BIMA Memo 96 & IRAM Memo 2003-2

Evaluation of the `GILDAS` Package for ALMA Off-line Data Processing

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2003-06-18

Change Record

Revision	Date	Author	Section/ Page affected	Remarks
1.0	2003-03-21	Pety	All	First version
1.1	2003-06-18	Pety	All	Edited using referee's remarks

$Id: gildas-evaluation.tex,v 1.29 2003/09/15 09:07:09 pety Exp $

Contents

1 General Considerations

This document presents the results of the evaluation of the GILDAS software Package for the purposes of ascertaining its compliance with the ALMA Offline Data Processing Requirements given in ALMA-SW MEMO 18.

We build this GILDAS evaluation following the AIPS++ audit. This is why we reproduce here most of the "General Consideration" section of the AIPS++ audit. This evaluation is based on the current version of GILDAS (as of March 2003) which is available on demand. Most of the functionnalities described here are extensively tested every day at Plateau de Bure (PdB) and the 30-m in Granada.

A. We use a descriptive scheme, with a set of grade codes stating how well the Package fulfills a given requirement: Adequate (A), Inadequate (I), Not Available (N), and Unable to Evaluate (U). The latter is used for items could not be properly evaluated at this time (e.g. items related to the tbd ALMA data format). There is an additional qualifier for "adequate" items (A/E) that indicates desired enhancements to the package.

B. For each requirement, the tool or function in the Package fulfilling that requirement is listed, where possible.

C. For items deemed inadequate (I) or missing (N), or which are adequate but enhancements are desired (A/E), the reasons for this are listed. Where possible, a *severity level* for the failure is noted: low, medium, high. This is based upon the importance of the requirement and the margin of failure of the package for the requirement. Note that a subjective choice is made between items at are adequate but could use further improvement (A/E), and those deemed (I) but low severity.

For (U) items that the authors felt they could not rate, the reason was noted (e.g. unfamiliarity with this part of the package, incomplete documentation).

D. The priority codes, as given in ALMA-SW MEMO 18 and repeated here, are:

1 = essential
2 = highly desirable
3 = desirable, but not critical

It is intended that Priority 1 items must be present in the Package and work with high efficiency. Priority 2 items should be in the Package, though there may have to be sacrifices in performance or availability may be delayed. We expect that the Package will fulfill all Priority 1 and 90% or more of Priority 2 requirements. Priority 3 items should be considered for upgrades or development.

E. The considerations during grading include the *functionality* (whether a feature is there and whether it does what is required), the *usability* (ease-of-use, efficiency, reliability), and the *documentation*. In this evaluation, grades are not given separately for these factors. Note that depending on the wording of the requirement, not all of these will apply to a given requirement. For example, some requirements only indicate the existence of a feature (functionality), while some in addition explicitly address the look and feel or ease of use (usability). Also, some of the performance issues will have to be deferred until a later cycle of evaluation, when detailed testing and benchmarks will be available.

2 Offline Data Processing Requirements

2.1 General Requirements and Interaction with Other ALMA Elements

2.1.1 Goals of the Offline Package and Relation to the Pipeline

Note: An ALMA Offline Data Processing Package (or "the Package") is primarily intended to enable end-users of ALMA (e.g. observers or Archive users) to produce scientifically viable results that involve ALMA data products. The secondary use is to enable ALMA staff to assess the state of the array and derive calibration parameters for the system, although it is anticipated that the Pipeline will be the primary engine for Online Data Processing and system monitoring.

Also note that not all offline analysis tools will necessarily be in the Pipeline Package. For example, one of the important differences between Pipeline and Offline reduction path is that Offline one should have extensive interactive capabilities to merge and compare data with different resolution, coordinate system, data grid, and so on.

The SSR does feel that there is a great deal of synergy between the Offline Package and Pipeline that should be exploited by the designers of the respective software.

OL–1.1–R1 There must be an Offline Data Processing Package that fulfills the requirements laid forth in this document.

Priority: 1

Grade: A

Summary: That was the easy one!

OL–1.1–R2 All standard observing modes supported by ALMA must be processable by the Package.

Priority: 1

Grade: U

Summary: ALMA standard modes are not finalized at this time.

OL–1.1–R3 The Package shall be installable at the users home institution and available at ALMA regional centers (both locally and remotely). It shall be portable to **supported platforms designated by the ALMA Project**, including systems without network connections and laptops.

Priority: 1

Grade: A

Summary: The list of supported platforms is unavailable at this time. However, UNIX, Linux and Windows are currently supported by `GILDAS`.

OL–1.1–R4 The performance of the Package shall be quantifiable and commensurate with the data processing requirements of ALMA output and the scientific needs of users at a given time. The timing and reproducibility of results for a fiducial set of reduction tasks on specified test data will be benchmarked (e.g. "AIPSmarks") and compared against other packages and **a list of benchmark specifications provided and maintained by the Project**.

Priority: 1

Grade: A

Summary: The benchmarking process has started and `GILDAS` is doing OK.

OL–1.1–R5 All standard processing functionality available in the Pipeline shall be available in the Package also as an offline analysis option.

Priority: 2

Grade: U

Summary: The pipeline functionality is being defined!

2.1.2 Operational Issues

OL–1.2–R1 Installation of the Package by an end user must be straightforward, preferably without special (e.g. root) user permission.

Priority: 1

Grade: A

OL–1.2–R2 Error reporting and handling shall be user-understandable and non-destructive at all levels in the Package:

OL–1.2–R2.1 Error reporting messages shall be written for end users, not programmers.
Priority: 1
Grade: A
Summary: Error messages are generally understandable by the user.

OL–1.2–R2.2 There must be provision for job control such as interrupt and abort.
Priority: 1
Grade: A
Summary: GUI tools have Abort buttons and CTRL-C gives the option to abort from `SIC` monitor; command scripts interrupted this way can be generally restarted.

OL–1.2–R2.3 Error handling shall be non-destructive (data shall not be left corrupted, and recovery of recent changes be available). Common failure modes (as enumerated: invalid application parameters, exceeding of resource limits (disk/memory), and algorithm failure modes (e.g. no convergence) should be handled gracefully.
Priority: 2
Grade: A
Summary: Nobody is perfect. However stability of `GILDAS` is generally good as estimated by the user.

OL–1.2–R2.4 Code traceback of execution errors shall be available. This should be geared to the effective reporting of failure modes and bugs by the user.
Priority: 3
Grade: A
Summary: There is traceback on errors, though they are nearly impossible for non-programmers to figure out.

OL–1.2–R3 There shall be session logging, including the following features:

OL–1.2–R3.1 logging of commands and user inputs shall be provided
Priority: 1
Grade: A
Summary: The `SIC` monitor logs all commands (except HELP, and failed commands).

OL–1.2–R3.2 logging of tool results such as success or error, files written, time of completion shall be provided
Priority: 1
Grade: A
Summary: Task logs go to task specific files.

OL–1.2–R3.3 logging of tool output such as summaries of results shall be provided
Priority: 2
Grade: A
Summary: Task logs go to task specific files

OL–1.2–R3.4 the session log shall be readable by the user (i.e. in a text file, not in a binary format)
Priority: 2
Grade: A

OL–1.2–R3.5 session logs shall be executable by the package UI, reproducing the entire session
Priority: 3
Grade: A/E
Summary: This is true for `CLASS` and `CLIC`. This is the general idea for other programs, but things like task input are in separate files that are not referenced in the log files.

OL–1.2–R4 There shall be comprehensive handling of multiple users and multi-tasking with access and process control.

Priority: 1

Grade: A/E

Summary: Multiple users are left to the operating system. Multi-tasking for a single user is available through the OS but not within programs (i.e. tasks can be detached but programs run sequentially).

OL–1.2–R5 The Package providers shall provide support for the Package, with bug-fixing on timescales appropriate to the severity level of the defect (e.g. 1 week or less for catastrophic bugs with no work-around). **These defect levels and timescales should be delineated by the ALMA project**.

Priority: 1

Grade: U

Summary: The levels and timescales have yet to be provided by ALMA.

OL–1.2–R6 The Package providers shall provide timely improvements and updates based on user feedback. There shall be a path for the ALMA Project, for its own use and as a proxy for the users, to influence the development cycle of the Package. It is the responsibility of the Project to negotiate needed improvements with the Package providers.

Priority: 1

Grade: A

Summary: Most of the past developers are deeply involved and committed into ALMA.

OL–1.2–R7 Backward compatibility of core package components should not be broken without compelling scientific reasons. Tools should be provided to parse user scripts and warn of package changes.

Priority: 2

Grade: A

Summary: Backward compatibility with data is generally good. We've had little problems so far accessing very old class, clic or image files. PdB data format has evolved but old files are converted on the fly. There was one major change a few years ago that necessitated some amount of scripts file edition.

OL–1.2–R8 Source code for the astronomical routines in the Package shall be available to the user.

Priority: 2

Notes: This does allow for the use of some proprietary data handling, output formatting, and special processing (e.g. Pixon) routines.

Grade: A

Summary: Source code (mainly FORTRAN), is available in the distribution.

OL–1.2–R9 User installation of the basic package shall not be restricted by other issues such as expensive or unduly restrictive licenses. The Package license should convey all other necessary licenses (such as GNU) or they should be available to the user for only a nominal fee.

Priority: 2

Comment: This allows for the use of commercial components. However, a balance must be struck between excessive costs to the project and requiring some cost to be borne by the user, should this issue arise.

Grade: A

Summary: Currently, it is free with no extra licenses necessary. In next releases, only FORTRAN-90 will be supported.

OL–1.2–R10 There shall be the provision for the development and incorporation of user-supplied code.

Priority: 2

Grade: A

Summary: Incorporation of `SIC` code (scripts) is straightforward. Incorporation of FORTRAN tasks is easy for most users and straightforward in FORTRAN-90.

OL–1.2–R11 The application of successive stages of calibration, correction, flagging and editing shall not be destructive to the data. The Package should be able to recover and revert to earlier stages without resorting to saving of the entire dataset at intermediate states.

Priority: 2

Grade: A

Summary: In `CLIC`, most operations add calibration tables. For the most part, the original data is untouched, and the process can be repeated at will to change the calibration without even needing to recreate the data (kept in a e.g. readonly file). This is safe enough. Large images are preferredly saved on disk after creation and deconvolution.

2.2 Interface

2.2.1 General User Interface Requirements

OL–2.1–R1 User must be able to choose from a variety of interface styles, including:

OL–2.1–R1.1 A Command Line Interface (CLI) must be provided, with access via both an interactive input and via script.
Priority: 1
Grade: A
Summary: The `SIC` interface is a suitable CLI environment.

OL–2.1–R1.2 A Graphical User Interface (GUI) must be provided for interactive processing. Actions taken under the GUI must be loggable, editable, and executable by the CLI.
Priority: 1
Grade: A
Summary: There is a built-in GUI interface to `SIC`.

OL–2.1–R2 The user shall be able to interact with the host operating system with command sequences invoked from the UI.

Priority: 1

Grade: A

Summary: There is a `shell` command (also available by prefixing by $). OS-like functionalities (e.g. file operations) are also available in a system independent way through the `SIC` command.

OL–2.1–R3 Multitasking for all interfaces shall be available where appropriate. It must be possible to run one or more long-running calculations in the background. While background tasks are running normal interactive activities must be possible.

Priority: 1

Grade: A

Summary: Multiple tools and windows can be run concurrently (through the **submit** command), as well as multiple instances of `GILDAS` applications (any `GILDAS` application is a stand-alone program).

2.2.2 Graphical User Interface (GUI)

Note: The GUI is intended to be the primary interactive mode for users, especially neophyte users, and thus should be tailored for clarity and ease of use. Use of the Package GUIs should be a pleasurable, not a frustrating, experience!

OL–2.2–R1 The GUI shall provide real-time feedback via standard compact displays:

OL–2.2–R1.1 Window updating must be fast (less than 0.1s on same host).
Priority: 1
Grade: A
Summary: Windows (even GUI from the user interface) are handled using compiled code, and updating is the fastest possible.

OL–2.2–R1.2 Windows shall not take up excessive screen space, with full GUI controls visible on a window one-third the size of a standard view surface (or approximately 800×800 pixels).
Priority: 1
Grade: A
Summary: GUIs have been explicitely limited to be compact.

OL–2.2–R1.3 Users shall have the choice of cascading windows or re-use of a single window for new operations.
Priority: 2
Grade: A/E
Summary: The manner of windowing is under script control, but not under end-user control. Windowing is limited to 3 levels.

OL–2.2–R1.4 Moving and resizing of all windows must be available, robust, and easy.
Priority: 2
Grade: A
Summary: Windows can be dragged and resized as normal X windows.

OL–2.2–R1.5 There shall be a master control GUI for process control which keeps track of sub-windows and tools.
Priority: 3
Grade: A/E
Summary: There is a "program" banner which controls available tools. Windows can be deleted by the users without impact on the operation; they will be re-created if needed.

OL–2.2–R2 It must be easy to run GUIs remotely from the host machine (e.g. via X displays).

Priority: 1

Grade: A

Summary: This is straightforward.

OL–2.2–R3 The use of the GUI shall not entail an excessive learning curve. Average users, with experience with the current generation of packages (e.g. AIPS, `GILDAS`, IRAF, MIRIAD) shall be able to become proficient in GUI use in a timescale of approximately 12 hours dedicated use, and truly neophyte users (e.g. graduate students) should be reach proficiency with an investment not exceeding 40 hours of dedicated use.

Priority: 2

Grade: A

Summary: The GUI have a very simple logic. Even creating new GUI is straightforward, once the command line mode is understood.

OL–2.2–R4 GUI-based tools shall be available for reduction of data taken in all standard ALMA observing modes.

Priority: 2

Grade: U

Summary: ALMA standard observing modes are undefined at this time. Currently, the GUI can assign values to any `SIC` variable, and activate any `SIC` script. This should be adequate.

OL–2.2–R5 The look and feel of the GUI will be uniform throughout the entire package.

Priority: 2

Grade: A

Summary: This is currently the case.

OL–2.2–R6 The look and feel of the GUI must be acceptable to both novice and more advanced users. The GUI mode might be customizable (perhaps through menu selection for "novice" or "advanced" mode) or a different simpler set of GUI tools might be available for beginners. The GUI features for beginner mode shall include:

OL–2.2–R6.1 built-in help facility with access to novice-oriented help documents (e.g. sections in the cookbook)
Priority: 2

Grade: A
Summary: There is an help button for any parameter controlled by the GUI (provided the entry has been filled by the developper)

OL–2.2–R6.2 sensible defaulting of values for parameters, with guidance for user choices where needed
Priority: 2
Grade: A/E
Summary: Many variables have default values. This could be easily improved if needed by having a **/default** option for variable assignments in GUI.

OL–2.2–R6.3 integrated functionality built around common data analysis tasks (e.g. single-field spectroscopic observations with fast switching, OTF mosaicing in continuum mode, snapshot observations of a large number of targets in single-field continuum mode)
Priority: 2
Grade: A
Summary: There are quite a few integrated tools at this time available from the GUI. Standard processing is often possible through a single command or keystroke (e.g. **go image** for imaging).

OL–2.2–R7 It shall be easy for users to develop and include their own custom GUIs in the Package.

Priority: 3

Grade: A

Summary: This is straightforward, because GUI essentially control variable assignments, and activate a user-defined procedure.

2.2.3 Command Line Interface (CLI)

Note: the CLI is the primary mode for automatic reduction for ALMA, and it is anticipated that there will be a suite of "standard" scripts developed to help users in data reduction tasks. Thus it is important that the Package support all of its critical modes in the CLI.

OL–2.3–R1 The interface must have the facility to read in command files for batch processing of a sequence of CLI commands.

Priority: 1

Grade: A

Summary: `SIC` scripts can be read in and executed easily.

OL–2.3–R2 The CLI shall have command-line recall and editing, with name completion where appropriate.

Priority: 1

Grade: A

Summary: There is command-line recall (with editing) in `SIC`. Non-ambiguous abbreviations can be used anywhere on commands and options. A list of possible completions is given in case of ambiguities. Variable names cannot be abbreviated however. `SIC` is a declarative language, so can provide the list of ambiguous variable names too.

OL–2.3–R3 All functionality of the GUI must also be available in CLI mode (although possibly with loss of simplicity in instances where the graphical selection is important).

Priority: 1

Grade: A

Summary: All GUI tools are direct implementations of the CLI equivalents.

OL–2.3–R4 The CLI shall be usable remotely over low-speed (14400 baud) modem lines or network connections, with ASCII terminal emulation.

Priority: 2

Grade: A

Summary: This works.

OL–2.3–R5 A CLI mode menu for display and editing of input parameters and execution of tasks is desirable.

Priority: 3

Grade: A

Summary: This is automatic for simple tasks. The GUI is implicitely derived from the the task parameters. However, tasks in which the developper has included some condition testing at the user input level do not benefit from this automated facility.

2.2.4 Interface Programming, Parameter Passing and Feedback

OL–2.4–R1 The UI must have basic programming facilities such as:

OL–2.4–R1.1 variable assignment and evaluation
Priority: 1
Grade: A

OL–2.4–R1.2 array handling
Priority: 1
Grade: A
Summary: Up to 4 dimensions only.

OL–2.4–R1.3 conditional statements
Priority: 1
Grade: A

OL–2.4–R1.4 control loops
Priority: 1
Grade: A

OL–2.4–R1.5 string manipulation
Priority: 1
Grade: A

OL–2.4–R1.6 user-defined functions and procedures with argument or parameter passing
Priority: 1
Grade: A

OL–2.4–R1.7 process control, interrupts, error handling
Priority: 1
Grade: A

OL–2.4–R1.8 standard mathematical operations and functions
Priority: 1
Grade: A

OL–2.4–R1.9 efficient special vector and matrix operations
Priority: 2
Grade: A
Summary: `SIC` handling of vectors and arrays is efficient in computing speed, but can be memory hungry (it may allocate intermediate arrays of the same size as the output, though it optimizes re-use of intermediate arrays).

OL–2.4–R1.10 user-defined data structures
Priority: 2

Grade: A
Summary: SIC structures use the same syntax as Fortran derived types.

OL–2.4–R2 Commands executed will be logged, with provision to re-execute the session.

Priority: 1

Grade: A/E

Summary: The CLI logs all commands. Status of the variables controlled from the GUI needs to be cleared up.

OL–2.4–R3 Input parameter and syntax checking shall be effected upon function calling or parsing with reporting of incorrect, suspicious or dangerous choices before execution where possible.

Priority: 1

Grade: A/E

Summary: Syntax checking is implemented. The parameter checking is inconsistent across tools, and seems to depend on whether the programmer bothered to implement this or not.

OL–2.4–R4 Parameters shall be passable between applications in as transparent a manner as possible. However, global variables should not be the default, unless designated specifically by the user-programmer.

Priority: 2

Grade: A

Summary: All SIC procedures can accept input arguments. By default, variables have *local scope* only, but can be defined to have a *global scope*.

OL–2.4–R5 Application variables shall be named consistently and as clearly as possible indicating their intended use using astronomical terms where appropriate.

Priority: 2

Grade: A/E

Summary: For the most part, variables have sensible names. However, there are cases where naming between tasks is not consistent.

OL–2.4–R6 Parameter inputs to tools shall be stored for later recall:

OL–2.4–R6.1 Tool inputs shall be saved on closure, and reinstated on the next instantiation of the tool.
Priority: 2
Grade: A
Summary: The task parameters are remember on a working directory basis when tasks are activated in their basic mode. For more integrated facilities, the usual behaviour is to return to the default values, but some tools (e.g. in CLIC) have their own save/restore scripts.

OL–2.4–R6.2 It shall be possible for the user to save the state of the parameters for the entire package, as well as for individual tools, as a named set (e.g. SAVE/GET in AIPS), and to recall these when desired.
Priority: 3
Grade: I Severity: low
Summary: This may depend on the package being used. Available in CLASS and CLIC, or in the ALMA imaging simulator, but not on others yet...

2.2.5 Documentation and Help Facility

OL–2.5–R1 There shall be a variety of help levels and documentation formats accessible from the UI and over the Internet, applicable to novices, experts, and technical users. These shall include:

OL–2.5–R1.1 user cookbooks with extensive examples
Priority: 1
Grade: A/E
Summary: Quite a lot has been done, but always more is required here...

OL–2.5–R1.2 application descriptions and reference manual (with all inputs to functions and tools);
Priority: 1
Grade: A/E
Summary: As above...

OL–2.5–R1.3 online help, FAQ, email contacts;
Priority: 1
Grade: A
Summary: The documentation is available internally as well as on the WEB. The WEB version only refers the latest state of the documentation however, with no association to a specific release of the software.

OL–2.5–R1.4 release history, bug reports and tracking, patch descriptions;
Priority: 1
Grade: I Severity: low
Summary: This is under re-organization.

OL–2.5–R1.5 programmer references and guides;
Priority: 2
Grade: A/E
Summary: There is a programming guide. The references would need some more work.

OL–2.5–R1.6 data format descriptions
Priority: 2
Grade: I Severity: low
Summary: The image format is simple, and documented. But the `CLASS` and `CLIC` format documentations is insufficient. This goes with probably inadequate reference programming manual on how to read and write these formats.

OL–2.5–R1.7 algorithm descriptions
Priority: 2
Grade: A/E
Summary: Sometimes lacking. References are given in the code, but often not in the documentation. This could be improved.

OL–2.5–R1.8 newsletters, email exploders, notes series
Priority: 3
Note: these would be maintained by the Package providers, with help from the ALMA project.
Grade: A/E
Summary: There are newsletters and memos, `gildas-prog` and `gildas-user` are available email exploders.

OL–2.5–R2 The Package creators must ensure the documentation is up-to-date and complete for all parts of the Package.

Priority: 1

Grade: A/E

Summary: This always require more work... S.Guilloteau played the documentation guru for years, but has not been replaced yet.

OL–2.5–R3 Help materials shall also be available in printable formats, including

OL–2.5–R3.1 standard document formats (pdf, postscript)
Priority: 1
Grade: A
Summary: Postscript is available for all documentation. PDF will be produce soon.

OL–2.5–R3.2 printer-friendly versions of HTML pages
Priority: 2
Grade: A
Summary: The HTML pages have a link to the Postscript version. Also individual sections of the HTML pages print quite well.

OL–2.5–R3.3 popular proprietary formats (MS-Word)
Priority: 3
Grade: N Severity: low
Summary: Not available, but useless. PDF should be used.

OL–2.5–R4 Help shall be context-sensitive where relevant. In GUI mode, fly-over banners should indicate use of buttons and fields, and clickable help buttons should be available on all pages.

Priority: 2

Grade: A/E

Summary: Clickable help is available, but fly-over pop-up is not implemented.

OL–2.5–R5 In GUI mode, help functions may direct a browser to a Web page. In CLI mode, the Package must support in-line text based help also.

Priority: 2

Grade: A/E

Summary: In CLI mode, the text based help is available, as well as a WEB browser mode. In GUI mode, the help does not point to WEB URLs, but to files.

OL–2.5–R6 Full search capability must be built into the documentation library.

Priority: 2

Grade: N Severity: medium

2.3 Data Handling

2.3.1 General Data Requirements

Summary: `GILDAS` has currently a specific data handling scheme which distinguishes between raw and calibrated visibilities, and images. This derived from the uselessness of self-calibration for Plateau de Bure images, since only a few antennas were available. When speaking of "data", the current document will refer to CLIC dataset, i.e. data for raw visibilities used in the calibration process. The imaging step uses simple UV tables and images.

OL–3.1–R1 The Package must support data taken in any of the standard ALMA hardware modes.

Priority: 1

Grade: U

Summary: The standard ALMA hardware modes are undefined at this time. Modifications will be required to handle polarization consistently.

OL–3.1–R2 The Package shall be able to handle the integrated data objects corresponding to the observational programs carried out by ALMA. These objects may be implemented in any manner appropriate, though relations between the components of the object must be maintained through some mechanism. These include:

OL–3.1–R2.1 Program header information;
Priority: 1
Grade: A
Summary: The `SIC` structures can handle complex tables. The `CLIC` data format is quite flexible, and a `CLIC` data scan could be mapped to a `SIC` structure. The `CLIC` data format contains *Sections* which handle various types of informations

OL–3.1–R2.2 Observation status information (and schedules themselves);
Priority: 1
Grade: A/E
Summary: The `GENERAL` *Section* have only the following information: project name, configuration, calibration status.

OL–3.1–R2.3 Field information;
Priority: 1
Grade: A
Summary: Coordinates are available in *Section* `POSITION`.

OL–3.1–R2.4 Data from interferometer and single-dish organized by:

OL–3.1–R2.4.1 position;
Priority: 1
Grade: A

OL–3.1–R2.4.2 subreflector state;
Priority: 1
Grade: N Severity: low
Summary: Does it make sense for ALMA?

OL–3.1–R2.4.3 polarization products;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not implemented yet.

OL–3.1–R2.4.4 spectral channels;
Priority: 1
Grade: A
Summary: The channel information is stored in the *Section* `LINE`.

OL–3.1–R2.4.5 frequency bands;
Priority: 1
Grade: A
Summary: The channel information is stored in the *Section* `LINE`, and the frequency setup in *Section* `RF_SETUP`.

OL–3.1–R2.4.6 IFs;
Priority: 1
Grade: A
Summary: The channel information is stored in the *Section* `LINE`, and the frequency setup in *Section* `RF_SETUP`.

OL–3.1–R2.4.7 subarray;
Priority: 1
Grade: A/E
Summary: Though sub-arrays are not formally defined, there is a correspondance between logical and physical antennas described in *Section* `CONFIGURATION`.

OL–3.1–R2.5 Coherence function (visibility) data from interferometer, including:

OL–3.1–R2.5.1 cross-correlations;
Priority: 1
Grade: A

OL–3.1–R2.5.2 auto-correlations;
Priority: 1
Grade: A
Summary: (spectral) Auto-correlations and cross-correlations are handled as separate entities. I don't see any limitation in this way of handling them, even when these are acquired simultaneously. Special data sections are used for WVR.

OL–3.1–R2.5.3 uncorrected and/or online WVR corrected (if chosen by user);
Priority: 1
Grade: A

OL–3.1–R2.5.4 phased-array data (if chosen by user);
Priority: 1
Grade: A/E
Summary: Can be computed and extracted, but is not stored.

OL–3.1–R2.6 Total power (autocorrelation) data from antennas in single-dish mode;
Priority: 1
Grade: A
Summary: Auto-correlations scans are handled separately from cross-correlation scans.

OL–3.1–R2.7 Weights and/or data uncertainties;
Priority: 1
Grade: A
Summary: These are derived from `TSYS` and calibration factors.

OL–3.1–R2.8 States indicating special modes (such as ON/OFF positions), for:

OL–3.1–R2.8.1 OTF scanning;
Priority: 1
Grade: A
Summary: This is in the `SCANNING` section.

OL–3.1–R2.8.2 subreflector switching;
Priority: 1
Grade: A
Summary: This is in the `SCANNING` section.

OL–3.1–R2.8.3 frequency switching;
Priority: 1

Grade: *A/E*
Summary: I presume that this should also go into the `SCANNING` section. Available in `CLASS`, and hence by extension in `CLIC`...

OL–3.1–R2.9 Flagging data or masks;
Priority: 1
Grade: A
Summary: Flagging is very extensive in CLIC. There are many flags, antenna or baseline based, user or system created, scan or record based. Each flag as a corresponding mask.

OL–3.1–R2.10 Diagnostic data and errors;
Priority: 1
Grade: A
Summary: System temperatures are available, as well as weather information, tracking errors, pointing corrections, focus corrections, and many other specific information.

OL–3.1–R2.11 A priori calibration data, including:

OL–3.1–R2.11.1 bandpasses;
Priority: 1
Grade: A
Summary: Available in data.

OL–3.1–R2.11.2 source flux densities;
Priority: 1
Grade: A
Summary: There is a `FLUX` variable in the `POSITION` section.

OL–3.1–R2.11.3 antenna polarization leakages;
Priority: 1
Grade: N *Severity:* high
Summary: Polarization is not yet handled.

OL–3.1–R2.12 Derived calibration data, including:

OL–3.1–R2.12.1 gain tables;
Priority: 1
Grade: A
Summary: In data.

OL–3.1–R2.12.2 flux bootstraps;
Priority: 1
Grade: A
Summary: These are not handled separately from the `FLUX` value in the `POSITION` section.

OL–3.1–R2.13 Images and/or models produced from data;
Priority: 1
Grade: A
Summary: These are separate files

OL–3.1–R2.14 Processing history;
Priority: 1
Grade: A/E
Summary: Processing history is kept in a `SIC` procedure, re-called by the standard data reduction tool. It is not associated to the data set.

OL–3.1–R3 There must be a selection mechanism integrated within tools to choose between the various available data subsets such as:

OL–3.1–R3.1 sourcenames, and user specified data qualifiers (with wildcarding);
Priority: 1
Grade: A
Summary: **find /source ...**

OL–3.1–R3.2 mosaic or scanning pointing centers;
Priority: 1
Grade: A
Grade: A
Summary: **find /offset ...**

OL–3.1–R3.3 polarization products or channels;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not implemented yet.

OL–3.1–R3.4 bands (frequency bands, IFs);
Priority: 1
Grade: A
Summary: **set selection ...**

OL–3.1–R3.5 spectral channels;
Priority: 1
Grade: A
Summary: **set selection ... /window**

OL–3.1–R3.6 frequency-switched data;
Priority: 1
Grade: N Severity: low
Summary:

OL–3.1–R3.7 interferometer: subarrays;
Priority: 1
Grade: A
Summary: This would be specified by **set telescope**

OL–3.1–R3.8 interferometer: WVR-corrected or uncorrected baselines;
Priority: 1
Grade: A
Summary: **set phase atm** or **noatm**

OL–3.1–R4 Multiple pointing centers for mosaics must be supported.

Priority: 1

Grade: A

OL–3.1–R5 For polarization products, transformation must be provided to the desired Stokes output parameter(s).

Priority: 1

Grade: N Severity: high

Summary: Polarization is not yet supported.

OL–3.1–R6 Averaging of data over time, bands and spectral channels shall be possible.

Priority: 1

Grade: A

Summary: The averaging of data over time is controlled by **set averaging** and over frequency by **set binning** for calibration purposes. For imaging (UV table creation, this is controlled by the **/resample** option of command **table**.

OL–3.1–R7 Data taken in arbitrary (but parameterized) scanning patterns must be dealt with.

Priority: 1

Grade: U

Summary: This is an unclear requirement. A position can be associated to each acquisition, so what does that mean?

OL–3.1–R8 All standard time systems shall be supported, including:

- **OL–3.1–R8.1** Universal Time (UT), also UT1;
  Priority: 1
  Grade: N Severity: low
- **OL–3.1–R8.2** Coordinated Universal Time (UTC);
  Priority: 1
  Grade: A
- **OL–3.1–R8.3** International Atomic Time (IAT);
  Priority: 1
  Grade: N Severity: low
- **OL–3.1–R8.4** Local Sidereal Time (LST);
  Priority: 1
  Grade: A
- **OL–3.1–R8.5** Greenwich Mean Sidereal Time (GMST);
  Priority: 1
  Grade: N Severity: low
  Summary: Is that really useful?
- **OL–3.1–R8.6** Julian Date (JD), also Modified Julian Date (MJD);
  Priority: 1
  Grade: A
- **OL–3.1–R8.7** Dynamical Times (TDT, TDB).
  Priority: 1
  Grade: U

OL–3.1–R9 All standard coordinate systems shall be supported, including:

- **OL–3.1–R9.1** equatorial (RA, DEC);
  Priority: 1
  Grade: A
- **OL–3.1–R9.2** ecliptic (ELON, ELAT);
  Priority: 1
  Grade: N Severity: low
- **OL–3.1–R9.3** helioecliptic (HLON, HLAT);
  Priority: 1
  Grade: N Severity: low
- **OL–3.1–R9.4** galactic (GLON, GLAT);
  Priority: 1
  Grade: A
- **OL–3.1–R9.5** supergalactic (SLON, SLAT);
  Priority: 1
  Grade: N Severity: low
- **OL–3.1–R9.6** terrestrial (AZ, EL);
  Priority: 1
  Grade: A

OL–3.1–R10 All standard coordinate reference frames and equinoxes shall be supported, including:

- **OL–3.1–R10.1** J2000 (and other FK5 equinoxes);
  Priority: 1
  Grade: A
- **OL–3.1–R10.2** B1950 (and other FK4 equinoxes);
  Priority: 1
  Grade: A

OL–3.1–R10.3 geocentric apparent place, coordinates of date;
Priority: 1
Grade: N Severity: low

OL–3.1–R10.4 topocentric coordinates;
Priority: 1
Grade: N Severity: low

OL–3.1–R10.5 International Celestial Reference System (ICRS);
Priority: 1
Grade: N Severity: low

OL–3.1–R11 All standard velocity definitions shall be supported, including:

OL–3.1–R11.1 radio;
Priority: 1
Grade: A

OL–3.1–R11.2 optical;
Priority: 1
Grade: N Severity: low

OL–3.1–R11.3 redshift;
Priority: 1
Grade: N Severity: low

Summary: The default doppler frame is RADIO.

OL–3.1–R12 All standard velocity frames shall be supported, including:

OL–3.1–R12.1 topocentric;
Priority: 1
Grade: N Severity: low

OL–3.1–R12.2 geocentric;
Priority: 1
Grade: N Severity: low

OL–3.1–R12.3 barycentric;
Priority: 1
Grade: N Severity: low

OL–3.1–R12.4 heliocentric;
Priority: 1
Grade: A

OL–3.1–R12.5 kinematic LSR;
Priority: 1
Grade: A

OL–3.1–R12.6 dynamic LSR;
Priority: 1
Grade: N Severity: low

OL–3.1–R12.7 galactocentric;
Priority: 1
Grade: N Severity: low

OL–3.1–R12.8 local group;
Priority: 1
Grade: N Severity: low

Summary: `GILDAS` works in the LSR frame, but tools are (may be?) available to go to other frames when needed.

OL–3.1–R13 Coordinates and locations (e.g. of the antennas, or the array center) defined with respect to the standard frames shall be supported, including:

OL–3.1–R13.1 topocentric;
Priority: 1
Grade: A/E
OL–3.1–R13.2 geocentric;
Priority: 1
Grade: A/E

Summary: Only topocentric coordinates of antennas and geocentric coordinates of the array center are recorded.

OL–3.1–R14 Any existing flagging mask or table must be maintained and associated with the data it refers to during any subsequent operations (such as splitting of data sets).

Priority: 1

Grade: A

Summary: Flags are preserved, though it would be nice to have two levels of flags, SYSTEM controlled flags and USER controlled flags.

OL–3.1–R14.1 The flagging mask or table shall be transferable to other equivalent data sets (e.g. flags derived for a continuum dataset should be transferable to a line dataset derived from the same observations).
Priority: 2
Grade: A
Summary: Continuum and Line data are in general handled together and share the same flags. But flags specific to continuum or line can also be stored.

OL–3.1–R15 Calibration and ancillary monitoring data (e.g. weather information, WVR data, pointing) that are provided in standard ALMA formats must be preserved, if requested by the user.

Priority: 1

Grade: U

Summary: There are no ALMA standard formats yet, but there are appropriate sections for PdB data at least.

OL–3.1–R16 Correlation products accumulated at multiple bit depths (16-bit,32-bit) or compressed data must be supported transparently (see ALMA-SW Memo 11 3.2.3-R5).

Priority: 1

Grade: N Severity: med

Summary: This is not possible. Only native Real format (or Double precision when needed) is used.

OL–3.1–R17 Comprehensive and understandable processing history information for the data must be maintained and be exportable (both as tables and as plain text).

Priority: 1

Grade: A/E

Summary: "Comprehensive" is often contradictory to "Understandable". Keeping the reduction scripts is often sufficient to offer an "Understandable", comprehensive, and concise history of processing. The last processing erases the previous one in the `GILDAS` concept... This requirement is often contradictory to the next one!

OL–3.1–R18 Users shall have access to, and the ability to change, all aspects of the data including the header.

Priority: 1

Grade: A

Summary: Full access to all variables of the data header is available, as well as to the data itself through `SIC` variables.

OL–3.1–R19 The Package must support locking data files so that there is no possibility of one process corrupting a file that is also being written to by another process in the Package. The default model should be: "one writer, multiple readers."

Priority: 1

Grade: A

Summary: This is the default on `CLIC` data files.

OL–3.1–R20 Merging (e.g. concatenation) and splitting of datasets shall supported:

- **OL–3.1–R20.1** Extraction of specified subsets of data (e.g. by source, time, subarray) shall be supported.
  Priority: 1
  Grade: A
  Summary: This is trivial through the selection process.
- **OL–3.1–R20.2** Merging and reinsertion of data subsets (e.g. combination of different configurations, different epochs, mosaic pointings) shall be supported.
  Priority: 2
  Grade: A
  Summary: Concatenation is trivial using the **copy** command.
- **OL–3.1–R20.3** The merging and splitting process, including selection of data to be merged (e.g. merging of frequency channels which may be differently labeled) shall be straightforward and not overly complex.
  Priority: 2
  Grade: A
  Summary: There is no provision to extract frequency channels in `CLIC` data files. Extraction of the frequency channels can only be done when creating UV tables, and this is straightforward. "Virtual" concatenation of several `CLIC` data files to produce a single UV table is also straightforward.
- **OL–3.1–R20.4** The use of merged or split data in the Package shall be robust and transparent to the user. Subsequent operations shall work the same, whether the data is in its original form or built from merged data subsets, where possible.
  Priority: 2
  Grade: A
  Summary: `CLIC` data headers can refer to separate data files transparently.
- **OL–3.1–R20.5** The appropriate calibration and ancillary monitoring data for the merged or split data (e.g. keeping only the data relevant to sources split out) shall be preserved.
  Priority: 3
  Grade: A
  Summary: Beware however that re-calibration requires the calibrator data to be available in the header file.

OL–3.1–R21 Distinctions between "single-source", "multi-source", single-dish, and interferometer datasets shall be avoided with context built into the dataset or header.

Priority: 2

Grade: A/E

Summary: There is no such distinction, with the exception of single-dish data which currently comes from another channel (30-m data at IRAM). But `CLIC` could accomodate these if needed.

OL–3.1–R22 Tools for access to header information, scan summaries (e.g. LISTR in AIPS), antenna locations (e.g. PRTAN in AIPS) shall be available, with printable output.

Priority: 2

Grade: A

Summary: This is possible with the **header** and **list** commands as well as other tools.

OL–3.1–R23 When sorting or indexing is needed for performance enhancement, it shall be carried out in a manner transparent to the user.

Priority: 3

Grade: A

OL–3.1–R24 Compression of the data, with a selectable level of loss, shall be possible at various stages of the processing path.

Priority: 3

Grade: I Severity: low

Summary: The only compression is from `CLIC` data files to UV tables. It is not controllable.

2.3.2 Data Import and Export

OL–3.2–R1 A variety of data formats must be supported by the Package:

OL–3.2–R1.1 The **ALMA standard archival data format** must be supported for both input and output without loss of functionality or information.
Priority: 1
Grade: U
Summary: These have not yet been designated.

OL–3.2–R1.2 Other standard formats **as designated by the ALMA Project** shall also be supported for both input and output without loss of functionality or information.
Priority: 1
Grade: U
Summary: These have not yet been designated, though it is likely that these will consist of FITS. ALMATI-FITS is supported for the test data.

OL–3.2–R1.3 Other popular data formats may be supported as the Package sees fit, possibly with some loss in information content. Flexibility and wider use beyond ALMA is to be encouraged.
Priority: 3
Grade: A/E
Summary: There is a generic and flexible FITS to `SIC` interface which allows "fillers" to be written relatively easily. It does not yet handle all types of binary tables, but this is a minor change.

OL–3.2–R2 Disk and offline data storage (e.g. DAT, DDS, DLT) must be supported. **The project will maintain a list of media which the Package must support.**

Priority: 1

Grade: A

Summary: Buffer to disk and use system. Anything else is a waste of time nowadays.

OL–3.2–R3 The Package must be able to handle, efficiently and gracefully, datasets larger than main memory of the host system.

Priority: 1

Grade: A/E

Summary: This works fine with CLIC. For imaging purpose, the model is essentially a memory base model, but (except for display) handling data sets larger than the main memory is possible.

OL–3.2–R4 The ability to drop flagged data on export shall be included.

Priority: 2

Grade: A

Summary: This is done at UV table creation.

OL–3.2–R5 The Package internal data format, which may be independent of other supported formats, must not be "bloated" and the required storage should not exceed by more than 1.5× the raw data format.

Priority: 2

Grade: A

Summary: This ratio is typically 1.2 for `CLIC` datasets, and 1.01 for images.

2.3.3 Images and Other Data Products

OL–3.3–R1 Standard multi-dimensional images and arrays must be supported, including:

OL–3.3–R1.1 Spectra and image slices (1D);
Priority: 1
Grade: A

OL–3.3–R1.2 Planar images (2D);
Priority: 1
Grade: A

OL–3.3–R1.3 Spectral and Time Cubes (3D);
Priority: 1
Grade: A

OL–3.3–R1.4 Higher-dimensional Arrays (4D+).
Priority: 2
Grade: A/E
Summary: Only up to 4-D

Summary: I/O to and from FITS is also provided. The I/O from FITS is rather general (and could be made quite general with little effort).

OL–3.3–R2 Other standard derived data products must be supported, including:

OL–3.3–R2.1 Point (CLEAN) models;
Priority: 1
Grade: A

OL–3.3–R2.2 Pixel (gridded image) models;
Priority: 1
Grade: A

OL–3.3–R2.3 Elliptical Gaussian models;
Priority: 1
Grade: A

OL–3.3–R2.4 Uniform (optically thick) disk models;
Priority: 2
Grade: A

OL–3.3–R2.5 Optically thin disk models;
Priority: 2
Grade: N Severity: low

OL–3.3–R2.6 wavelets;
Priority: 3
Grade: N Severity: low

OL–3.3–R2.7 Pixons;
Priority: 3

Grade: N Severity: low

OL–3.3–R3 Blanking of pixels shall be maintained through the processing of images.

Priority: 1

Grade: A

Summary: A *blanking value* and *tolerance* is included as part of an image. However, blanking is tricky if not at all impossible when dealing with Fourier Transform.

OL–3.3–R4 The package shall support all standard projections, including:

OL–3.3–R4.1 sine or slant orthographic (SIN);
Priority: 2
Grade: A

OL–3.3–R4.2 tangent or gnomonic (TAN);
Priority: 2
Grade: A

OL–3.3–R4.3 cylindrical plate carrée (CAR);
Priority: 2
Grade: N Severity: low
Summary: Name unknown

OL–3.3–R4.4 Mercator (MER);
Priority: 2
Grade: N Severity: low
Summary:

OL–3.3–R4.5 stereographic (STG);
Priority: 2
Grade: A

OL–3.3–R4.6 Hammer-Aitoff (AIT).
Priority: 2
Grade: A

2.3.4 Foreign Data

OL–3.4–R1 Data produced by other interferometers and single dishes in similar observing modes shall be importable and processable if provided in **ALMA standard archival data format** or an **ALMA supported data format**

Priority: 2

Grade: U

Summary: ALMA format currently undefined.

OL–3.4–R2 Imaging data in standard formats (e.g. FITS) from astronomical instruments at different wavelengths shall be importable, with the ability to combine (coadd) these with ALMA data where appropriate. This should be through a set of widely used formats, with a **minimal list of supported standards established by the project**.

Priority: 2

Grade: U

Summary: List of standards not available. FITS is currently supported.

2.3.5 Interaction with the Archive

OL–3.5–R1 Access from the archive (when such access is granted, e.g. when Package is run by ALMA staff) must be supported.

Priority: 1

Grade: U

Summary: Archive not available

OL–3.5–R2 The interface between the Package and archive must be able to provide data access (when such access is granted) without interfering with other access to the archive.

Priority: 1

Grade: U

Summary: Archive not available

OL–3.5–R3 Security and integrity of the archive must be ensured during these operations.

Priority: 1

Grade: U

Summary: Archive not available

2.4 Calibration and Editing

2.4.1 General Calibration and Editing Requirements

OL–4.1–R1 The Package must be able to handle reliably all **designated ALMA standard calibration modes** , possibly including but not exclusive to: temperature controlled loads, semi-transparent vanes, apex calibration systems, WVR data, noise injection, fast-switching calibration transfer, planetary observations.

Priority: 1

Grade: U

Summary: These have not been defined yet. This item will require input from the ALMA Science IPT and the SSR.

OL–4.1–R2 Calibration, editing, flagging, and correction of data shall be easily reversible within the Package (i.e. not requiring re-reading of the data from the archive).

Priority: 1

Grade: A

Summary: Calibration steps affect only the data headers (which now reside on a separate file). The actual data is not modified. Calibration are only applied for intermediate plotting purposes and when producing the final calibrated visibilities for imaging. Various calibrations may be tried and compared by using different header files.

OL–4.1–R2.1 Logging of editing steps will be clearly marked in a history table or data object (possibly distinct from a more readable history).
Priority: 2
Grade: I *Severity:* low
Summary: There is a separate log file of all commands, and a message file where all actions are tracked in each session. However there is no data object in the header file with a history of consecutive editing states.

OL–4.1–R2.2 Individual edit undo is desirable.
Priority: 3
Grade: A
Summary: Editing is performed by setting quality on an observation level, and setting flags on a baseline/antenna level with a qualification of flagging motivation (for on-line flagging). Both can be reset individually. Also flags can be masked or 'marked' (i.e. tried) without affecting the data or headers on disk.

OL–4.1–R3 Data calibration operations shall take into account the scan structure and switching scheme of the data. The user shall be able to request calibration solution intervals that correspond to and reference from scan boundaries, for example.

Priority: 1

Grade: A

Summary: This is fully available. Calibration solutions can be solved for and applied to individual scans. Naturally `CLIC` checks whether extrapolation of time-based solutions is attempted by the user.

OL–4.1–R4 Data editing and flagging shall be possible based upon array, environmental, astronomical, and calibration monitoring data, including:

OL–4.1–R4.1 pointing data;
Priority: 1
Grade: A

OL–4.1–R4.2 array tracking information (encoders);
Priority: 1
Grade: A
OL–4.1–R4.3 weather data (wind speed, temperature, relative humidity, pressure);
Priority: 1
Grade: A
OL–4.1–R4.4 T_{sys} data;
Priority: 1
Grade: A
OL–4.1–R4.5 WVR data;
Priority: 1
Grade: A
OL–4.1–R4.6 RFI monitoring;
Priority: 2
Grade: N *Severity:* low
Summary: The user may set the DATA flag based on his own identification of RFI, but none is automatically detected on site.
OL–4.1–R4.7 site-test interferometer (STI) and/or tipping radiometer;
Priority: 2
Grade: N *Severity:* low
Summary: No such equipment on site.
OL–4.1–R4.8 array monitoring points (e.g. dewar temperatures) if data provided in standard format;
Priority: 3
Grade: A
Summary: The user may set the DATA flag on any monitored point in the header, in an antenna based way.
OL–4.1–R4.9 other site instrument (e.g. FTS) providing data in standard format.
Priority: 3
Grade: N *Severity:* low
Summary: No such equipment on site.

Summary: These are well handled, provided that the data is available in the headers.

OL–4.1–R5 Calibration shall involve flexible averaging of data and calibration quantities with user-controllable interpolation, filtering, weighting, and application scope.

Priority: 1

Grade: A

Summary: Data can be averaged in time inside a scan if needed, and in frequency bins of time bins to evaluate frequency based or time-based solutions.

OL–4.1–R6 Interactive data editing, calibration, and display of calibration quantities shall be largely graphical and intuitive. Specialized editing display tools should include:

Summary: Interactive editing is available both in `CLIC` and mapping. In `CLIC` it can be done in a time based, and baseline or antenna based way. In `MAPPING`, it is done on visibility plots.

OL–4.1–R6.1 specification of data by selection on observational parameters, and/or plotting versus these parameters, including:
OL–4.1–R6.1.1 antenna;
Priority: 1
Grade: A
OL–4.1–R6.1.2 baseline;
Priority: 1

Grade: A

OL–4.1–R6.1.3 time range;
Priority: 1
Grade: A

OL–4.1–R6.1.4 uv range;
Priority: 1
Grade: A

OL–4.1–R6.1.5 pointing center;
Priority: 1
Grade: A

OL–4.1–R6.1.6 azimuth, elevation;
Priority: 1
Grade: A

OL–4.1–R6.1.7 hour angle range;
Priority: 1
Grade: A

OL–4.1–R6.1.8 parallactic angle;
Priority: 1
Grade: A

OL–4.1–R6.1.9 slice through data cube;
Priority: 1
Grade: I Severity: low
Summary: Plotting is possible but it does not allow editing.

OL–4.1–R6.2 displays of spectra and spectral cubes;
Priority: 1
Grade: A

OL–4.1–R6.3 display of closure quantities;
Priority: 1
Grade: A

OL–4.1–R6.4 display of and selection on monitor data quantities (e.g. Tatm, Tamb);
Priority: 1
Grade: I Severity: med
Summary: display can be easily done; selection is possible through quality setting (a form of editing).

OL–4.1–R6.5 the above with baseline, time, band and/or channel averaging;
Priority: 1
Grade: A
Summary: Note however that baseline averaging is done by typing a few `GREG` command lines.

OL–4.1–R6.6 for interferometer data, amplitude (phase) vs. time on each baseline (Difmap vplot), vs. time-baseline (AIPS TVFLG) with interactive zoom, selection, and clipping;
Priority: 1
Grade: A/E
Summary: Amplitude and/or phase vs time is available, but not amplitude and/or phase vs baseline.

OL–4.1–R6.7 editing of data points based on statistical quantities, including:

OL–4.1–R6.7.1 a data point versus a running mean over a timescale;
Priority: 1
Grade: N Severity: med

OL–4.1–R6.7.2 a data point versus a median over a timescale;
Priority: 1
Grade: N Severity: med

OL–4.1–R6.7.3 an rms scatter in a time range;

Priority: 1
Grade: N Severity: med

OL–4.1–R6.7.4 difference versus a model;
Priority: 1
Grade: N Severity: med

Summary: Control of interactive editing and plotting versus statistical quantities is lacking; such plotting and thus editing would normally be done by custom scripts.

OL–4.1–R6.8 auto-scaling and user-specified scaling of axes;
Priority: 1
Grade: A

OL–4.1–R6.9 auto-scaled and user-specified colormap or greyscale;
Priority: 1
Grade: A

OL–4.1–R6.10 inclusion and marking of flagged data in plots and in auto-scaling;
Priority: 1
Grade: A/E
Summary: This is easy to do but requires a sequence of a few commands.

OL–4.1–R7 Non-interactive and automated editing tools shall be available in the Package, including:

OL–4.1–R7.1 direct editing of data based user-specified ranges for quantities available for plotting or editing in interactive mode
Priority: 1
Grade: A/E
Summary: The `visi` script does this based on phase rms and calibrator amplitude. More specialized operations (e.g. use Tsys) would use custom scripts.

OL–4.1–R7.2 automated editing with tunable criteria for automated selection of parameter ranges
Priority: 2
Grade: N Severity: med

OL–4.1–R8 Data calibration, correction and flagging shall be possible based upon standard or user-defined models in either functional or tabular form. Arbitrary user-specified scaling of data shall be simple.

Priority: 2

Grade: N Severity: high

Summary: Not available.

OL–4.1–R9 Access to time history of calibration information (e.g. source catalogs containing flux density histories) shall be built into calibration engines. Output of calibration procedures shall be exportable into similar structures.

Priority: 2

Grade: A

Summary: The fluxes of MWC349 and CRL618 are known, as well as models for planets; on line fluxes (approximate measurements) of the main calibrators are included in each data file.

OL–4.1–R10 The Package shall support the establishment and verification of the relative calibration of the various component epochs, configurations or other subsets for merged datasets.

Priority: 2

Grade: A

Summary: To the extent that this means that concatenation of data sets with different calibrator fluxes, this is available. There is a tool to set the fluxes in a consistent way by using a common reference (e.g. MWC 349, or a common passband calibrator). If this means checking the consistency of the calibration in a quasi-automatic way, this is a non-trivial issue.

OL–4.1–R11 Data display and editing shall be effected through generic tools applicable to both single-dish and interferometer modes. These shall, as far as possible, present similar interfaces to the user and have the same look-and-feel.

Priority: 2

Grade: A/E

Summary: Although the interferometric calibration tool (`CLIC`) has some single dish capabilities (ON-OFF), single dish work is better done with `CLASS` and `OTFCLASS`. However, they have the same CLI and similar GUIs.

OL–4.1–R12 Editing shall be incorporated into most visualization tools where data or data-derived quantities are plotted, such as from calibration solutions, amplitude vs. uv-distance plots, or any number of other plots. A "see-it, flag-it" capability shall be the standard within the tools.

Priority: 2

Grade: A/E

Summary: Scan based editing is available in all time-based plots I believe.

2.4.2 Atmospheric Calibration

OL–4.2–R1 Atmospheric modeling shall be available in the Package. **The ALMA Project shall provide a standard model as used in the Pipeline processing of data which the package must support.** There shall be provision for the use of user-supplied models, or the package may have its own built-in models as an option.

Priority: 1

Grade: A

Summary: Atmospheric modeling is available online, and in `CLIC` and `CLASS` (though not with the latest ATM model; the current model in use is limited in accuracy above 300 GHz).

OL–4.2–R2 The Package shall be able to predict the absorption, emission and path length on the line of sight through the atmosphere at all ALMA bands using the model. The prediction will be based on the following data:

OL–4.2–R2.1 measured atmospheric parameters at the site: temperature, pressure, humidity
Priority: 1
Grade: A

OL–4.2–R2.2 measured atmospheric emission in the observed ALMA bands
Priority: 1
Grade: A
Summary: But restricted in accuracy above 300 GHz.

OL–4.2–R2.3 data from site test interferometer or tipping radiometer
Priority: 2
Grade: N Severity: low
Summary: Not available at PdB site so not developed.

OL–4.2–R2.4 measured FTS data (if FTS available for ALMA)
Priority: 3
Grade: U
Summary: Not available at PdB site so not developed; pending ALMA FTS and format.

OL–4.2–R2.5 measured atmospheric profiles of temperature and water content if available from atmospheric sounders or other devices
Priority: 3
Grade: U
Summary: Pending ALMA scoping of this.

OL–4.2–R3 Atmospheric modeling shall be usable to derive the system temperatures corrected for atmospheric absorption in all astronomical bands in use, in order to correct the observed amplitudes at various elevations.

Priority: 1

Grade: A

Summary: Has worked for 17 years ...

OL–4.2–R4 Atmospheric modeling shall be also usable to provide the conversion factors between WVR data and the water contribution to the astronomical phase in the astronomical bands.

Priority: 1

Grade: A

Summary: ... Since 7 years only.

2.4.3 Interferometer Data

Note: Antenna-based determination of calibration quantities such as gains, polarization leakages, bandpasses, will be the primary form of calibration where appropriate. However, in addition to antenna-based calibration, baseline dependent corrections will be important in some cases. For example, coherence loss due to atmospheric phase fluctuation depends on baseline length (this aspect will be more important at higher frequencies) and orientation, and must be taken into account if some of the WVR corrections are discarded while others are applied. Also, in general, the bandpasses are baseline dependent and contain non-closing terms.

OL–4.3–R1 Antenna-based determination of calibration quantities shall be available, and are the default choice for calibration in tools where appropriate, for quantities including:

OL–4.3–R1.1 antenna gains;
Priority: 1
Grade: A

OL–4.3–R1.2 polarization leakages;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not yet handled.

OL–4.3–R1.3 antenna-dependent bandpasses;
Priority: 1
Grade: A

Summary: A specific mode useful for mm wave (i.e. low SNR) data is used (antenna-based gains modelled as cubic splines and polynomials) at IRAM PdB.

OL–4.3–R2 Baseline dependent corrections shall be supported for quantities including:

OL–4.3–R2.1 WVR corrections to subsets of baselines;
Priority: 1
Grade: A

OL–4.3–R2.2 closure errors;
Priority: 1
Grade: A
Summary: This is handled as ‘baseline-based calibration’.

OL–4.3–R2.3 baseline-dependent bandpasses;
Priority: 1
Grade: A
Summary: This is handled as ‘baseline-based calibration’, both for amplitude and phases.

OL–4.3–R3 Gain corrections will be made based on differences between observed and modeled data quantities, possibly with iteration (e.g. self-calibration and determination of gains using calibration sources). Where solutions are discrepant or poor, automatic editing shall be possible.

Priority: 1

Grade: A/E

Summary: This is available, though rather confidential and tested only by the author on one case. Should be more extensively tested now than 6 antennas are available, and should then be documented.

OL–4.3–R4 Calibration quantities (possibly stored in tables or data structures) shall be transferable between sources and/or frequency bands, after any necessary interpolation, extrapolation or smoothing. This will be the primary method of phase calibration transfer using fast-switching between source and calibrator.

Priority: 1

Grade: A

Summary: This is the standard way of calibrating the 1mm band at PdB.

OL–4.3–R5 Determination of the time-variable, complex bandpass using calibration source observations, and transfer to target sources, shall be simple and robust.

Priority: 1

Grade: I Severity: low

Summary: The calibration solution interval can be set when solving for the bandpass so tracking of time variability is possible. Interpolation is not available in a straighforward way.

OL–4.3–R6 Determination of polarization calibration quantities such as leakage (D-term or Jones matrix) and complex gain difference shall be an integral part of the Package, with the capability of performing full matrix calculations.

Priority: 1

Grade: N Severity: high

Summary: Polarization is not yet handled.

OL–4.3–R7 Determination of, correction for, examination of, and flagging based on closure errors shall be straightforward to carry out.

Priority: 2

Grade: A

Summary: Closure errors are checked for when solving for antenna based calibrations. Correction for the errors have to be done by using baseline-based calibrations (note: I've never seen phase closure errors so far).

OL–4.3–R8 Incorporation of standard models (e.g. planetary disks, models for HII region structure, known source spectra) shall be easy for calibration operations. User-supplied models in a standard format (e.g. ASCII table) for these quantities shall be supported.

Priority: 2

Grade: A/E

Summary: This is done through tasks (`uv_model`, and `uv_ascal`).

OL–4.3–R9 Redundancy (e.g. same, similar, or crossing baselines) shall be used wherever possible to increase accuracy of or to check calibration solutions. Editing based on this comparison shall be possible.

Priority: 2

Grade: N Severity: low

Summary: There is no dedicated tool for this, though it is feasible using uv plots

OL–4.3–R10 Interferometric pointing, focus, baseline, and beam response fitting shall be available in the Package as a supplement to the on-line calibration.

Priority: 3

Grade: A

2.4.4 Single Dish Data

OL–4.4–R1 Straightforward and flexible fitting of spectral bandpass from calibration source observations is required.

Priority: 1

Grade: A/E

Summary: We can fit a baseline and transport it. A passband can be fitted too. transporting it is not implemented.

OL–4.4–R2 De-striping and adjustment of scan normalization factors must be available for single-dish OTF observations with overlapping and crossing scans.

Priority: 1

Grade: I Severity: med

Summary: Not available as a specific function or tool, but can be done by FFT-ing the data, filtering, and transforming back. Should be bundled into a tool, with more options (e.g. using interlocking scans to solve for scan offsets).

OL–4.4–R3 Calibration of system parameters such as temperature controlled loads and noise sources from observations of celestial sources shall be supported.

Priority: 3

Grade: A

OL–4.4–R4 Processing for pointing, focus, tipping, or beam-fitting data must be available for both single-scan calibration observations and for multiple datasets.

Priority: 3

Grade: A

Summary: Mostly for staff use, and can be done using custom scripts running low-level functions.

2.4.5 Mosaicing Considerations

OL–4.5–R1 Determination of and correction for pointing offsets and the polarized primary beam is critical to the ability to reliably mosaic using ALMA, and thus must be available in the Package, preferably in several algorithmic forms.

Priority: 1

Grade: U

Summary: There does not appear to be a method for determination of or implementation of pointing corrections to amplitude and phase, though this could be done with special scripting. Development of mosaicing algorithms, including pointing effects, should be a high priority of the ALMA Science IPT, which can then be coded into the DRP.

OL–4.5–R2 Careful cross calibration of the flux scales between ALMA interferometric data and single dish data is required for high fidelity imaging. There must be tools to cross-check and correct the relative calibration between mosaics and different component observations. *Note: this is particularly important and more difficult for ACA data.*

Priority: 2

Grade: U

Summary: Work is being done in this field.

OL–4.5–R3 The Package shall allow user-input of scan information given a parameterized pattern or interpolated from a provided list of pointing centers versus time

Priority: 3

Grade: A

Summary: The pointing information is available in the headers, and you're free to change them by any data or formula if you believe they are wrong by any amount (as anything in the headers incidently).

2.4.6 Ancillary and Diagnostic Data

OL–4.6–R1 Output from the atmospheric monitoring (e.g. WVR, FTS) instrumentation provided in ALMA format shall be importable to the calibration software, for example to be used in flagging.

Priority: 1

Grade: U

Summary: An ALMA format needs to be detailed.

OL–4.6–R2 Derivation of calibration and correction of data based on pointing, focus and subreflector status information shall be available in the Package.

Priority: 1

Grade: I Severity: med

Summary: One can correct the visibilities for the phase effect of a mispositioned subreflector.

OL–4.6–R3 Environmental data such as weather (e.g. wind speed, temperature, dew point) supplied in ALMA format, as FITS extension tables, or as ASCII tables shall be importable for editing or calibration procedures, and easily incorporated into user-specified calibration models.

Priority: 2

Grade: U

Summary: The ALMA formats needs to be detailed. These parameters should be in the standard metadata (e.g. they are in PdB format) and thus should not need be imported.

OL–4.6–R4 Engineering monitoring information such as temperature sensor readings and tilt-meter outputs, included in ALMA format, as FITS extension tables, or as ASCII tables, shall be readable and incorporated into the calibration and editing process.

Priority: 3

Grade: U

Summary: The ALMA formats needs to be detailed. We will want to include in the DRP native format all data that needed for calibration and editing. This is the strategy we used at PdB.

2.5 Imaging

2.5.1 General Imaging Requirements

Because ALMA is inherently a multi-channel instrument, spectral cube mapping shall be built in as the primary mode from the beginning. Also, due to the high volume of data that can be produced by ALMA, it is imperative that the imaging and deconvolution tools in the Package be user-friendly, efficient, and flexible. This is the workhorse of the Package as far as most users will be concerned, and suitability and success of the Package will be judged with this in mind.

OL–5.1–R1 Imaging of data taken from any combination of ALMA exported data, the ALMA archive, or other instruments supporting common export formats must be provided. **A list of supported data and formats will be maintained by the project.**

Priority: 1

Grade: U

Summary: ALMA must supply a list.

OL–5.1–R2 Efficient selection of subsets of the imaging data must be provided.

Priority: 1

Grade: A

Summary: Bottom,left and top,right corners of a 4-D cube may be defined as global variables. Most of the imaging GUI have a field for those.

OL–5.1–R3 Provision must be made for the utilization and development of a variety of imaging, deconvolution, and analysis algorithms, including:

Summary: The commands are available inside the `MAPPING` program unless stated otherwise. This program has a GUI called `Interferometric Simple Mapping` which allows the users to customize and call all these commands.

OL–5.1–R3.1 raw ("dirty") images with selectable weighting (natural, uniform, Briggs robust);
Priority: 1
Grade: A
Summary: These are available through 1) the **uv_map** and **show dirty** commands and/or 2) the `UV_MAP` task.

OL–5.1–R3.2 residual images after model subtraction;
Priority: 1
Grade: A
Summary: These are available through the **show residual** command.

OL–5.1–R3.3 single-scale CLEAN (Hogbom, Clark, Cotton-Schwab);
Priority: 1
Grade: A
Summary: This is carried out by the **hogbom**, **clark** and **mx** commands.

OL–5.1–R3.4 maximum entropy method (MEM);
Priority: 1
Grade: N Severity: high
Summary:

OL–5.1–R3.5 linear mosaics;
Priority: 1
Grade: A
Summary: Easy to be done in a script.

OL–5.1–R3.6 non-linear mosaics;
Priority: 1

Grade: A
Summary: Available through the `MAKE_MOSAIC` task followed by **hogbom**, **clark** or **sdi** commands.

OL–5.1–R3.7 non-negative least-squares (NNLS);
Priority: 2
Grade: N Severity: med

OL–5.1–R3.8 multi-scale CLEAN;
Priority: 2
Grade: A
Summary: Different flavors are available through the **multi** or **mrc** commands.

OL–5.1–R3.9 modelfitting (point, Gaussian, disk);
Priority: 2
Grade: A
Summary: Available through the `UV_FIT` task.

OL–5.1–R3.10 multi-frequency synthesis with different spectral models;
Priority: 2
Grade: I Severity: med
Summary: This is of little interest for narrow band as currently used at PdB.

OL–5.1–R3.11 special function deconvolution (Pixon, wavelet);
Priority: 3
Grade: A/E
Summary: Wipe deconvolution method is available. There is no wavelet deconvolution.

OL–5.1–R4 Image pixel and spectral channel blanking must be supported.

Priority: 1

Grade: A

Summary: Available through the **polygon** and **mask** commands.

OL–5.1–R5 Interactive graphical selection of deconvolution region masks shall be available.

Priority: 1

Grade: A

Summary: Available through the **support** command. Automatically called in GUI mode.

OL–5.1–R6 Multiple input datasets shall be supported directly in the tools, rather than requiring previous concatenation of the data.

Priority: 2

Grade: I Severity: med

Summary: Not currently available. Data is automatically concatenated at *uv* table creation.

OL–5.1–R7 An integrated deconvolution, self-calibration, and editing/filtering tool shall be available, especially for novice users with data taken in commonly used modes.

Priority: 2

Grade: A/E

Summary: Calibration, editing/filtering and deconvolution are very well integrated for novice users (Indeed PdB data is often reduced by new students). Self-calibration is only confidentially available.

OL–5.1–R8 Images made on different coordinate systems (e.g. OL–3.1–R9), equinoxes (e.g. OL–3.1–R10), or projections (e.g. OL–3.3–R4) shall be transformed, merged and compared appropriately.

Priority: 2

Grade: A

Summary: Available through the `REPROJECT` task.

OL–5.1–R9 Image cubes using different velocity definitions (e.g. OL–3.1–R11) and velocity frames (e.g. OL–3.1–R12) shall be transformed and merged correctly.

Priority: 2

Grade: N Severity: low

2.5.2 Interferometer Imaging

OL–5.2–R1 High-fidelity imaging of the entire primary beam in all Stokes parameters is the primary goal — therefore, incorporation of the polarized primary beam response of the array is required.

Priority: 1

Grade: N Severity: high

Summary: Primary beams are modelized and used in imaging. However, no polarization is available.

OL–5.2–R2 Imaging of direct polarization products (e.g. RR, LL, RL, LR) or Stokes polarization states (e.g. I, Q, U, V) must be selectable and interchangeable where possible given the data.

Priority: 1

Grade: N Severity: high

Summary: Polarization not yet available.

OL–5.2–R3 There must be straightforward and seamless integration of data from multiple epochs and configurations.

Priority: 1

Grade: A

Summary: Transparently done in `CLIC` at *uv* table creation.

OL–5.2–R4 Simultaneous multiple-field imaging and deconvolution must be supported.

Priority: 1

Grade: A

Summary: Available through the `MAKE_MOSAIC` tasks and standard deconvolution commands.

OL–5.2–R5 Subtraction of continuum level from spectral data is required, in both the Fourier and image domain. In the case of uv-plane subtraction, flexible setting of the frequency channel ranges for the calculation of the continuum level and selection of the type of fitting (polynomial, spline) should be available in both GUI and CLI.

Priority: 1

Grade: A

Summary: Available through `UV_SUBTRACT` in the Fourier domain. This is just a baseline removal in the image domain (Available inside the `CLASS` program.).

OL–5.2–R6 There must be the ability to include "zero-spacing" values and short-spacing data taken in single-dish mode (both ALMA and non-ALMA data), with selectable weighting.

Priority: 1

Grade: A

Summary: Available through the `UV_ADDSH` task.

OL–5.2–R7 There shall be the choice of FFT and DFT imaging (especially for small datasets).

Priority: 2

Grade: A

Summary: Useless but available through the `UV_DFT` task.

OL–5.2–R8 There shall be the provision for the near-field imaging of solar-system objects. This can be done through the introduction of phase corrections based upon the sphericity of the incoming wave front.

Priority: 2

Grade: I Severity: low

Summary: R.Lucas implemented near-field correction for holography of ALMA antenna prototype.

2.5.3 Mosaicing and Single Dish Imaging Considerations

OL–5.3–R1 Combination of interferometer and single-dish data into mosaic imaging is essential.

Priority: 1

Grade: A

Summary: Done almost routinely at PdB.

OL–5.3–R1.1 The ACA (if and when it is scoped as part of ALMA) must be integrally supported by the Package.
Priority: 1
Grade: A
Summary: Implemented in 2001 to check the importance of ACA for the wide-field imaging capabilities of ALMA.

OL–5.3–R2 Careful (polarized) primary beam correction and pointing correction is critical for high fidelity mosaic imaging and must be incorporated into the mosaicing algorithms.

Priority: 1

Grade: I Severity: high

Summary: This overlaps with OL–5.2–R1, OL–4.5–R1, and OL–4.6–R2.

OL–5.3–R2.1 The primary beam calculation and correction must take into account the effect of on-the-fly scanning.
Priority: 1
Grade: N Severity: low

OL–5.3–R2.2 A set of **ALMA standard beam images** will be made available by the project and distributed with the Package, with updates available for download when appropriate.
Priority: 1
Grade: U
Summary: Must be provided by ALMA.

OL–5.3–R2.3 The user shall be able to specify the primary beam in a number of forms, both analytic and tabular, in addition to the ALMA provided primary beam.
Priority: 2
Grade: A/E
Summary: Available except for polarization.

OL–5.3–R3 Image plane and uv-plane gridding parameters and interpolation shall be selectable based on desired image criteria (e.g. field-of-view, accuracy)

Priority: 1

Grade: A/E

Summary: Default guess are good in `MAPPING`. However, all those parameters are tunable through global variables. The **uv_stat** command gives noise levels and synthesized beams as a function of imaging parameters.

OL–5.3–R4 Scaling and de-striping of scans on image-plane combination shall be available.

Priority: 2

Grade: A/E

Summary: Available as a contributed tool from outside IRAM.

OL–5.3–R5 The Package must be able to produce an image by combining data observed on different rasters, possibly taken with different (regular or irregular) spacings and image centers.

Priority: 2

Grade: A

Summary: Available inside the `CLASS` (for spectra) and `NIC` (for continuum) programs.

OL–5.3–R6 Pointing corrections (e.g. as determined by optical cameras or through monitoring data) shall be applicable to the data during imaging

Priority: 2

Grade: N Severity: med

Summary: This overlaps with OL–5.2–R1, OL–4.5–R1, and OL–4.6–R2, and further development is needed on algorithms.

OL–5.3–R7 The imaging tools shall allow the option for the mitigation of the effects of non-coplanar baselines and sky curvature.

Priority: 2

Grade: I Severity: med

Summary:

2.6 Data Analysis

2.6.1 General Analysis Requirements

OL–6.1–R1 Seamless transformation between image-plane and uv-plane analysis is necessary:

OL–6.1–R1.1 Analysis based on goodness-of-fit to models, in both uv-plane (for interferometry) and image plane, shall be available.
Priority: 1
Grade: A/E
Summary: Fits in the UV plane are possible using task `UV_FIT`. Fit in the Image plane are more tricky.

OL–6.1–R1.2 Fourier transform of images between angular and uv domains shall be available.
Priority: 2
Grade: A
Summary: The Fourier Transform between UV and Image planes is widely used in `GILDAS`. It is available for the user in various implementations.

OL–6.1–R2 Spectral and scanning baseline removal facility is required:

OL–6.1–R2.1 Polynomial baseline fitting shall be supported
Priority: 1
Grade: A
Summary: This is available for single dish in `CLASS` (**base** command). RF bandpass calibration of interferometric data is done in `CLIC` (**solve rf**).

OL–6.1–R2.2 Baseline fitting based on image statistics (e.g. median filtering) shall be supported
Priority: 1
Grade: N Severity: low
Summary: Not available.

OL–6.1–R2.3 Fourier analysis of standing waves and their removal from spectra shall be available.
Priority: 2
Grade: A
Summary: `CLASS` allows the user to perform a Fourier Transform of the spectra and intercatively cancel one or several frequency regions (**fft** command).

OL–6.1–R3 Translation between various astronomical quantities and units shall be available, including:

OL–6.1–R3.1 flux density — Jy, mJy, μJy, mag
Grade: N Severity: low

OL–6.1–R3.2 temperature — K, mK (Rayleigh-Jeans, Planck)
Grade: N Severity: low

OL–6.1–R3.3 surface brightness — Jy/beam, Jy/sr, MJy/sr, mag/arcsec^2
Grade: N Severity: low

OL–6.1–R3.4 frequency — Hz, MHz, GHz, cm^{-1} (wave number)
Grade: N Severity: low

OL–6.1–R3.5 velocity — km/s, m/s, z (redshift)
Grade: N Severity: low

OL–6.1–R3.6 wavelength — m, cm, mm
Grade: N Severity: low

Priority: 2

OL–6.1–R4 The astronomer must have the capability to develop their own tools or tasks, with easy access to data and images, and straightforward interface with the Package.

Priority: 2

Grade: A

Summary: Developping new tasks and GUIs in `GILDAS` is easy. Developping scripts is trivial.

2.6.2 Spectral Line Analysis

ALMA will be a spectroscopic machine, and thus the ease and flexibility of spectral line analysis is likely to be a driver for the Package. Automatic and user-controlled fitting routines will need to be included. Note that there is necessarily some overlap with the image cube analysis, but here we concentrate on issues relevant to traditional 1-D spectra.

OL–6.2–R1 Automatic and user-controlled measurement of line parameters shall be available.

Priority: 1

Grade: A

Summary: Fitting procedures are available in `CLASS` for single-dish spectra (**gauss** and **fit** commands), but not easily for interferometric data. Interactive measurements of line properties are available through various procedures. Plugging a cube into `CLASS` is easy.

OL–6.2–R2 It shall be possible for the user to specify a velocity or frequency windowing region for line fitting.

Priority: 1

Grade: A

Summary: Available in `CLASS`.

OL–6.2–R3 Available line fitting parameters and profiles shall include:

OL–6.2–R3.1 Gaussian line parameters (central and integrated intensity, line width, line center) for single or multiple lines
Priority: 1
Grade: A
Summary: Available in `CLASS`.

OL–6.2–R3.2 Damping profiles (Lorentzian)
Priority: 2
Grade: N Severity: low
Summary: This does not appear to be supported.

OL–6.2–R4 A set of **ALMA standard line catalogs** shall be made available by the project and distributed with the Package, with updates available for download when appropriate.

Priority: 1

Grade: U

Summary: The ALMA standard line catalog has yet to be defined.

OL–6.2–R5 User importable line catalogs shall be supported by the Package as an ASCII table and in the **ALMA standard format**.

Priority: 2

Grade: U

Summary: The ALMA standard line catalog format has yet to be defined.

OL–6.2–R6 Setting of fit constraints (e.g. spacing for multiple lines) shall be available and flexible (i.e. by GUI or by parameter list).

Priority: 2

Grade: A

Summary: This is available in `CLASS` for single-dish spectra.

OL–6.2–R7 Export of fit results in ASCII-format is desirable.

Priority: 3

Grade: A

Summary: This is available in `CLASS` for single-dish spectra.

2.6.3 Image Cube Analysis and Manipulation

Because ALMA is inherently a multi-channel instrument, and due to the design of the ALMA correlator, spectral image cubes can be considered to be the fundamental image structure. Single-channel or continuum images can be considered as subsets or instances of cubes. Note that the ability to pull lower-dimensional structures from larger-dimensional cubes is especially important.

OL–6.3–R1 The Package shall support the construction and analysis of image cubes with a variety of axis choices, including:

OL–6.3–R1.1 time (e.g. OL–3.1–R8);
Priority: 1
Grade: A

OL–6.3–R1.2 position (e.g. OL–3.1–R9 or general X,Y);
Priority: 1
Grade: A

OL–6.3–R1.3 Fourier (u,v);
Priority: 1
Grade: A/E

OL–6.3–R1.4 channel (frequency, velocity, channel number, band, IF);
Priority: 1
Grade: A

OL–6.3–R1.5 polarization;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not yet handled.

OL–6.3–R2 Basic cube rotation and transposition operations shall be available, including rotation not orthogonal to cube faces.

Priority: 1

Grade: A/E

Summary: Rotation and transposition are easily doable (e.g. `REPROJECT` or `TRANSPOSE` tasks). Rotation not orthogonal to cube face is not possible.

OL–6.3–R3 It shall be possible to define multi-dimensional regions of the cube for further processing, both interactively and by specifying coordinates manually.

Priority: 1

Grade: A/E

Summary: This is available e.g. using **go view**. Most image analysis tasks are taking TRC/BLC parameters as inputs.

OL–6.3–R4 Identification and reporting of image features (e.g. as determined in processing operations) shall be available, and interactive (where appropriate). Features shall include:

OL–6.3–R4.1 output in pixel coordinates (e.g. row, column);
Priority: 1
Grade: A

OL–6.3–R4.2 output in world coordinates (e.g. RA, Dec, Vel);
Priority: 1
Grade: A

OL–6.3–R4.3 convertible to other supported coordinate systems (e.g. precessed to B1950);
Priority: 2
Grade: A/E

OL–6.3–R4.4 exportable (e.g. as an ASCII file);
Priority: 3
Grade: A/E

Summary: These are all available using the **draw** command.

OL–6.3–R5 The ability to extract same or lower-dimensional structures from higher-dimensional data cubes efficiently is required:

OL–6.3–R5.1 Extraction of "cubical" sub-structures aligned with the original cube axes must be straightforward.
Priority: 1
Grade: A
Summary: `EXTRACT` task.

OL–6.3–R5.2 User selection of extraction criteria must be possible through the GUI as well as scriptable.
Priority: 1
Grade: A
Summary: GUI of `EXTRACT` task.

OL–6.3–R5.3 User-selectable sub-structures with arbitrary orientation within the parent cube, with appropriate transformation or interpolation, shall be possible.
Priority: 2
Grade: N Severity: med
Summary: Arbitrary orientation not supported.

OL–6.3–R5.4 Extraction of data structures based on standard database (e.g. SQL) queries shall be available.
Priority: 3
Grade: N Severity: low
Summary: Not available.

OL–6.3–R6 The ability to collapse or integrate over sub-dimensions of data cubes in order to form "moments" is required. This shall be possible along any direction(s) in the cube aligned with the axes.

Priority: 1

Grade: A

Summary: Available in `MOMENTS` task.

OL–6.3–R6.1 Moments along arbitrary user-specified directions in the cube shall be possible.
Priority: 3
Grade: N Severity: low
Summary: Arbitrary orientation not supported. But I don't see what would be the interest!

OL–6.3–R7 The Package must have the capability of assembling lower-dimensional data structures into higher-dimension cubes.

Priority: 1

Grade: A

Summary: Merging images in one single data cube is trivial. Can be done by simple `SIC` procedure.

OL–6.3–R8 Blanking of pixels must be maintained through the analysis process.

Priority: 1

Grade: A/E

Summary: Warning: blanking is a problem when computing Fourier transform. Setting the data to zero is not a good solution.

OL–6.3–R8.1 It must be possible to turn on and off different blanking (mask) levels, when blanking is set within the Package.
Priority: 1
Grade: A
Summary: **set blanking** command.

OL–6.3–R8.2 Blanking shall not be destructive, and the original pixel value is retained (if defined).
Priority: 2
Grade: I Severity: high
Summary: Blanking affects the data.

OL–6.3–R8.3 Interactive and automatic facilities for setting of any blanking parameters shall be provided.
Priority: 2
Grade: I Severity: med
Summary: **set blanking** command allows interactive choice of the blanking parameters. Nothing available for automatic determination.

OL–6.3–R9 A variety of image processing and filtering operations on the cube shall be available, including:

OL–6.3–R9.1 Smoothing and convolution, with kernels including:

OL–6.3–R9.1.1 Uniform (box-car or top-hat) kernel;
Priority: 1
Grade: A
Summary: `SMOOTH` task.

OL–6.3–R9.1.2 Elliptical Gaussian kernel;
Priority: 1
Grade: A
Summary: `SMOOTH` task.

OL–6.3–R9.1.3 Symmetric polynomial;
Priority: 2
Grade: N Severity: med
Summary: Not available.

OL–6.3–R9.1.4 User-supplied;
Priority: 3
Grade: A
Summary: `SMOOTH` task.

OL–6.3–R9.2 Clipping
Priority: 1
Grade: A
Summary: Trivialy done in a few `SIC` lines.

OL–6.3–R9.3 Windowing and boxing, with definitions of regions of interest recordable and passable for subsequent use
Priority: 1
Grade: A

Summary: Polygon definition easily done with cursor.

OL–6.3–R9.4 Arithmetical operations, including:

OL–6.3–R9.4.1 addition of uniform level;
Priority: 1
Grade: A

OL–6.3–R9.4.2 multiplicative scaling;
Priority: 1
Grade: A

OL–6.3–R9.4.3 logarithm;
Priority: 2
Grade: A

OL–6.3–R9.4.4 exponential;
Priority: 2
Grade: A

OL–6.3–R9.5 Statistical operations over a defined region, including:

OL–6.3–R9.5.1 mean
Priority: 1
Grade: A

OL–6.3–R9.5.2 rms
Priority: 1
Grade: A

OL–6.3–R9.5.3 standard deviation from mean
Priority: 1
Grade: A

OL–6.3–R9.5.4 median
Priority: 1
Grade: N Severity: low
Summary: Could easily been added.

OL–6.3–R9.5.5 mode
Priority: 2
Grade: U
Summary: What is it?

Summary: **mean** or **go flux** commands.

OL–6.3–R9.6 Fourier and correlation operations on cube or cubical sub-regions, including:

OL–6.3–R9.6.1 Fourier transform
Priority: 1
Grade: A
Summary: `FOURIER` task.

OL–6.3–R9.6.2 power spectrum
Priority: 1
Grade: N Severity: med
Summary: Not available.

OL–6.3–R9.6.3 autocorrelation
Priority: 1
Grade: N Severity: med
Summary: Not available.

OL–6.3–R9.6.4 structure function
Priority: 2
Grade: N Severity: med
Summary: Not available.

OL–6.3–R9.7 Scalar arithmetic between different regions (including treatment of masked regions and differently shaped regions), including:

OL–6.3–R9.7.1 sum (difference);
Priority: 1
Grade: A

OL–6.3–R9.7.2 product (division);
Priority: 1
Grade: A

OL–6.3–R9.7.3 spectral index;
Priority: 1
Grade: A

OL–6.3–R9.7.4 median;
Priority: 2
Grade: N Severity: low
Summary: Could easily been added.

OL–6.3–R9.7.5 maximum (minimum);
Priority: 2
Grade: A

Summary: Unclear what this requirements means. But image manipulation is trivial in `GILDAS`.

OL–6.3–R9.8 Construction and comparison of vector quantities in the cube, including:

OL–6.3–R9.8.1 polarization (E) vector at each cube pixel;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not yet handled.

OL–6.3–R9.8.2 rotation measure between different frequencies;
Priority: 1
Grade: N Severity: high
Summary: Polarization is not yet handled.

OL–6.3–R9.9 Vector arithmetic between different regions (including treatment of masked regions and differently shaped regions), including:

OL–6.3–R9.9.1 sum (difference);
Priority: 1
Grade: N Severity: high
Summary: Polarization not supported in `GILDAS`.

OL–6.3–R9.9.2 dot product;
Priority: 2
Grade: N Severity: high
Summary: Polarization not supported in `GILDAS`.

OL–6.3–R9.9.3 cross product;
Priority: 2
Grade: N Severity: high
Summary: Polarization not supported in `GILDAS`.

OL–6.3–R9.10 Interpolation across blanked or masked regions
Priority: 1
Grade: A
Summary: `FILL_CUBE` task.

OL–6.3–R9.11 Fitting of models, shapes, profiles and functions over regions including:

OL–6.3–R9.11.1 polynomials
Priority: 1
Grade: I Severity: low
Summary: Available through **mfit** command (at least in 1D).

OL–6.3–R9.11.2 exponentials

Priority: 1
Grade: A/E
Summary: Can be done in UV plane using `UV_FIT` task.

OL–6.3–R9.11.3 Fourier modes
Priority: 1
Grade: I Severity: low
Summary: One could in principle FT the image and find the peaks.

OL–6.3–R9.11.4 elliptical Gaussian components
Priority: 1
Grade: A/E
Summary: Can be done in UV plane using `UV_FIT` task.

OL–6.3–R9.11.5 uniform (multi-dimensional) spheres
Priority: 2
Grade: N Severity: med
Summary: Not available.

OL–6.3–R9.11.6 trigonometric functions
Priority: 2
Grade: I Severity: low
Summary: Available through **mfit** command (at least in 1D).

OL–6.3–R9.11.7 Lorentzian profiles
Priority: 2
Grade: I Severity: low
Summary: Available through **mfit** command (at least in 1D).

OL–6.3–R9.11.8 user-supplied functions
Priority: 3
Grade: I Severity: low
Summary: Available through **mfit** command (at least in 1D).

Summary: Note that a number of other functions can be fitted to the data using `UV_FIT`, as e.g. ring, or power functions.

OL–6.3–R9.12 Filtering, including:

OL–6.3–R9.12.1 Fourier (Wiener) filtering
Priority: 2
Grade: N Severity: low
Summary: Not available.

OL–6.3–R9.12.2 Sobel filtering
Priority: 3
Grade: N Severity: low
Summary: Not available.

OL–6.3–R9.12.3 unsharp mask
Priority: 3
Grade: A
Summary: `SMOOTH` task.

OL–6.3–R9.12.4 user-supplied filtering functions
Priority: 3
Grade: A
Summary: `SMOOTH` task.

OL–6.3–R9.13 Deconvolution
Priority: 2
Grade: A
Summary: The `MAPPING` software proposes several deconvolution method with a variety of options and possibilities.

OL–6.3–R9.14 Resampling (e.g. at lower temporal or spectral resolution) after processing

Priority: 2
Grade: A
Summary: This can be done by various tasks.

OL–6.3–R9.15 Calculus on scalar and vector fields in cube, including:

OL–6.3–R9.15.1 differentiation along paths;
Priority: 3
Grade: N Severity: low

OL–6.3–R9.15.2 integration over regions;
Priority: 3
Grade: N Severity: low

OL–6.3–R9.15.3 gradient of scalar fields;
Priority: 3
Grade: N Severity: low

OL–6.3–R9.15.4 divergence of vector fields;
Priority: 3
Grade: N Severity: low

OL–6.3–R9.15.5 curl of vector fields;
Priority: 3
Grade: N Severity: low

OL–6.3–R9.15.6 Laplacian of vector fields;
Priority: 3
Grade: N Severity: low

OL–6.3–R10 There shall be the capability to manipulate data cubes as general data structures, so that arithmetical and logical operations can be applied as object methods.

Priority: 3

Grade: A

Summary: This is available using the **define image** command which allows the user to read an image in a `SIC` variable.

2.7 Visualization

This is intended as the purely graphical part of data analysis. There is by necessity some overlap with the functionality discussed under Data Analysis, particularly that for image cube manipulation, and it would in fact be ideal if visualization and analysis were so closely integrated that there were no effective difference. The intention here is that the user is not only able to display pre-calculated images (processed using tools from the Data Analysis suite), but also has the capability of doing some processing and display on-the-fly as an integral part of the visualization.

2.7.1 General Visualization and Plotting Requirements

OL–7.1–R1 Plotting and display capabilities shall be integrated into the GUI tools throughout the Package.

Priority: 1

Grade: A

Summary: Available through the `Display control panel` GUI of the `GRAPHIC` program. However it must be recalled that it may be easier to call a plotting command inside the CLI than having to search it deeply hidden in the GUI. That's why in the following only CLI commands are cited (not their GUI counterpart).

OL–7.1–R2 Standard type of plots must be supported, such as:

OL–7.1–R2.1 X-Y plots;
Priority: 1
Grade: A
Summary: Available through the **connect** command.

OL–7.1–R2.2 histograms;
Priority: 1
Grade: A
Summary: Available through the **histogram** command.

OL–7.1–R2.3 contour plots;
Priority: 1
Grade: A
Summary: Available through the **rgmap** command.

OL–7.1–R2.4 vector plots;
Priority: 1
Grade: N Severity: high
Summary: Polarization not yet handled.

OL–7.1–R2.5 2D images;
Priority: 1
Grade: A
Summary: Available through the **plot** command.

OL–7.1–R2.6 wireframe 3D surfaces;
Priority: 1
Grade: A
Summary: Available through the **perspective** command.

OL–7.1–R3 "Blinking" between two different images, or stepping through a set of ordered images, at a user-selected rate and with adjustable transfer functions must be possible.

Priority: 1

Grade: I Severity: high

Summary: Unavailable.

OL–7.1–R4 Standard plotting formats shall be supported, both displayed (e.g. X window) and hardcopy:

OL–7.1–R4.1 There must be at least one designated standard output format (e.g. postscript) that can be converted by the user to a variety of formats using easily obtainable tools.
Priority: 1
Grade: A
Summary: PostScript is `GILDAS` standard.

OL–7.1–R4.2 The Package shall also support the output of a variety of commonly used formats such as FITS, postscript, pdf, gif and/or jpeg.
Priority: 3
Grade: A/E
Summary: FITS, PS, PNG (a free replacement of GIF) are currently available. Adding others should not be a big deal.

OL–7.1–R5 Identification of cursor position shall be available for interactive plots. Where appropriate, this information shall be recordable and exportable. If you "see-it" you should be able to figure out where it came from.

Priority: 1

Grade: A

Summary: Available through the **draw** command.

OL–7.1–R6 An extra "axis" of information shall be encodable on the standard plot types using color and/or intensity.

Priority: 2

Grade: A/E

Summary: Doable through scripts.

OL–7.1–R7 The displays shall have similar look and feel to reduce the plotting learning curve.

Priority: 2

Grade: A

Summary: All `GILDAS` programs use the same graphical library.

2.7.2 Display Appearance and Interactivity

OL–7.2–R1 Plot selection parameters (axes, limits, colormap) shall be conveniently controllable.

Priority: 1

Grade: A

Summary: Available through straightforward options of the **axis**, **limits** and **plot** commands.

OL–7.2–R2 There shall be interactive display zooming and unzooming capability within plot windows.

Priority: 1

Grade: A

Summary: Available through the **zoom** command.

OL–7.2–R3 The plot update speed shall not be a bottleneck. Speed shall be benchmarked, and should be commensurate with comparable plotting packages.

Priority: 1

Grade: A

Summary: Significantly faster than PGPlot.

OL–7.2–R4 Different line styles, sizes, thicknesses and colors must be available. User shall be able to manipulate intensity and color scales, interactively for graphical displays. The setup shall be saveable and reloadable.

Priority: 1

Grade: A

Summary: Different line styles, sizes, thicknesses and colors are available for graphics; interactive LUT are also avaible in the plotting window.

OL–7.2–R5 Basic axis transformations shall be built in to plotting, such as:

OL–7.2–R5.1 Logarithmic amplitude and intensity scale
Priority: 1
Grade: A
Summary: Available through an option of the **wedge** commands.

OL–7.2–R5.2 Different time and coordinate units and formats (e.g. hours, hhmmss, radians, ddmmss.s)
Priority: 1
Grade: A
Summary: Available through the **/abs** and **/unit** option of the **axis** and **box** commands.

OL–7.2–R6 User shall be able to augment plots and produce overlays of different data sets of standard formats:

OL–7.2–R6.1 Images with same axes, size and orientation shall be superposable directly, with basic control of colors and symbols.
Priority: 1
Grade: A
Summary: Available.

OL–7.2–R6.2 Overlay layer style shall be selectable, e.g. contours, greyscale, colormapped (RGB or HSV), or single color (i.e. one layer gets assigned intensity scales of red, another one of green, and one of blue).
Priority: 1
Grade: A/E
Summary: Contour and color are selectable.

OL–7.2–R6.3 Overlay of selectable coordinate grids (e.g. J2000, B1950, galactic, ecliptic, pixel number) shall be available. It must also be possible to overlay multiple grids.
Priority: 1
Grade: A
Summary: Available through the **grid /alternate** command.

OL–7.2–R6.4 The user must be able to overlay functional fits (e.g. polynomials) or points read in from standard tabular files
Priority: 2
Grade: A
Summary: Available through the **curve** command.

OL–7.2–R6.5 It shall be possible to place data sets in “layers” which can be interactively colormapped, and switched on and off.
Priority: 2
Grade: N Severity: med

OL–7.2–R6.6 It shall be possible to display and overlay data with different coordinate systems, i.e. the coordinate system of the display can be chosen independent of the system the data were observed in and the data transformed appropriately with pre-computation.
Priority: 3
Grade: N Severity: low

Summary: All the tools are there to do this and indeed some work is currently done to implement it.

OL–7.2–R6.7 It shall be possible to shift, rotate and scale the images interactively.
Priority: 3
Grade: A/E
Summary: Tools are there but not through GUI.

OL–7.2–R7 Users shall be able to synchronize multiple display windows, for example such that zooming to a given pixel in one image window will select the equivalent pixel in the slaved windows.

Priority: 2

Grade: I Severity: low

Summary: Not currently available.

OL–7.2–R8 Users shall be able to add annotation, both interactively and through scripts, including text with various fonts (including Greek letters), symbols (e.g. all the symbols provided by the LaTeX package with AMSTeX extension), arrows, geometrical figures like boxes and circles, etc.

Priority: 2

Grade: A

Summary: Easy annotation system using Hershey fonts. Not all AMSTeX symbols are available though.

2.7.3 Visibility Data

OL–7.3–R1 Plotting of commonly used basic data and calibration quantities must be straightforward and easily accessible from all relevant tools. Any quantity should be displayable versus any other (or any two plus another encoded as a z-axis or intensity) as long as these quantities are defined for the same visibility or calibration solution interval.

These displayable quantities include:

OL–7.3–R1.1 real and/or imaginary;
Priority: 1
Grade: A

OL–7.3–R1.2 amplitude and/or phase;
Priority: 1
Grade: A

OL–7.3–R1.3 delay and/or rate;
Priority: 1
Grade: N Severity: low

OL–7.3–R1.4 time;
Priority: 1
Grade: A

OL–7.3–R1.5 hour angle;
Priority: 1
Grade: A

OL–7.3–R1.6 parallactic angle;
Priority: 1
Grade: N Severity: med

OL–7.3–R1.7 uv distance;
Priority: 1
Grade: A

OL–7.3–R1.8 u and/or v;
Priority: 1
Grade: A

OL–7.3–R1.9 baseline;
Priority: 1
Grade: N Severity: med

OL–7.3–R1.10 channel or frequency or velocity;
Priority: 1
Grade: A
Summary: Available inside `CLIC`

OL–7.3–R1.11 azimuth and/or elevation;
Priority: 1
Grade: A
Summary: Available inside `CLIC`

OL–7.3–R2 Data selection parameters shall be understandable (e.g. by antenna name or number instead of antenna table entry number, polarization name RR or I) and straightforward, using graphical browsers (in GUI mode) and/or standard selection language (e.g. SQL queries) in script mode.

Priority: 1

Grade: A

Summary: Available through the powerful `CLIC` **find** command but there is no graphical browser.

OL–7.3–R3 It shall be possible to interpolate or extrapolate any tabulated quantity onto a visibility or calibration solution point, and then manipulate these like extra visibility information.

Priority: 3

Grade: N Severity: low

Summary: Is extrapolation a good practice?

2.7.4 Other ALMA Data

Although the Package will not likely be the primary vehicle for the ALMA staff to assess the state of the array, it is intended that users (as well as staff) have the full capability of using ancillary data provided by ALMA to aid in the processing and understanding of their data. Therefore, the Package should be able to deal with this data in as user-friendly a manner as possible.

OL–7.4–R1 The Package shall be able to plot standard ALMA-format ancillary data, including:

OL–7.4–R1.1 amplitude or single-dish power versus AZ and EL;
Priority: 1
Grade: A
Summary: Daily done for PdB data.

OL–7.4–R1.2 focus data and curves;
Priority: 2
Grade: A
Summary: Daily done for PdB data.

OL–7.4–R1.3 pointing data and offset vectors;
Priority: 2
Grade: A
Summary: Daily done for PdB data.

OL–7.4–R1.4 WVR output data;
Priority: 3

Grade: A/E
Summary: Currently in test for PdB use.

OL–7.4–R1.5 holography and beam map data;
Priority: 3
Grade: A
Summary: Indeed it will be used at the Antenna Test Facility!

OL–7.4–R1.6 monitor point values (e.g. temperatures);
Priority: 3
Grade: A
Summary: Daily done for PdB data.

2.7.5 Image-cube Manipulation

OL–7.5–R1 Histograms of pixel values must be easily produced for selected regions of the cube.

Priority: 1

Grade: I Severity: low

Summary: Works well for 2 or 3D, but not for a selected region of the cube.

OL–7.5–R2 It shall be possible to view subsets or slices of data cubes:

OL–7.5–R2.1 for axes aligned with cube faces;
Priority: 1
Grade: A

OL–7.5–R2.2 for arbitrarily aligned axes.
Priority: 3
Grade: A/E
Summary: Command **slice** of **go view** works for any slice in the first 2D.

These shall be interactively selected in GUI mode.

OL–7.5–R3 It must be possible to plot values of the same pixel in different cube layers, or in different images, against each other.

Priority: 1

Grade: I Severity: low

Summary: Trivial but need a script to do so.

OL–7.5–R4 Data cubes must be viewable as movies with selectable frame rates and layer step directions.

Priority: 1

Grade: A/E

Summary: Available through the **go view** command but not yet documented. Also the speed is not controled.

OL–7.5–R5 Interactive display of spectra corresponding to a pixel or region in a displayed image shall be supported.

Priority: 2

Grade: A

Summary: Available through the `go view` procedure.

OL–7.5–R6 Interactive display of a 1D slice taken from a 2D image, such as dragging the line on the map to bring up a position-velocity diagram, shall be available.

Priority: 2

Grade: A

Summary: Available through the `SLICE` task.

OL–7.5–R7 Plotting of spectra on a pseudo-grid corresponding to position on a raster (e.g. a "stamp map" or "profile map", basically thumbnail spectra in panels corresponding to position) shall be possible.

Priority: 2

Grade: A

Summary: Available in `CLASS`.

2.8 Special Features

2.8.1 Simulation

Note: Inclusion of at least moderate simulation capability in the Package will benefit the user who may not have access to the more comprehensive simulator built into the Pipeline and Online systems. In the spirit of providing the user with offline options equivalent to those available in the project, it is desirable that some simulation capability also makes it into the Package albeit at low priority. The main goals would be to allow the user to simulate basic ALMA modes based on input models or images and to replace existing data in ALMA format with simulated data.

OL–8.1–R1 The Package shall inherit the basic simulation capability of the ALMA Online Data Processing Pipeline (Levels 1 and 2) as outlined in ALMA-SW MEMO 11, as per (OL–1.1–R5).

Priority: 2

Grade: A

Summary: Basic simulation capabilities have already been implemented for the ACA evaluation done in 2001.

2.8.2 VLBI

Note: It is assumed that VLBI data will be reduced in whatever package supports general VLBI observations, as ALMA will not be a stand-alone VLBI instrument. There are no VLBI requirements on the ALMA Offline Data Processing Package, though it may end up being the case that the Package also supports VLBI processing. This would have some advantage to users of the ALMA Package, and thus it is worth including a low-priority requirement to this effect.

OL–8.2–R1 It is desirable that the Package also support general VLBI processing suitable for dealing with ALMA data, in order to allow general ALMA users access to VLBI science without having to learn a completely new software package.

Priority: 3

Grade: N Severity: High

Summary: VLBI processing is not available in `GILDAS`.

2.8.3 Solar System Object Observing

The Sun and planets are likely to be important and interesting targets for ALMA observing. The requirements are likely to be strongest on the actual hardware (e.g. high frequency and time resolution) but software compatibility must also be considered. In particular, solar and planetary observations require a special effort in tracking and handling of ephemerides.

OL–8.3–R1 The Package must be able to calculate and compensate for the position of moving objects in the solar system:

OL–8.3–R1.1 Ephemerides must be provided for major solar system objects, including:

OL–8.3–R1.1.1 Sun;
Priority: 1
Grade: A
Summary: This is available in `ASTRO`.

OL–8.3–R1.1.2 Moon;
Priority: 1
Grade: A
Summary: This is available in ASTRO.

OL–8.3–R1.1.3 planets;
Priority: 1
Grade: A
Summary: This is available in ASTRO.

OL–8.3–R1.1.4 major asteroids (all known with 50km dia. greater);
Priority: 1
Grade: N Severity: low
Summary: I don't think any asteriod is included in the ASTRO ephemeris, but there should be no problem at all to include them.

OL–8.3–R1.1.5 known short period comets;
Priority: 1
Grade: N Severity: low
Summary: I don't think any comet is included in the ASTRO ephemeris, but there should be no problem to include them.

OL–8.3–R1.2 Ephemerides must be calculated in all available reference frames (e.g. OL–3.1–R10)
Priority: 1
Grade: A
Summary: This is done by ASTRO.

OL–8.3–R1.3 The Package shall be able to import a user-supplied ephemeris in tabular form.
Priority: 2
Grade: N Severity: med
Summary: I don't think this is easily doable in ASTRO.

OL–8.3–R1.4 The Package shall calculate positions from user-provided orbital elements.
Priority: 2
Grade: N Severity: med
Summary: Not available.

OL–8.3–R2 The Package must carry out astrometry for moving sources.

Priority: 1

Grade: U

Summary: I'm not sure to know what it implies.

OL–8.3–R3 The distance visibility amplitude correction for distance (from ephemeris for major objects, or user-supplied) shall be computed.

Priority: 1

Grade: N Severity: low

Summary:

OL–8.3–R4 The Package must calculate quantities for the "physical ephemeris" for the enumerated major solar system objects, including:

OL–8.3–R4.1 subearth latitude and longitude;
Priority: 2
Grade: N Severity: med

OL–8.3–R4.2 subsolar latitude and longitude;
Priority: 2
Grade: N Severity: med

OL–8.3–R4.3 position angle of North Pole;
Priority: 2
Grade: A
OL–8.3–R4.4 season;
Priority: 2
Grade: N Severity: med
OL–8.3–R4.5 phase angle;
Priority: 2
Grade: N Severity: med

OL–8.3–R5 The Package shall do coordinate transformations from plane-of-sky to planetocentric for a selection of projections, including those of OL–3.3–R4, and in addition:

OL–8.3–R5.1 3-D backprojection (onto the planetary sphere).

Priority: 2

Grade: N Severity: med

OL–8.3–R6 The imaging corrections for the near-field shall be included.

Priority: 2

Grade: N Severity: med

OL–8.3–R7 In addition to the standard models available in the data analysis tools, there shall be provision for:

OL–8.3–R7.1 prolate and oblate ellipsoids;
Priority: 2
Grade: N Severity: med
OL–8.3–R7.2 limb-darkened disks (polynomial, $\cos^n$, Legendre polynomial).
Priority: 2
Grade: N Severity: med

OL–8.3–R8 The Package shall support the 3-D reconstruction of the emission using observations of the target object at different aspect angles and/or rotational phases.

Priority: 3

Grade: N Severity: med

2.8.4 Pulsar Observing

ALMA's pulsar needs will be much easier to satisfy than those of centimeter-wave arrays since dispersion smearing is a non-issue at these frequencies. We expect the main out-of-the-ordinary requirement will be integration into multiple phase bins. A minimum of 16 phase bins would be scientifically interesting. Pulsars have periods as short as 1.6 ms, so a minimum bin size of 0.1 ms would probably suffice. The main use of this binning capability will likely be measuring the on-pulse and off-pulse brightness which can be used to estimate or place bounds on the temperature of the neutron star. Pulsar timing is unlikely to be done with ALMA, barring the installation of specialized hardware. It is conceivable that ALMA would be a great instrument for pulsar parallaxes, especially if pulsars are detectable at 900GHz, and will likely be the best instrument in the southern hemisphere for years to come. The minimal spec of 16 pulsar phase bins would be sufficient for this work.

OL–8.4–R1 The Package shall support the processing of time-series data by folding into multiple phase bins which are synchronous with a user-specified pulsar period.

Priority: 3

Grade: N Severity: low

Summary: `GILDAS` does not support pulsar observing.

OL–8.4–R2 The Package shall support at least 16 phase-bins.

Priority: 3

Grade: N Severity: low

Summary: `GILDAS` does not support pulsar observing.

OL–8.4–R3 Interpolation onto the phase bins from the correlator output (integration times) shall be available.

Priority: 3

Grade: N Severity: low

Summary: `GILDAS` does not support pulsar observing.