
5. User specifies number of IF bands, line names; the frequencies are obtained from the Line Catalog.
   Alternate Course: User enters line name and line frequencies
   Alternate Course: User enters continuum frequency
6. User specifies center velocities, velocity reference systems, velocity bandwidths, velocity resolutions.
   Alternate Course: For continuum, the user specifies frequency bandwidths and frequency resolutions

7. User specifies phase calibrator choice policy (closest with given minimum flux, strongest with maximum distance, calibrator named explicitly from the ALMA catalog)

8. User specifies phase calibration observing frequency and phase rms goal on calibrators at target observing frequency.

9. User specifies the parameters of the phase calibration cycle, either explicitly, or by requesting that those parameters are optimally determined at run time from measured phase rms.

10. User specifies the parameters of bandpass calibration: the calibrator is either to be chosen at observing time or explicitly specified; the goal in rms phase is specified.

11. User specifies the parameters for pointing calibration. See UC *SetupPointingCalibration* for the details.
12. User specifies atmospheric pathlength correction selection for visibility archiving:
    - Uncorrected
    - Corrected
    - Both
13. User specifies atmospheric pathlength correction selection for the image pipeline and image archiving:
    - Uncorrected
    - Corrected
    - Best of uncorrected or corrected
14. The OT evaluates the proposed setup:

    1. Examines field spacing to determine if they are close enough to create mosaic image.
       Alternate Course: Inform user that fields are too far apart for mosaic.
       Alternate Course: Recognize that scan goal is not a mosaic and skip examining field spacings.
    2. Beam information is computed (ellipticity, actual size)
    3. The OT computes maximum and minimum baseline lengths needed, and makes some comments about configuration availability (TBD).
    4. Map cell size and number of pixels are computed.
    5. The correlator setup is explicitly computed from the spectral information. Warnings are given if the spectral coverage is affected by Doppler effect variations.
    6. Compute visibility data rate and data volume and warn User if it exceeds proposal allocation.
15. User may either refine the input parameters, modify the deduced setup parameters, or accept the setup.
16. OT creates pipeline data reduction script.
17. User optionally edits pipeline data reduction script.
18. OT computes image data rate and data volume and warns User if it exceeds proposal allocation.
19. OT generates Preamble Block (PreB), Postamble Block (PosB), and SBs for the scan.
20. User optionally edits PreB, PosB, and SBs.
21. User specifies a unique name to attach to the final results (PreB, PosB, SBs, pipeline reduction script).
22. OT automatically saves the results at the completion of the setup.

Postconditions:
A set of PreB, PosB, SBs, and pipeline data reduction script.

Issues to be Determined or Resolved
None currently recognized.

Notes:

- This setup is done with the ObservingTool.
- The User may save partial results from the setup at any time and exit, assigning a unique name to the results.
- The User may start the OT with previously saved partial results.
- The User may start the OT with a previous setup, using it as a template.

Last modified: $Id: SetupMultiField.html 2000/11/07 Scott

7.2.2 ObserveMultiField

Use Case: ObserveMultiField

Describe the observing actions needed to obtain data in the Multi-Field interferometric mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority:Major

Performance: Realtime; overhead should be minimal and dominated by hardware.

Frequency: Frequently used.

Preconditions: All the user parameters have been properly entered and checked (UC *SetupMultiField*), and the Preamble Block (PreB), Postamble Block (PosB), and SBs have been created.

Basic Course

1. The PreB is executed (only once in the observing session).
    1. Doppler effect is calculated for the target source and current time.
    2. The receivers are set up and tuned.
    3. The correlator is setup.
    4. The pipeline is started.
    5. The bandpass calibration is executed, after automatic selection if so specified. This includes observing this source at both the target frequency and the calibration frequency.
    6. The phase calibrator is selected if necessary by observing a few candidates in the source vicinity, according to the selection policy as specified.
    7. If the phase calibrator is not suitable (too weak) as a pointing reference, a pointing calibrator is selected.

2. For each scheduled SB:
    1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures.
    2. Update the pointing and focus corrections using feedback from the pipeline.
    3. Select which atmospheric pathlength corrected data will be archived based on earlier input (see UC *SetupMultiField*).
    4. Collect and archive correlator output on the phase calibrator at the calibration frequency then at the observing frequency (TBD) for a specified or calculated time.
    5. Collect and archive correlator output on a sequence of the specified fields at the observing frequency for a specified or calculated time. This calculation is based on the current phase rms or phase structure function (TBD).
    6. Repeat steps 3, 4, and 5 until all of the fields have been observed and the goals are achieved (e.g. minimum rms reached), or the SB time is exhausted .

    Exception Course: If the phase rms increases over a specified limit, the SB is terminated (keep the data observed so far, with appropriate flag).

3. The associated PosB is executed: the phase calibrator is reobserved one last time. The pipeline is instructed to make the final image and is closed.

Postconditions:

1. Data is stored in the archive.
2. Completion status of observed fields is updated.

Issues to be Determined or Resolved:

- An amplitude calibrator may need to be observed at some rate if the phase calibrator is not strong enough.
- The amplitude calibrator may also be used to monitor the relative phases at the observing and the calibration frequency
- The policy to choose the bandpass calibrator is to be defined.
- The algorithm to determine the dwell time for phase calibration is TBD.
- Measuring the sideband gain ratios could be needed in the preamble if both sidebands can be measured.
- This use case might be extended to include a calibrator as a test source at regular intervals, for quality evaluation.

Notes: none

Last modified: $Id: ObserveMultiField.html 2000/11/07 Scott$

7.2.3 ReduceMultiField

Use Case: ReduceMultiField

This Use Case describes the on-line data reduction operations for the Multi-Field interferometric observing mode. See also *SetupMultiField*, *ObserveMultiField*.

***Role(s)/Actor(s)*:**
Primary: The AOS, or the observer; the image pipeline.
Secondary:

***Priority*:** Major

***Performance*:** Need to feed back data nearly in real time.

***Frequency*:**At least every scan.

***Preconditions*:** The user input parameters have been input and have been made available to the pipeline, preferably in the data headers. A data reduction script has been created.

***Basic Course*:**

1. For each available integration, the current system temperature spectra are computed using auto-specta and total power on the sky and on the ambient load (previously measured).
2. When the bandpass scan is available, the bandpass calibration is computed (UC ReduceBandPass).
3. Whenever a new phase calibrator scan is available, the phase rms is computed, the antenna based amplitudes are checked against the known calibrator flux.
4. At the end of the session:
    1. An atmospheric pathlength corrected data set is selected for the pipeline data reduction as specified in UC *SetupMultiField.*.
    2. The phase calibration is computed and applied to all target scans by interpolation.
    Alternate Course: The phase calibration is computed and applied on the fly, as soon as a sufficient number of calibration scans are available
    3. The amplitude calibration is computed and applied to all target scans by interpolation.
    Alternate Course: The amplitude calibration is computed and applied on the fly, as soon a sufficient number of calibration scans are available
    4. If a mosaic was specified, data from all fields are handled together as the UV data is gridded, Fourier transformed into a dirty map, and deconvolved.
    Alternate Course: The individual fields are processed using the same steps
    5. The data cube is archived.

Postconditions:

1. An archived image data cube is produced.
2. The project status is updated to reflect completion of archiving.

***Issues to be Determined or Resolved*:** None at this time.

Notes:

1. We assume that the pointing and focus scans reduction is described in another Use Case.
2. We assume that online displays to be regularly updated are described in another Use Case.
3. If resources allow maps may be computed and displayed at more frequent intervals, for diagnostic purposes.

Last modified: $Id: ReduceMultiField.html 2000/11/07 Scott

7.3 OTF Mosaic

7.3.1 SetupOTFMosaic

Use Case: SetupOTFMosaic

Starting from user's scientific input, determine all parameters necessary to perform On The Fly (OTF) Mosaic interferometric observations.

Role(s)/Actor(s):
Primary: Observer
Secondary: Line Catalog, Source Catalog, Array Configuration Catalog

Priority: Major

Performance: seconds.

Frequency: 100/hour

Preconditions:

1. ...

Basic Course:

1. User specifies field name, coordinate system, and field center coordinates (either by absolute coordinates or offsets from a direction specified by its absolute coordinates);
2. System checks the declination.
   Exception Course: The source is not observable from the ALMA site.
3. User specifies the desired synthesized beam size and field width.
4. User specifies number of IF bands, Line names; the frequencies are obtained from the line catalog.
   Alternate Course: User enters line name and line frequencies
   Alternate Course: User enters continuum frequency
5. User specifies center velocities, velocity reference systems, velocity bandwidths, velocity resolutions
   Alternate Course: for continuum, the user specifies frequency bandwidths and frequency resolutions
6. User specifies phase calibrator choice policy (closest with given minimum flux, strongest with maximum distance, calibrator named explicitly from the instrument catalog)
7. User specifies phase calibration observing frequency and phase rms goal on calibrators at target observing frequency, and whether the radiometric phase correction is to be used.
8. User specifies the parameters of the phase calibration cycle, either explicitly, or by requesting that those parameters are optimally determined at run time from measured phase rms.
9. User specifies the parameters of bandpass calibration: the calibrator is either to be chosen at observing time or explicitely specified; the goal in rms phase is specified.
10. User specifies the performance goals: total integration time and/or final rms.
11. The system evaluates the proposed setup:
    1. The field size is compared to the primary beamwidth at the observing frequency.
       Alternate Course: if field size is too small single field or pointed mosaic observation is suggested
    2. beam information is computed (ellipticity, actual size)
    3. the system computes maximum and minimum baseline lengths needed, and makes some comments about configuration availability (TBD).
    4. map cell size and number of pixels are computed.
    5. the correlator setup is explicitly computed from the spectral information. Warnings are given if the spectral coverage is affected by Doppler effect variations.
    6. proposes splitting into OBs based on observatory policy (max OB length).
    7. proposes subdividing mosaic field into OTF scans with scan length and slew rate determined from the maximum baseline length, size of field to be mosaiced......

12. The User may either refine its input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

Notes: Coordinates may be also graphically determined from a user provided map or image.

Last modified: $Id: SetupOTFMosaic.html,v 1.1 2000/11/29 14:57:43 lucas Exp lucas $

7.3.2 ObserveOTFMosaic

Use Case: ObserveOTFMosaic

Describe the actual observing actions needed to obtain data in the OTF mosaic interferometric mode.

Role(s)/Actor(s):
Primary: The AOS
Secondary:

Priority:Major

Performance: real-time; overhead should be minimal and dominated by hardware.

Frequency: if successful, this mode will be commonly used for large mosaics.

Preconditions: all the user parameters have been properly entered and checked (UC *SetupOTFMosaic.html*)

Basic Course

1. The preamble block is executed (only once in the session).
    1. Doppler effect is calculated for the target source and current time.
    2. The receivers are set up and tuned.
    3. The correlator is set up.
    4. The pipeline is started.
    5. The bandpass calibration is executed, after automatic selection if so specified. This includes observing this source at both the target frequency and the calibration frequency.
    6. The phase calibrator is selected if necessary by observing a few candidates in the source vicinity, according to the selection policy as specified. Determine the calibration integration time from the flux density.
    7. If the phase calibrator is not suitable (too weak) as a pointing reference, a pointing calibrator is selected.
2. For each scheduled SB:
    1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures.
    2. Update the pointing and focus corrections using feed back from the pipeline.
    3. Record correlator output on the phase calibrator at the calibration frequency then at the observing frequency (TBD) for a specified or calculated time.
    4. Set the fringe rate for the mid point of the OTF scan.
    5. OTF scan: Record correlator output on the target source at the observing frequency whilst synchronously slewing the antennas for a specified time at a specified slew rate.
    6. Repeat steps 4 and 5 until the calibration interval , then re-observe the phase calibrator.
    7. Repeat until the SB time is exhausted or the goals are achieved (e.g. minimum rms reached).

    Exception Course: If the phase rms increases over a specified limit, the SB is terminated (keep the data observed so far, with appropriate flag).
3. The system executes the associated postamble SB: the phase calibrator is reobserved one last time. The pipeline is instructed to make the final image and is closed.

Postconditions:

1. ...

Issues to be Determined or Resolved:

- An amplitude calibrator may need to be observed at some rate if the phase calibrator is not strong enough.

- That calibrator may also be used to monitor the relative phases at the observing and the calibration frequency
- The policy to choose the bandpass calibrator is to be defined.
- The algorithm to determine the dwell time for phase calibration is TBD.
- Measuring the sideband gain ratios could be needed in the preamble if both sidebands can be measured.
- This use case might be extended to deal with more than one target source.
- This use case might be extended to include a calibrator as a test source at regular intervals, for quality evaluation.

Notes:

Last modified: $Id: ObserveOTFMosaic.html,v 1.1 2000/11/29 15:16:21 lucas Exp lucas $

7.4 On-The-Fly Mapping

7.4.1 SetupOTFMap

Use Case: SetupOTFMap

Starting from user's scientific input, determine all parameters necessary to perform Total Power On-The-Fly Mapping observations.

Role(s)/Actor(s):
Primary: Observer
Secondary: Line Catalog, Source Catalog, Array Configuration Catalog

Priority: Major

Performance: Seconds

Frequency: Several/hour

Preconditions:

1. ...

Basic Course:

1. User specifies field name, coordinate system and field center coordinates (either by absolute coordinates or offsets from a direction specified by its absolute coordinates);
2. System checks the declination.
   Exception Course: The source is not observable from the ALMA site.
3. User specifies
   - number of IF bands,
   - Line names, the frequencies are obtained from the line catalog.
     Alternate Course: User enters line name and line frequencies
     Alternate Course: User enters continuum frequency
   - observing mode:
     - Position switching
     - Beam switching using the wobbler
     - Frequency switching (only applicable for line observations)
4. For line observations, the user specifies
   - center velocities
   - velocity reference systems
   - velocity bandwidths
   - velocity resolutions

   Alternate Course: for continuum, the user specifies
   - frequency bandwidths
   - frequency resolutions
5. System calculates beam size.
6. User specifies the desired geometric mapping details:
   - the map size, shape (rectangular, circular, etc.).
   - the mapping strategy (zig-zag, spirals, etc.).
7. User specifies the desired time and / or scanning speed details:

- the desired RMS noise for a given velocity resolution (which may be larger than the specified correlator channel width) per OTF point.
  Alternate Course: User specifies the integration time per OTF point.
- System calculates and displays step sizes between OTF scanning points according to the beam size and the Nyquist sampling theorem.
  Alternate Course: User specifies the step size between subsequent OTF scanning points and the distance between scan lines perpendicular to the scan axis.

Alternate Course: User specifies scanning speed and total time per basic geometric OTF map element

8. User specifies sky reference position(s) in absolute or relative coordinates for On-Off OTF map.
   Alternate Course I: User specifies nutator / wobbler offset(s) for Beam Switched OTF map.
   Alternate Course II: User specifies to use edges of OTF map as reference positions.
   Alternate Course III: frequency throw for frequency switching observations
9. User specifies time intervals for alternation between reference and target.
10. User specifies time intervals between amplitude calibrations during the OTF map to be determined at run time depending on changes in elevation and atmospheric water vapor content
    Alternate Course: User specifies time intervals explicitly, optionally as upper limits
11. User specifies time intervals between pointing calibrations
12. The system evaluates the proposed setup:
    1. The system calculates the estimated time for completion of the specified map
    2. The system compares the given OTF step sizes to the beam size at the specified frequency, notifies user and suggests changes if the sampling theorem is violated or the beam smearing is too large.
    3. the correlator setup is explicitly computed from the spectral information. Warnings are given if the spectral coverage is affected by Doppler effect variations.
    4. The system suggests to split the given OTF map into smaller pieces to be executed in parallel by software-subarrays.
    5. The system proposes splitting into SBs based on observatory policy (max SB length) .
13. The User may either refine its input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

- Projects may ask for maps of the same area at different frequencies, which implies different beam sizes and therefore a different mapping step sizes etc. This has to be addressed somewhere.
- It is unclear if frequency switching will be implemented for ALMA.
- It is unclear if there will be software-subarrays.
- It is unclear if there will be LO / frequency subarrays which would allow simultaneous mapping of different lines within one subarray.

Notes:

- Coordinates may be also graphically determined from a user provided map or image.
- For performance reasons, all allowed OTF mapping patterns should use only continuous movements of the antennas, e.g. in a rectangular zig-zag pattern the rows should be connected by half circles.
- Time intervals both for observing reference positions and for performing calibrations should, in case of mapping patterns with identifiable subpatterns (e.g. a row in a zig-zag pattern) be expressible in time units needed to complete a subpattern (e.g. Off after each row).

Last modified: 2000/11/10, D. Muders, P. Schilke

7.4.2 ObserveOTFMap

Use Case: ObserveOTFMap

This use case describes the actual observing actions needed to obtain data in the Total Power On-The-Fly Mapping mode.

Role(s)/Actor(s):
Primary: The AOS
Secondary:

Priority: Major

Performance: real-time; overhead should be minimal and dominated by hardware.

Frequency: this mode is likely to be among the most frequently used.

Preconditions: all the user parameters have been properly entered and checked (UC *SetupOTFMap.html*)

Basic Course

1. The preamble block is executed (only once in the session).
    1. The receivers are set up and tuned.
    2. The correlator is setup.
    3. The pipeline is started.
    4. A pointing calibrator is selected.
2. For each scheduled SB:
    1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures every n times - n being determined by the performance requirements and the weather conditions.
    2. Update the pointing and focus corrections using feed back from the pipeline, if applicable.
    3. Calculate the trajectories specified in the OTF map setup.
    4. Optionally calculate integration time per OTF point from current receiver and atmospheric conditions
    5. Calculate the scanning speed from the OTF map setup (step size along scanning trajectory divided by dwell time per OTF point).
    6. Execute until map is finished:
        1. Perform pointing calibration
        2. Execute for time specified between pointing calibrations:
            1. Perform amplitude calibration.
            2. Execute for time specified between calbrations:

                Observe reference position.
                Alternate course I: For beam switch: switch on nutator
                Alternate course II: For frequency switch: initiate frequency switching

                Execute for time specified between reference positions:

                Move telescope(s) with given speed along trajectory.

                Update Doppler effect for the target source and current time continuously.

                Record autocorrelator output on the target source at the observing frequency and observed position(s) for a specified or calculated time. This calculation is based on the current weather conditions.

    Exception Course: If the weather conditions deteriorate to a given limit (opacity, anomalous refraction) the SB is terminated (keep the data observed so far, with appropriate flag).
3. The system executes the associated postamble SB: pointing is performed one last time.The pipeline is instructed to make the final image and is closed.

Postconditions:

1. ...
2. ...

***Issues to be Determined or Resolved*:**

- Measuring the sideband gain ratios could be needed in the preamble if both sidebands can be measured.
- This use case might be extended to deal with more than one target source.
-

Notes:

- Pointing may be performed at a different frequency.

Last modified: 2000/11/10, D. Muders, P. Schilke

7.4.3 ReduceOTFMap

Use Case: ReduceOTFMap

This Use Case describes the on-line data reduction operations for the Total Power On-The-Fly Mapping mode.

Role(s)/Actor(s)
Primary: The AOS, or the observer
Secondary:

Priority Major

Performance need to feed back data nearly in real time.

Frequency At least every scan.

Preconditions The user input parameters have been input and have been made available to the pipeline, preferably in the data headers

Basic Course

1. For each available observation, the current system temperatures are computed using total power on sky and ambient load (previously measured).
2. Calculate spectrum for each observed OTFpoint.

Postconditions:

1. ...

Issues to be Determined or Resolved: ...

Notes:

1. we assume that the pointing and focus scans reduction is described in another Use Case
2. we assume that online displays to be regularly updated are described in another Use Case.
3. we assume that data reduction for On-Off observations, Beam switching and Frequency switching are described in other Use Cases.
4. the reference data for each OTFpoint may be interpolated between adjacent reference positions.
5. if resources allow maps may be computed and displayed at more frequent intervals, for diagnostic purposes.

Last modified: 2000/10/06, D. Muders, P. Schilke

7.5 PositionSwitchedMapping

7.5.1 SetupPositionSwitchedMapping

Use Case: SetupPositionSwitchedMapping

Starting from user's scientific input, determine all parameters necessary to perform Position Switched Mapping (total power) observations.

Role(s)/Actor(s):
Primary: Observer
Secondary: Line Catalog, Source Catalog

Priority: Major

Performance: seconds.

Frequency:

Preconditions:

1. ...

Basic Course:

1. User specifies coordinate system, and 1..n source names and coordinates (either by absolute coordinates or offsets from a position specified by its absolute coordinates); note that these positions must be close together in the sky (separation less than ~5 degrees, exact value TBD)
   Alternate Course: User gives map center and its dimensions; system chooses absolute positions
2. System checks the declination.
   Exception Course: The source is not observable from the ALMA site.
3. User specifies the position to be used as "blank sky", e.g., from an optical image or a map previously obtained in a representative molecular transition. Both absolute and offset coordinates will be accepted. Default coordinate system is that indicated in Step 1 above, but user may choose a different system.
4. User specifies number of IF bands, Line names; the frequencies are obtained from the line catalog.
   Alternate Course: User enters line name and line frequencies
5. User specifies center velocities, velocity reference systems, velocity bandwidths, velocity resolutions
6. System will allow the user to examine expected line transitions that could come from image sidebands and, as a result, tune the correlator (or receivers?) appropriately.
7. User specifies the performance goals: final rms.
   Alternate Course: User specifies the total integration time desired. In this case, he/she may specify the desired system temperature or maximum opacity, or may allow the system to determine these quantities (default).
8. The system evaluates the proposed setup and:
   1. suggests frequencies of amplitude calibration and of blank sky observation
      Alternate Course: If requested, the system will choose the frequency of calibrations based on actual conditions at time of observation
   2. computes map cell size and number of pixels if user has requested a map
   3. computes the correlator setup explicitly from the spectral information. Warns the user if the spectral coverage is affected by Doppler effect variations.
   4. proposes splitting into SBs based on observatory policy (max SB length) ...
9. The User may either refine the input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

1. How can we help the user to determine what to use as "blank sky"? Possibilities:
   1. The observatory generates a catalog of blank sky positions
   2. The user proposes a list of candidate blank sky positions which are then observed via frequency switching to determine whether they are really blank
   3. Some amount of human intervention in near-real-time may be required (depends upon the–missing–ALMA operations concept)
2. "Beam Switched Mapping" UC is needed to describe observations using nutating subreflector. This is the mode that will be used for continuum observations.
3. If the Compact Array becomes a reality, the user will need to specify the desired angular resolution, and the system will need to choose between the smaller compact array antennas and the 12m ones
4. How many antennas to use will be a scheduling issue (e.g., 12 antennas for 1 hour or 1 antenna for 12 hours?). If the atmospheric transmission at different antennas is uncorrelated, then there is a simple tradeoff between number of antennas used and integration time.
5. We should consider allowing the user to specify a rotated coordinate system, *e.g.*, to map an elongated object.

Notes: Coordinates may be also graphically determined from a user provided map or image.

Last modified: SetupPositionSwitchedMapping.html,v 2.0 2000/10/06 jschwarz

7.5.2 PerformPositionSwitchedMapping

Use Case: Perform Position Switched Mapping (Total Power)

Describe the actual observing actions needed to obtain data in the position switched mapping mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority Major

Performance real-time; overhead should be minimal and dominated by hardware.

Frequency: this mode is likely to be used less often than on-the-fly total power modes, but is important for commissioning

Preconditions: all the user parameters have been properly entered and checked (UC SetupPositionSwitchedMapping.*html*)

Basic Course

1. If necessary, the following initialization steps are executed (only once in the session).
    1. A subarray of antennas is assigned to this session
    2. Doppler effect is calculated for the target source and current time.
    3. The receivers are set up and tuned.
    4. The correlator is setup.
    5. The pipeline is started.
    6. If user has requested, current atmospheric conditions are used to set initial frequencies of amplitude calibration and blank sky observation
2. For each Schedule Block (SB):
    1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures.
    2. Update the pointing and focus corrections using feed back from the pipeline.
    3. Perform amplitude calibration
    4. Record (auto) correlator output on the blank sky at the observing frequency for a specified or calculated time.
    5. For each target position:
        1. Record (auto) correlator output at the observing frequency for a specified or calculated time. Integration time will be determined by a TBD algorithm whose objective is to arrive at the total integration time desired for this SB
        2. Every m targets, record (auto) correlator output on the blank sky as in Step 3 (m was either specified by the user or calculated in near-real-time based on atmospheric conditions). Integration time will be determined by an algorithm similar to that used on-source.
        3. Every n minutes, perform an amplitude calibration. The default value of n is calculated at run-time based on observing frequency, sky stability and opacity; the minimum integration time depends on the interval between amplitude calibrations.
    6. Repeat last step until the SB time is exhausted or the goals are achieved (*e.g.*, minimum rms reached).
3. The system ensures that the last scans were blank sky and amplitude calibration.
4. If the last SB has been executed, the pipeline is instructed to make the final spectra (and image, if a map was specified) and is closed.

Postconditions: Issues to be Determined or Resolved:

- The algorithm to decide when to do an amplitude calibration is to be defined.

- This will depend on the observing frequency, and on parameters determined by other parts of the system, *i.e.*, sky stability and opacity

- The algorithm to determine the dwell time on blank sky and on sources is TBD. There will be some minimum (~1 sec), but some observations will require much longer times.
- Measuring the sideband gain ratios could be needed as an initialization step if both sidebands can be measured.

Notes:...

Last modified: PerformPositionSwitchedMapping.html,v 2.0 2000/10/06 jschwarz

7.6 FrequencySwitchedMapping

7.6.1 SetupFrequencySwitchedMapping

Use Case: SetupFrequencySwitchedMapping

Starting from user's scientific input, determine all parameters necessary to perform Frequency Switched Mapping (total power) observations.

Role(s)/Actor(s):
Primary: Observer
Secondary: Line Catalog, Source Catalog

Priority: Major

Performance: seconds.

Frequency:

Preconditions:

1. ...

Basic Course:

1. User specifies coordinate system, and 1..n source names and coordinates (either by absolute coordinates or offsets from a position specified by its absolute coordinates); note that these positions must be close together in the sky (separation less than ~5 degrees, exact value TBD)
   Alternate Course: User gives map center and its dimensions; system chooses absolute positions
2. System checks the declination.
   Exception Course: The source is not observable from the ALMA site.
3. User specifies the frequency switch rate and throw (frequency difference between "signal" measurement and "reference" measurement).
4. User specifies number of IF bands, Line names; the frequencies are obtained from the line catalog.
   Alternate Course: User enters line name and line frequencies
5. User specifies center velocities, velocity reference systems, velocity bandwidths, velocity resolutions
6. System will allow the user to examine expected line transitions that could come from image sidebands and, as a result, tune the correlator (or receivers?) appropriately.
7. User specifies the performance goals: final rms.
   Alternate Course: User specifies the total integration time desired. In this case, he/she may specify the desired system temperature or maximum opacity, or may allow the system to determine these quantities (default).
8. The system evaluates the proposed setup and:
   1. suggests frequencies of amplitude calibration and of frequency switching rate
      Alternate Course: If requested, the system will choose the frequency of calibrations based on actual conditions at time of observation
   2. computes map cell size and number of pixels if user has requested a map
   3. computes the correlator setup explicitly from the spectral information. Warns the user if the spectral coverage is affected by Doppler effect variations.
   4. proposes splitting into SBs based on observatory policy (max SB length) ...
9. The User may either refine the input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

1. How can we help the user to determine what to use as the frequency switch rate and throw? Some possibilities include:

1. Frequency switch throw decision based on knowledge of standing wave properties of ALMA antennas
2. Frequency switch rate based on knowledge of stability of receiver phase lock

2. If the Compact Array becomes a reality, the user will need to specify the desired angular resolution, and the system will need to choose between the smaller compact array antennas and the 12m ones
3. How many antennas to use will be a scheduling issue (e.g., 12 antennas for 1 hour or 1 antenna for 12 hours?). If the atmospheric transmission at different antennas is uncorrelated, then there is a simple tradeoff between number of antennas used and integration time.
4. We should consider allowing the user to specify a rotated coordinate system, *e.g.*, to map an elongated object.

Notes: Coordinates may be also graphically determined from a user provided map or image.

Last modified: SetupFrequencySwitchedMapping.html,2000 December 11 by Jeff Mangum

7.6.2 PerformFrequencySwitchedMapping

Use Case: Perform Frequency Switched Mapping (Total Power)

Describe the actual observing actions needed to obtain data in the frequency switched mapping mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority Major

Performance real-time; overhead should be minimal and dominated by hardware.

Frequency: This mode is likely to be used less often than on-the-fly total power modes.

Preconditions: all the user parameters have been properly entered and checked (UC SetupFrequencySwitchedMapping.*html*)

Basic Course

1. If necessary, the following initialization steps are executed (only once in the session).
    1. A subarray of antennas is assigned to this session
    2. Doppler effect is calculated for the target source and current time.
    3. The receivers are set up and tuned.
    4. The correlator is setup.
    5. The pipeline is started.
    6. If user has requested, current atmospheric conditions are used to set initial frequencies of amplitude calibration
2. For each Schedule Block (SB):
    1. Measure pointing and focus offsets on the pointing calibrator using the standard procedures.
    2. Update the pointing and focus corrections using feed back from the pipeline.
    3. Perform amplitude calibration
    4. Record (auto) correlator output on the "signal" and "reference" frequencies while switching at the specified rate and throw.
    5. For each target position:
        1. Record (auto) correlator output at the observing frequency for a specified or calculated time. Integration time will be determined by a TBD algorithm whose objective is to arrive at the total integration time desired for this SB
        2. Every n minutes, perform an amplitude calibration. The default value of n is calculated at run-time based on observing frequency, sky stability and opacity; the minimum integration time depends on the interval between amplitude calibrations.
    6. Repeat last step until the SB time is exhausted or the goals are achieved (*e.g.*, minimum rms reached).
3. The system ensures that the last scan is an amplitude calibration measurement.
4. If the last SB has been executed, the pipeline is instructed to make the final spectra (and image, if a map was specified) and is closed.

Postconditions: Issues to be Determined or Resolved:

- The algorithm to decide when to do an amplitude calibration is to be defined.
    - This will depend on the observing frequency, and on parameters determined by other parts of the system, *i.e.*, sky stability and opacity
- The algorithm to determine the optimum frequency switch rate and throw is TBD. This will depend upon the final ALMA first LO design.

- Measuring the sideband gain ratios could be needed as an initialization step if both sidebands can be measured.

Notes:...

Last modified: PerformFrequencySwitchedMapping.html, 2000 December 11Jeff Mangum

8 Project Calibration

8.1 Temperature Scale Calibration

Use Case: Temperature Scale Calibration

This Use Case outlines the basic process of Temperature Scale Calibration with ALMA. Temperature scale calibration is the process of converting total power measurements from a receiver into system temperatures which have been corrected for the opacity due to the Earth's atmosphere.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: The Operator, the Staff Astronomer, the Reviewer

***Priority*:** Critical

***Performance*:** hours to months

***Frequency*:** seconds

***Preconditions*:**

1. The Alma System has reached at least partial operational state and accepts observing proposals from astronomers.

***Basic Course*:**

1. Everything that needs to be done to execute an SB needs to be done.
2. Temperature Scale Calibration system operates continuously during all observations.
3. Control system measures total power signals and physical load temperatures from calibration loads in Temperature Scale Calibration system in synchronation with data acquisition.
4. Find tipping curves appropriate for data to be calibrated and derive zenith opacity at frequency of observation.
5. Calibration scale is derived from difference between calibration load total power measurements, physical load temperature difference, and opacity at current elevation.
6. Calculated calibration scale is stored in accessible area.
7. Derive autocorrelation system temperature versus frequency. Used for data weighting in subsequent processing.

Postconditions:

1. Calculated calibration scale is available for application to data.

***Issues to be Determined or Resolved*:**

- Exact design for Temperature Scale Calibration system. Could be switching load system located at the prime focus of the antenna or insertable load system located near the top of the receiver system.

Notes:...

Last modified: Mon Dec 11 00:25:00 UTC 2000 Jeff Mangum

8.2 Gain Calibration

8.2.1 SetupGainCal

Use Case: SetupGainCal

Starting from user's scientific input, determine all parameters necessary to perform the Gain Calibration in a standard Interferomtric Observation. The Gain calibration is obtained be periodically observing a nearby point source.

Role(s)/Actor(s):
Primary: Observer
Secondary: Source Catalog, Array Configuration Catalog

Priority: Critical

Performance: seconds.

Frequency: setup is made for each observing program.

Preconditions:

1. Receiver and correlator setup have been specified
2. The main target source, or a list or nearby target sources have been specified, in SingleField, Mosaic or OnTheFly Mosaic modes

Basic Course:

1. User specifies the amplitude (in per cent) and phase accuracy (in degrees) needed. These numbers will be used at observing time to compute the on-calibrator integration time depending on achieved sensitivity.
2. User specifies the frequency for phase calibration. It may either be the same as that of the target observations, or a lower receiver band may be used. A frequency-dependent default policy may be proposed depending on the accuracies needed.
3. User specifies the number of gain calibrators, and for each one:
    1. whether it is aimed at amplitude or phase calibration
    2. if it is aimed at phase calibration, whether it is to be observed at the target frequency,at the calibration frequency, or at both.
4. User specifies the gain calibrator(s): the gain calibrators are either to be automatically chosen at observing time (in a preamble observation) or explicitely specified. The default is automatic selection.
   Exception Course: In the case of explicit selection, the calibrators are searched for in the calibrator data base; their position and (if known) fluxes in the last few onths are read in.
    1. The calibrator directions are compared to that of the main target source. If further than (TBD: 10 ?) degrees, or if the time to move to/from them at full speed at any hour angle exceeds (TBD: 1 min?) a strong warning is issued.
    2. If the calibrator fluxes are unknown or lower than a TBD (frequency dependent) value, a strong warning is issued
5. User specifies the cycle time of gain calibration (i.e. the time between two successive observations of the same calibrator): this time is either to be automatically chosen at observing time (and revised as seeing conditions change) or explicitely specified. The default is automatic selection.
   Exception Course: In the case of explicit selection, a warning is issued if the cycle time is larger that a TBD (frequency dependent) value.
   Exception Course: In the case of explicit answers above, this integration time is computed; a warning is issued if the resulting duty cycle exceeds a (TBD:20%?) value.
6. The user may either refine his/her input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

- The calibrator cannot be far away from the target source. This needs to be considered when setting distance-from-target limits for SBs.
- The limits to issue warnings will have to be determined and periodically reviewed (every deadline at first) as knowledge on the hardware and site weather conditions builds up.
- Those limits will depend on the (hopefully growing) confidence on the radiometric phase correction.

Notes:

- Usually the receiver and correlator setup is the same for the bandpass calibration and the target source; this may not be always the case, switching the correlator to broadband on the calibrator may improve sensitivity considerably.
- If zero calibrators are selected, this means that the user intends to perform fully self-calibrated observations. This may be considered as an expert-omly option for the length of the interim science period.

$Id: SetupGainCal.html,v 1.3 2000/11/03 15:26:12 lucas Exp lucas $

8.2.2 ObserveGainCal

Use Case: ObserveGainCal

Describe the actual observing actions needed to obtain data for Gain calibration of standard interferometric observations. There may be several calibrators, each one aimed to amplitude or phase calibration. Each will need to be observed with a given cycle time.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Critical

Performance real-time; overhead should be minimal and dominated by hardware.

Frequency: at least once per observing session

Preconditions:

1. All the user parameters have been properly entered and checked (UC *SetupGainCal.html*)
2. Receivers and correlator are set up properly
3. The calibrator catalog is available.

Basic Course

1. **At preamble stage:**
   1. If no user-choice is provided for the **cycle times** (the default) compute them based on the current seeing conditions and phase structure function (for phase calibrators).
   2. If **the list of calibrators is known from setup** (UC *SetupGainCal.html*) each one is observed at the required frequencies (calibration/target) to estimate its flux, using known Jy/K calibration factors.
      1. An integration time computed based on the accuracy goal and the measured flux. If an integration time was selected at setup, it may need to be increased.
      2. If the resulting integration time is too large (i.e. implying too large a duty cycle with either user-specified or most probable calibration cycle times), a better calibrator will be searched for as in (2) below.
   3. If **one or more calibrators are to be found:**
      1. A minimum flux is guessed for each based on the accuracy goals, current sensitivity, and allowed integration time (limited by duty cycle in current seeing conditions).
      2. About twice as many candidates as needed calibrators are selected in the calibrator catalog in a (TBD: 5 deg?) circle centered on the target direction. For this the strongest sources are chosen; if there are too few in the catalog, the circle is extended by steps to a maximum of (TBD: 15 deg?) radius.
      3. Each one is observed at the required frequencies (calibration/target) to estimate its flux, using known Jy/K calibration factors.
      4. The final choice is made on the basis of the observed fluxes, and the integration times updated as needed.
2. **In the observing loop, during SB execution**:
   1. Observe each calibrator at the requested frequencies for the determined integration time.
   2. Upgrade the cycle time value (if required) on the basis of the current seeing and phase structure function.
   3. Go back to target source observations for the requested or determined cycle time of that calibrator.

Issues to be Determined or Resolved:

1. Calibrator selection radii
2.

Notes:

1. Obviously for efficiency the cycle times need to be rounded to multiples of the same basic time.
2. Gain calibrators will also be used as pointing and focus calibrators to save observing time.

$Id: ObserveGainCal.html,v 1.2 2000/11/02 16:26:31 lucas Exp lucas $

8.2.3 ReduceGainCal

Use Case: ReduceGainCal

This Use Case describes the on-line data reduction operations for the interferometric Gain Calibration. This is needed for standard interferometric observations.

Role(s)/Actor(s)
Primary: The AOS, or the observer
Secondary:

Priority: Critical

Performance: Need to feed back data nearly in real time.

Frequency: After each Gain Calibration observation.

Preconditions: The user input parameters have been input and have been made available to the pipeline, preferably in the data headers

Basic Course:

1. The time-averaged measured amplitude of the calibrator in the last observation is calculated in the Ta* scale using current frequency-averaged value of Tsys in each band.
2. The phase-corrected and uncorrected antenna-based amplitude values are compared. If the difference is statistically significant (thermal fluctuations), a validity flag for the phase correction is set or reset in an antenna-based way.
3. Antenna-based efficiencies are computed by comparing the antenna based TA* amplitudes and the flux measured in the preamble observations.
   Exception Course If these are significantly lower than the stored antenna efficiencies (K/Jy) at the relevant frequency, an error message is issued to the operator and logged.
4. If the calibrator is an amplitude calibrator, cubic spline is fitted into the last few amplitude measurements. The corresponding plot can be displayed. The fitted functions are available for further data processing (e.g. quick look display of interim science data).
5. Whatever the calibrator aim, a cubic spline is fitted into the last few phase measurements.
   1. The corresponding plot can be displayed.
   2. The fitted functions are available for further data processing (e.g. quick look display of interim science data).
   3. The residual phase rms are used to evaluate a seing parameter and phase structure functions. These are made available to the corresponding Observing System session to update the calibration cycle times, and to the Dynamic Scheduler.

***Issues to be Determined or Resolved*:**

1. How the Gain calibration is done in detail (antenna or baseline based, fitting polynomials or other functions ...) needs to be determined.
2. The parametrisation of the phase structure functions is TBD

Notes:

$Id: ReduceGainCal.html,v 1.3 2000/11/03 15:25:15 lucas Exp lucas $

8.3 Bandpass Calibration

8.3.1 SetupBandpassCal

Use Case: SetupAstroBandpassCal

Starting from user's scientific input, determine all parameters necessary to perform an interferometric Bandpass Calibration observation using an astronomical source.

Role(s)/Actor(s):
Primary: Observer
Secondary: Line Catalog, Source Catalog, Array Configuration Catalog

Priority: Critical

Performance: seconds.

Frequency: at least once per receiver tuning

Preconditions:

1. Receiver and correlator setup has been specified

Basic Course:

1. User specifies the parameters of bandpass calibration: the calibrator is either to be chosen at observing time or explicitely specified
2. User specifies the goal in rms amplitude and phase across the band is specified.
3. User specifies the performance goals: total integration time and/or final rms.
4. System checks that bandpass calibrator has a featureless spectrum at the observing frequency.
5. System checks for atmospheric lines and issues a warning if there are any in this band.
6. The User may either refine its input parameters, modify the deduced setup parameters, or accept the system provided values.

Issues to be Determined or Resolved ...

- Bandpass calibrator can be far away from the target source. This needs to be considered if there will be any "distance-from-target limits" for SBs.
- Details of how the bandpass calibration is actually performed (astronomical source only/part of it with noise diode) are not known yet.
- Bandpasses can "age" through Doppler tracking. This should trigger a re-calibration.

Notes:

- The spectral appearance of the bandpass calibrators has to be in the catalog.
- The tool should check that explicitly specified calibrators are visible.
- The signal-to-noise ratio of the bandpass calibrator should normally exceed the expected SNR of the target source significantly.
- Usually the receiver and correlator setup is the same for the bandpass calibration and the target source.

Last modified: 2000/11/10 D. Muders, P. Schilke

8.3.2 ObserveBandpassCal

Use Case: ObserveAstroBandpassCal

Describe the actual observing actions needed to obtain data in the interferometric Bandpass Calibration mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Critical

Performance: real-time; overhead should be minimal and dominated by hardware.

***Frequency*:** at least once per observing session

***Preconditions*:**

1. all the user parameters have been properly entered and checked (UC *SetupBandpassCal.html*)
2. receiver and correlator units are set up properly

Basic Course

1. System checks water vapor content and calculates atmospheric lines. A warning is issued if the line contribution exceeds given limits.
2. Record correlator output on the target source at the calibration frequency for a specified or calculated time. This calculation is based on the current phase rms or phase structure function (TBD).
3. Record correlator output on the target source at the target frequency for a specified or calculated time. This calculation is based on the current phase rms or phase structure function (TBD).

Postconditions:

1. ...
2. ...

***Issues to be Determined or Resolved*:**

- What are the limits concerning atmospheric line contributions ?

Notes:...

Last modified: 2000/11/10 D. Muders, P. Schilke

8.3.3 ReduceBandpassCal

Use Case: ReduceAstroBandpassCal

This Use Case describes the on-line data reduction operations for the interferometric Bandpass Calibration mode.

Role(s)/Actor(s):
Primary: The AOS, or the observer
Secondary:

Priority: Critical

Performance: may need to feed back data nearly in real time.

Frequency: After each Bandpass Calibration observation.

Preconditions: The user input parameters have been input and have been made available to the pipeline, preferably in the data headers

Basic Course:

1. Calculate bandpass by fitting polynomial (or other functions) through antenna based/baseline based data points, both in phase and amplitude.

Postconditions:

1. ...

Issues to be Determined or Resolved:

How the bandpass calibration is done in detail (antenna or baseline based, fitting polynomials or other functions or not fitting anything at all) needs to be determined.

Does one need direct feedback from the pipeline to the AOS or the observing program ?

Notes:

Last modified: 2000/11/10 D. Muders, P. Schilke

8.4 Flux Scale Calibration

Use Case: Flux Calibration

This Use Case outlines the basic process of Flux Scale Calibration with ALMA. Flux scale calibration is the process of converting total power measurements which have been calibrated to an antenna temperature scale (see the TemperatureScaleCalibration use case) to an absolute temperature scale. This is done through comparison with one or more standard flux calibration sources.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary: The Operator, the Staff Astronomer, the Reviewer

***Priority*:** Critical

***Performance*:** hours to months

***Frequency*:** seconds

***Preconditions*:**

1. The Alma System has reached at least partial operational state and accepts observing proposals from astronomers.

***Basic Course*:**

1. Everything that needs to be done to execute an SB needs to be done.
2. Temperature Scale Calibration must have been completed.
3. The monitor data system must be operational and storing flux calibration measurements.
4. Flux calibration scale is derived from either:
   - Measurements of a standard flux calibration source during the observing program, or
   - Flux calibrator measurements made during the past several days.

   Postconditions:

   1. Calculated flux calibration scale is available for application to data.

   ***Issues to be Determined or Resolved*:**

   - Determination of standard flux scale calibrators requires examination early in the operation of ALMA. Studies of how accurately the absolute fluxes of planets, asteroids, stars, and other potential flux calibration sources need to be made.

   Notes:...
   Last modified: Mon Dec 15 00:25:00 UTC 2000 Jeff Mangum

8.5 Delay Calibration

8.5.1 SetupDelayCal

Use Case: SetupDelayCal

Starting from user's scientific input, determine all parameters necessary to perform an interferometric Delay Offset Calibration observation using an astronomical source. Delay calibration makes sure no sensitivity is lost in interferometric continuum observations, in particular for the phase calibration. There is one delay offset for each antenna, frequency band, and baseband.

***Role(s)/Actor(s)*:**
Primary: Observer
Secondary:

***Priority*:** Critical

***Performance*:** seconds

***Frequency*:** at least once per receiver tuning

***Preconditions*:**

1. Receiver and correlator setup have been specified

***BasicCourse*:**

1. User specifies the precision in nanoseconds of delay for the calibration; the calibrator source itself will be be chosen at observing time
2. User specifies the range in nanoseconds of delay to be searched.
3. System prepares the correlator setup (bandwidths and resolutions)

Issues to be Determined or Resolved

- Calibrator can be far away from the target source. This has no impact on scheduling if we assume that a strong enough calibrator will always been available in the sky.

Notes:

- The correlator setup need not be the same as for the for the target source.
- The correlator setup need not be the same as for the for the target source.

$Id: SetupDelayCal.html,v 1.2 2000/11/29 14:42:51 lucas Exp $

8.5.2 ObserveDelayCal

Use Case: ObserveDelayCal

Describe the actual observing actions needed to calibrate the delay offsets.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Critical

Performance: real-time; overhead should be minimal and dominated by hardware.

Frequency: at least once per observing session

Preconditions:

1. receiver and correlator are set up properly (UC *SetupDelayCal*)
2. Baseline is known with relatively good accuracy; large errors (1cm) produce samll, time varying delay errors.

Basic Course:

1. Compute the minimum flux needed to get to the desired precision in a each of the frequency bands to be used (target and calibration), by assuming a TBD integration time (~ 60 sec ?)
2. Find the closest calibrator that meets the minimum flux requirement. If none, increase the integration time.
3. Record correlator output on that calibrator in both target and calibration frequency bands for the specified time.

Postconditions:

1. Data is available to compute the delay offsets

Issues to be Determined or Resolved:

- What is the acceptable integration time range.
- What should be done at high frequencies, if no suitable calibrator is available

Notes:

- The delay precision needed to limit the losses to 1 percent in a 2~GHz band is about 0.03 nanoseconds.
- The delay precision will be improved by repeating the measurement, particularly if the delay error was large.

$Id: ObserveDelayCal.html,v 1.2 2000/11/29 14:43:37 lucas Exp lucas $

8.5.3 ReduceDelayCal

Use Case: ReduceDelayCal

This Use Case describes the on-line data reduction operations for the interferometric delay offset calibration scans.

Role(s)/Actor(s):
Primary: The (calibration) pipeline.
Secondary:

Priority: Critical

Performance: need to feed back calibration data nearly in real time.

Frequency: After each delay offset calibration, at least once per observing session.

Preconditions: The raw data of the delay measurement raw data is available to the (calibration) pipeline.

Basic Course:

1. Fit an antenna based, linear dependency of phase versus frequency in each spectrum, taking into account two-pi phase ambiguities.
2. Display the results
3. Make the calibration data (one delay offset for each antenna, baseband and frequency band) available to the observing process.

Postconditions:

1. The delay offsets are used in the correlator further data taking.

***Issues to be Determined or Resolved*:**

-

Notes:

-

$Id: ReduceDelayCal.html,v 1.1 2000/11/28 14:54:45 lucas Exp lucas $

8.6 Pointing Calibration

8.6.1 SetupPointingCalibration

Use Case: SetupPointingCalibration

The User describes a Pointing Calibration so that it can be executed by the system. This is usually done in Phase II Proposal preparation.

A pointing calibration measurement can be done in one of four pointing modes:

1. Interferometric
2. Integrated line from auto-spectrum (with or without nutator)
3. Total Power with nutator
4. Optical

A pointing calibration observation produces an estimated azimuth and elevation offset for each antenna. The interferometric, integrated line from auto-spectrum, and total power observations measure the radio offsets in a single band, while the optical observations measure the optical offsets. These measurements are commonly done conditionally in a Preamble Block.

See also UC *ObservePointingCalibration*.

***Role(s)/Actor(s)*:**
Primary: The User (Observer, Staff Scientist, Array Operator), the AOS
Secondary: Line Catalog, Source Catalog

***Priority*:** Major

***Performance*:** Interactive.

***Frequency*:** About one per Preamble Block.

***Preconditions*:** The observing program being prepared has a sub-array consisting of at least:

- Interferometric mode: two antennas (preferably three)
- Integrated line mode: one antenna
- Total power mode: one antenna with nutator
- Optical pointing: one antenna with optical telescope

***Basic Course*:**

1. Using the ObservingTool (OT), the User specifies the pointing calibration mode to use for the pointing calibration measurement.
2. If integrated line mode is selected, the User specifies the band, the correlator setup, and the frequency range over which to integrate.
3. The User specifies one of the following intended applications of the pointing calibration:
   - Offset pointing for a specified source at a specified frequency, with one of the following science goals:
     - Mosaicing
     - Single field
       * Detection
       * Imaging
   - Measurement for a pointing calibration session on a specified source, with a goal of measuring:
     - General radio beam offsets.
     - Band specific offsets at a specified frequency.
4. The OT automatically specifies the details of the pointing calibration measurement based on the mode and intended use. The details include:

- Pointing source
- Correlator setup
- Frequency band of pointing calibration measurement
- If interferometric mode, frequencies over which to integrate to achieve maximum sensitivity (e.g. wide bandwidths, maser lines).
- Desired accuracy of measurement (arcseconds on the sky)
- One of the following pointing calibration patterns:
  - Circular pattern
  - Five point
  - Four point
  - Three point
- Realtime correction of the radio beam pointing offsets:
  - Based on current measurement
  - Based on average over specified time period
  - No realtime correction, just measure and record results
- Other details of the pointing algorithm (TDB).

Alternate Course: User specifies the details.

5. User optionally edits the details automatically selected by the OT. The OT will aid with source selection by sorting sources by radio flux in the desired band or optical magnitude, and distance from program source.

Postconditions:
A set of Observation Descriptors and a pipeline data reduction script.

Issues to be Determined or Resolved

- There may be other criteria for prematurely stopping the pointing calibration measurement other than achieving the requested accuracy, e.g. if overall sensitivity loss from pointing errors is less than a fixed amount.
- Other details of the pointing calibration algorithm, starting with ALMA Memo 189 (Lucas).

Notes: This setup is done with the ObservingTool.

Pointing calibration measurements are used to:

- Measure antenna pointing offsets of individual bands (including the optical telscope) with respect to the bore sight.
- Dynamically measure the general *radio beam offset*, an offset with respect to the bore sight in common to all radio bands that can vary with time. If the radio beam offset is measured and corrected, accurate radio pointing can be used for program source observations. This measurement may be done in a band that is different from the program source observations, and is referred to as *reference pointing*. Reference pointing allows pointing to be done in bands where sources are stronger and the atmosphere is more transparent, but does rely on accurate and stable pointing offsets for the bands with respect to the radio beam.

Last modified: $Id: SetupPointingCalibration.html 2000/12/02 Scott

8.6.2 ObservePointingCalibration

Use Case: ObservePointingCalibration

The observing actions required for a Pointing Calibration measurement.

***Role(s)/Actor(s)*:**
Primary: The AOS
Secondary:

***Priority*:** Major

***Performance*:** Realtime feedback of pointing offsets into the system.

***Frequency*:** Several to hundreds per hour.

***Preconditions*:** AOS has access to a sub-array consisting of at least:

- Interferometric mode: two antennas (preferably three)
- Integrated line mode: one antenna
- Total power mode: one antenna with nutator
- Optical pointing: one antenna with optical telescope

User has specified the setup as part of UC *SetupPointingCalibration*, which has produced the necessary Observation Descriptors and pipeline data reduction scripts.

***Basic Course*:**

1. Using the Observation Descriptors, the correlator is setup and the receiver band is selected and setup, including band specific pointing offsets.
   Alternate Course: The optical telescope is setup (lens cap removed, etc).
2. Using the Observation Descriptors, pointing calibration measurements are begun and fed to the pipeline.
3. While observations continue, the pipeline reduces the data producing estimates of pointing offsets and errors. If intermediate results indicate that an antenna has large offsets (and the errors indicate that they are statistically significant), its pointing is corrected so that the measurements are improved by:
   - Increasing the signal to noise
   - Reducing systematic errors based on assumptions of the beam shape
4. Observing and reduction continue, looping back to Step 2 until the desired accuracy limit is reached on all antennas or the maximum allotted time has been reached.
   Alternate Course: The pointing calibration is prematurely terminated (e.g. interactively). The accumulated results are written to the archive. The radio beam pointing offsets for all antennas that have achieved the requested accuracy are updated according.
5. The pointing calibration results are archived.
6. The radio beam pointing offsets are corrected based on the policy selected in the setup:
   - Use current measurement
   - Use average over specified time period
   - No realtime correction, just measure and record results

Postconditions:
A pointing calibration measurement is written to the archive. The measurement contains:

- Azimuth and elevation offsets
- Estimated error in the measured azimuth and elevation offsets
- Azimuth and elevation of measurement

- Frequency of measurement
- Source name
- Time of measurement

The radio beam offsets have optionally been updated.

Issues to be Determined or Resolved
Other details of the pointing calibration algorithm, starting with ALMA Memo 189 (Lucas).

Notes:

Last modified: $Id: ObservePointingCalibration.html 2000/12/02 Scott

9 Array Calibration

9.1 Baseline Calibration

9.1.1 SetupBaselineCal

Use Case: SetupBaselineCal

Starting from user's input, determine all parameters necessary to perform an interferometric Baseline Calibration observation.

***Role(s)/Actor(s)*:**
Primary: Staff Astronomer
Secondary: Line Catalog, Basline Calibration Point Source Catalog(s), Array Configuration Catalog

***Priority*:** Critical

***Performance*:** One to a few hours

***Frequency*:** After moving one or more antennas; maybe more often, and after earthquakes.

***Preconditions*:**

1. Must have access to the full sub-array that needs to be calibrated, which consists of at least one (better: a few) antenna(s) of known position, and the newly moved antennas. In case of earthquakes one antenna has to be defined as reference antenna.
2. Defaults for frequency and correlator setup is defined.
3. Default performance goals (integration time per source/final rms) are defined.

***Basic Course*:**

1. User specifies which Baseline Calibration point source catalog to be used.
2. User specifies number of sky positions to be observed.
3. System checks the declination(s).
   Exception Course: The source is not observable from the ALMA site.
4. System loads default frequency and correlator setup for baseline calibrations (TBD by SSR).
5. Optionally: User modifies observing frequency.
6. Optionally: User modifies performance goals: total integration time and/or final rms.

***Issues to be Determined or Resolved* ...**

If ALMA is a traveling array (i.e. an array constanly being reconfigured) it may not make sense to perform a baseline calibration every time one or some antennas are moved. One can even observe with antennas, and apply the baseline correction later. This requires a good book-keeping, and would result in these antennas being flagged for the online pipeline reduction, but available for the final image. The frequency of baseline calibrations depends on the details of the array reconfiguration process, which is not determined yet.

Notes:

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Last modified: 2000/10/09 D. Muders, P. Schilke

9.1.2 ObserveBaselineCal

Use Case: ObserveBaselineCal

Describe the actual observing actions needed to obtain data in the interferometric Baseline Calibration mode.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Critical

Performance: real-time; overhead should be minimal and dominated by hardware.

Frequency: After moving one or more antennas; maybe more often, and after earthquakes.

Preconditions: all the user parameters have been properly entered and checked (UC *SetupBaselineCal.html*)

Basic Course:

1. The receivers are set up and tuned.
2. The correlator is setup.
3. The pipeline is started.
4. The system calculates a homogeneous sky distribution for the current LST using the specified number of point sources.
5. The system calculates the optimum sequence in which to observe the sources.
6. The system records the cross correlator output at the observing frequency for each source in the sequence for a specified or caluclated time. This calculation is based on current phase rms or phase structure function (TBD).
7. The pipeline is instructed to calculate the final solution and is closed.

Postconditions:

- ...
- ...

Issues to be Determined or Resolved:

- Would it be an option to measure antenna positions via GPS instead of a baseline calibration session ? GPS resolution is about 3 times worse than using astronomical determination.

Notes:

- Optimum sequence means the most efficient observing sequence with the least amount of dead times.
- Baseline calibrations should be done under very good atmospheric conditions.
- This mode should only be accessible in interactive technical sessions and should not have a time limit.

Last modified: 2000/11/10 D. Muders, P. Schilke

9.1.3 ReduceBaselineCal

Use Case: ReduceBaselineCal

This Use Case describes the on-line data reduction operations for the interferometric Baseline Calibration mode.

Role(s)/Actor(s):
Primary: The AOS, or the observer
Secondary:

Priority: Critical

Performance: A few seconds to minutes.

Frequency: After moving one or more antennas; maybe more often, and after earthquakes.

Preconditions The user input parameters have been input and have been made available to the pipeline, preferably in the data headers

Basic Course

1. Baseline solutions for all telescopes relative to reference telescope(s) are computed.

Postconditions:

1. ...

Issues to be Determined or Resolved: ...

Notes:

- The data reduction is performed after all (about 100) baseline calibration point sources have been observed. There is no need for immediate feedback while observing.

Last modified: 2000/10/09 D. Muders, P. Schilke

9.2 Pointing Calibration Session

9.2.1 SetupPointingCalSession

Use Case: SetupBaselineCal

Starting from Staff Astronomer's input, determine all parameters necessary to perform a Pointing Calibration Session. The goal of a Pointing Calibration Session is to determine the parameters of the pointing models for a sub-array of antennas. The session is performed by making individual pointing measurements in the direction of a set of N sources covering the whole visible sky in a quasi-uniform way; N must be large enough to allow a determination of the pointing model cofficients by the method of least squares; the session must be short enough so that thermal effects are kept to a minimum.
All pointing measurements in a session are performed in the same way, using one of the following pointing modes:

- interferometry mode,
- pseudo-continuum mode (using maser line sources),
- continuum total power mode (with nutators),
- optical mode (with optical telescopes).

Role(s)/Actor(s):
Primary: Staff Astronomer
Secondary: Line Catalog, Pointing Source Catalogs

Priority: Critical

Performance: One to a few hours

Frequency: After moving one or more antennas and/or at regular time intervals (weekly ?).

Preconditions:

1. Must have access to the full sub-array that needs to be calibrated, which consists of:
    - at least two (better three) antenna(s) in interferometry mode,
    - at least one antenna, in pseudo-continuum mode,
    - at least one antenna, equipped with a nutator, in continuum total power mode,
    - at least one antenna, equipped with an optical telescope, in optical mode,

Basic Course:

1. User specifies the number of sources to be observed.
2. User specifies the setup parameters to be used for all pointing measurements (UC SetupPointCal), including which pointing mode will be used.

Issues to be Determined or Resolved

-

Notes:

-

$Id: SetupPointCalSession.html,v 1.3 2000/11/29 14:40:17 lucas Exp lucas $

9.2.2 ObservePointingCalSession

Use Case: ObservePointCalSession

Describe the actual observing actions needed to perform a Pointing Calibration Session.

Role(s)/Actor(s)
Primary: The AOS
Secondary:

Priority: Critical

Performance: real-time; overhead should be minimal and dominated by hardware.

***Frequency*:** After moving one or more antennas and/or at regular time intervals (weekly ?).

***Preconditions*:** All the user parameters have been properly entered and checked (UC *SetupPointCalSession.html*)

Basic Course:

1. The receivers, correlator, optical telescopes, are set up and tuned.
2. The (calibration) pipeline is started.
3. The system calculates a homogeneous sky distribution for the current LST and the time duration of the upcoming session using the specified number of sources, from the appropriate Pointing Catalog
4. The system calculates the optimum sequence in which to observe the sources.
5. The system records data for each source in turn (UC ObservePointCal).
6. The (calibration) pipeline is instructed to calculate the pointing model and is closed.

Postconditions:

- The pointing model coefficients are fed back from the pipeline and updated in the active pointing models for further observations.

***Issues to be Determined or Resolved*:**

-

Notes:

- Optimum sequence means the most efficient observing sequence with the least amount of dead times, while as much as possible keeping the effect of time drifts in the resulting pointing model constants to a minimum. For instance, to first order, the mean azimuth and the mean elevation in the first and second halves of the session should be equal to mid-range values.
- The requirement on observing conditions depends on the actual pointing mode chosen

$Id: ObservePointCalSession.html,v 1.1 2000/11/28 16:27:35 lucas Exp lucas $

9.2.3 ReducePointingCalSession

Use Case: ReducePointCal

This Use Case describes the on-line data reduction operations for the Pointing Calibration Session.

Role(s)/Actor(s):
Primary: The (calibration) pipeline, the AOS
Secondary:

Priority: Critical

Performance: A few seconds to minutes.

Frequency: After moving one or more antennas and/or at regular time intervals (weekly ?)

Preconditions The raw data of the Pointing Calibration Session scans are made available to the pipeline right after each one is observed.

Basic Course

1. After each scan, the (calibration) pipeline performs the data reduction operations (UC ReducePointCal), including a display, and saves the pointing offsets.
2. At the end of the Session, the (calibration) pipeline uses the measured pointing offsets and the corresponding antenna coordinates for each scan, to determine by a least square method the pointing model coefficients of each antenna. Other variables than antenna coordinates (time, temperatures) may be used in addition if these affect the pointing model.
3. The results are displayed (including a comparison of new and old model coefficients).
4. Finally the pointing model coefficients are fed back to the AOS.

Postconditions:

1. A new pointing model is available for each antenna used, and available for following observing sessions.

***Issues to be Determined or Resolved*:**

- ...

Notes:

- The data reduction is performed after all pointing sources have been observed. There is no need to feedback the pointing offsets after each individual pointing measurement.

$Id: ReducePointCalSession.html,v 1.1 2000/11/28 16:51:33 lucas Exp lucas $