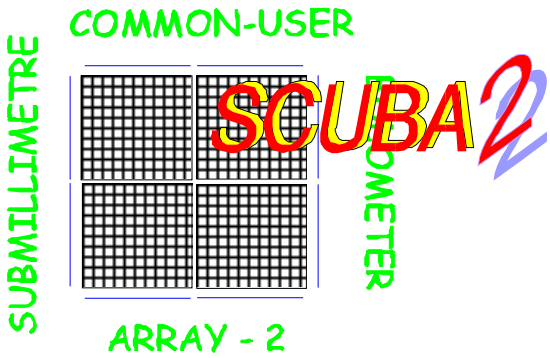

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Change Record

Issue	Date	Section(s) Affected	Description of Change / Change Request Reference / Remarks
0.1	11/21/2003	All	draft version
0.2	11/26/2003	All	Implement feedback to version 0.1
0.3	11/26/2003	All	Clean up to previous version
0.4	11/26/2003	All	Clean up to previous version
0.5	11/29/2003	Intro, table	Pre-delta PDR release
0.6	05/30/2005	All	CDR Release

Table of Content

Introduction

This document is the Compliance Matrix (CM) for developing Data Reduction (DR) Software for use with the SCUBA-2 detector system.

The CM provides a cross reference between the Science Requirements and all other design documents, stemming from the Science Requirements. This document helps clearly identify how the requirements are justified, how they can be complied with and what aspects of the design will ensure that the SCUBA-2 Data Reduction SW will meet the requirements.

The level of compliance may vary from full demonstrable compliance to partial, conditional or no compliance. In the Table below we will indicate full compliance with a double check (√√), while requirements for which we have a clear plan for compliance, but full compliance cannot yet be demonstrated are denoted with a single check (√). It may turn out that during the development some requirements become obsolete or get replaced by others, or that full compliance would make the design unnecessarily complex or unmanageable. Therefore the CM will be updated for each major milestone and whenever a significant change occurs relative to an earlier approved document.

Compliance Matrix

The table lists All requirements captured in the Science Requirements document

- the "Source" column indicates where the requirement is coming from.
  Blank in the source column indicates that the requirement emanates from discussions within the science community.
- the "Number" column contains the reference to the particular requirement in the Science Requirements Document
- the "Description" is the full or abbreviated text of a given requirement In the description "shall" corresponds to requirement, which has to be met, while "should" corresponds to a Goal, which is not absolutely necessary to meet and still produce high quality Data Reduction SW for SCUBA-2
- the "Implementation" section shows the document and its section, which describes the implementation of corresponding requirements.
- the "Level of compliance proven at given project stage" also contains the explanation if it is proven to be in full compliance (√√) or we have planned for achieving full compliance (√) at various stages of the project, such as D (design), S (simulation and designer testing), I (integration and acceptance testing) and C (commissioning).

Requirement			Implementation of requirement			Level of compliance proven at given project stage
Source	No	Description	Docu	Section	Notes	
General Requirements						
JAC	G 1.	The Linux/x86 and Solaris/SPARC operating systems shall be supported for the DR Software.	[3]	1. Introduction		√√ **D**
FPR 5.2.5	GR 2.	The DR Software shall be easy to use, and not require that the observer be an expert in sub-mm techniques or have detailed knowledge of the hardware.	[3]	1. Introduction	Met by adoption of ORAC-DR	√ **C**
JAC [8]	GR 3.	The Software shall conform to the JAC Software Requirements.	[7]	Compliance with DR SW Requirements		√ **I**
FPR 5.2.5 , JAC	GR 4.	All of the DR Software shall be fully compatible with the JCMT OMP and other relevant software maintained by the JAC	[3]	1. Introduction	Met by adoption of ORAC- DR	√√ **D**
FPR 5.2.5 , JAC	GR 5.	The Software shall use the information prepared by the observer through specification of the MSBs (e.g. the name of the recipe as specified in the Observing Tool).	[6]	2.Recipes and Primitives		√ **C**
JAC	GR 6.	Appropriate use shall be made of software already developed at the ATC for running the instrument, and of material already in existence for SCUBA, e.g. from the SCUBA User Reduction Facility (SURF[13]).	[4] [5] [6] [6]	4.1.2.DREAM and STARE 3.3.Skydip 3.Basic SCUBA-2 Recipes 6.TRhe Off-line Pipeline	We will use SURF Skydip and REBIN algorithms and the Data Acquisition algorithms.	√√ **D**
JAC	GR 7.	The software shall run robustly without user intervention				√ **C**
FPR 6.1, JAC	GR 8.	The software shall recover from all common failure modes				√ **C**
	GR 9.	There shall be a small number of data reduction Recipes to select from, with no free parameters.	[6]	3.Basic SCUBA-2 Recipes		√ **S**
FPR 5.2.8 , JAC	GR 10.	The Software shall be flexible enough to allow new observing modes and reduction recipes to be developed if necessary.	[3]	1. Introduction	Met by adoption of ORAC-DR	√ **D**
FRP 4.6.2	GR 11.	The relative calibration precision within a night shall be 5% at 850 μm and 10% at 450 μm				√ **C**
FRP 4.6.2	GR 12	There shall be a procedure to correct for calibration drifts.	[6]	4.1.Calibration		√ **S**
JAC	GR 13.	The DR Software is a purely data-driven system that is no external files shall be required other than the data files themselves, or calibration data which can be selected using the header information.	[3] [6]	1. Introduction	Met by adoption of ORAC-DR	√ **C**

Requirement			Implementation of requirement			Level of compliance proven at given project stage
JAC	GR 14.	The DR Software shall have a facility for over-riding the header data with information from other files.	[6]	4.1.Calibration	Met by the adoption of the ORAC-DR calibration system.	√ **D**
	GR 15.	The data generated by the Pipeline shall conform to a well documented format and content.	[2] [2a]		The whole of ICD2 meets this requirement	√ **I**
JAC	GR. 16	All file sizes shall be kept less than 2GB and shall be able to be manipulated by systems with a 32 bit address space.				√ **S**
FPR 5.2.8	GR. 17	Errors shall be propagated in all data reduction methods.				√ **S**
General Goals						
FPR 4.2.1 .1	GR 18.	The Pipeline should produce images which will be near to publication quality for the majority of users. Later off-line reduction will provide some improve-ment through better calibration, or improved reduction algorithms, for example.				√ **C**
FRP 4.6.2	GR 19.	The relative calibration precision within a night should exceed 5% at 850 µm and 10% at 450 µm, although the actual reasonable expectation is governed by the observation strategy	[6]	4.1.Calibration		√ **C**
JAC	GR 20.	The DR Software should support MacOS X.				√ **D**
Observing Mode Requirements						
FRP 5.2.2 .	MR 1.	All available observing modes shall be supported by the Pipeline.	[6]	3.Basic SCUBA-2 Recipes		√ **I**
FRP 5.2.7 .	MR 2.	In Off-line mode the DREAM or STARE data shall be re-reducible from the raw 200 Hz time series rather than just the 1 Hz images (using the same algorithms).	[6]	6.The Off-line Pipeline		√ **I**
FPR 4.2.1 .3, FPR 5.2.3	MR 3.	There shall be an efficient SCAN reduction method which is fast enough to compute that it does not make the Pipeline fall behind.	[4]	4.1.3 SCAN		√ **S**
	MR 4.	Any reduced image shall not degrade the resolution by more than 10% compared with a perfect telescope beam.				√ **S**
	MR 5.	There shall be no unrecoverable astrometry errors introduced by the DR system which are worse than the resolution at 450 microns.				√ **S**
Observing Mode Goals						

Requirement			Implementation of requirement			Level of compliance proven at given project stage
	MR 6.	Images obtained from each of the observing modes should be reduced in a way which gives demonstrably reproducible results on brightness and morphology of extended sources.				√ **C**
FPR 4.2.1 .3	MR 7.	There should be the possibility of running a nearly lossless SCAN reduction algorithm off-line even although that may take much more computing resources.	[6]	6.The Off-line Pipeline		√ **S**
Pipeline Requirements						
FPR 5.2.3 , JAC	PR 1.	The Data Reduction Pipeline shall not be allowed to feed anything back to the Data Acquisition System (e.g. pointing and focus), during normal observing (i.e. engineering mode can generate reduced data for the instrument), and hence shall not be allowed to be a bottle-neck for taking data.				√ **D**
	PR 2.	Ny default the Pipeline shall be generating just images (which may subsequently be converted to polarization Stokes parameters or an FTS spectal cube).	[6]	3.10.FTS 3.11.Polarimetry observations		√ **S**
	PR 3.	Engineering recipes shall exist for array setup and flat-fielding etc.	[6]	3.1Set-up Arrays and Flatfielding		√ **I**
	PR 4.	Specific Recipes shall be written that will be optimizaed for different situations, e.g. for when there is a bright point source in the map, when large areas are being mapped, or the map is going very deep.	[6]	5.Special Recipes		√ **I**
FPR 5.2.3 , JAC	PR 5.	The Pipeline shall be able to handle the expected data rate, with up to a 30% margin, so that quality control information is delivered in a timely manner in most circumstances.	[6]	3.Basic SCUBA-2 Recipes		√ **S**
	PR 6.	The summit Pipeline shall provide a fully automated calibration procedure	[6]	4.1.Calibration		√ **C**
	PR 7.	The Pipeline shall handle each night's data separately.				√ **D**
	PR 8.	The Pipeline shall generate and store calibration data from each night in order for it to be possible to use the information later.	[2a]	4.4 log.fef		√ **S**
FPR 4.2.1 .2	PR 9.	The noise shall be estimated robustly and accurately based on detector element variances and integration times.				√ **S**
FPR 4.2.1 .2	PR 10.	It shall also be possible to obtain a noise map based on the variances of pixel values among individual images (this is separate from the local spatial variances in the image, which includes confusion and source structure).	[2a]	2. Reduced Data		√ **S**

Requirement			Implementation of requirement			Level of compliance proven at given project stage
FPR 4.2.1 .2	PR 11	A measure of the 'weight per pixel' (the number of recorded bolometer values contributing to each reconstructed pixel) shall be available.	[2a] [4]	2. Reduced Data 4.1.2. DREAM and STARE		√ **S**
	PR 12.	As well as noise estimates, Recipes shall make basic data quality assessments, including the expected range of the data, so that data can be flagged...	[6]	7.Data Quality Parameters		√ **S**
	PR 13.	All images generated by the Pipeline shall have a full astrometry header.	[2a]	2. Reduced Data		√ **S**
	PR 14.	The Pipeline shall be able to process data from the two wavelength channels independently.				√ **S**
FPR 4.2.2 .	PR 15.	The Pipeline shall be able to reduce a combined image at each wavelength (although the DA system deals with each sub-array separately).	[3] [6]	5.1. Data monitoring 3.Basic SCUBA-2 Recipes		√ **S**
Pipeline Goals						
JAC, OMP	PR 16.	Observers will need to know that the observations are proceeding correctly and that the signal-to-noise is improving through the night.	[2a]	4.1 log.integrated		√ **S**
	PR 17.	The Pipeline should be able to correct for pointing drifts using bright sources in fields which are observed multiple times in one night.	[6]	4.2.Mosaicking and "Group" co-adding		√ **S**
	PR 18.	The Pipeline should produce an estimate of the beam-shape at each wavelength, based on bright sources observed during each night.	[6]	4.2.Mosaicking and "Group" co-adding 7.Data Quality Parameters (Beam size FWHM)		√ **C**
	PR 19.	The Pipeline should be able to compare reduced image data with source catalogues extracted from a previous night's data.	[2a]	3.Catalogue Products		√ **S**
Off-line Requirement						
FPR 5.2.7 ,JAC	OR 1.	The Off-line system shall be able to reproduce all of the steps performed by the Data Acquisition System on the raw data	[6]	6.The Off-line Pipeline		√ **S**
	OR 2.	In Off-line mode the Pipeline shall be able to process all 4 sub-arrays as a single unit using the 200 Hz data.	[3]	5.3. Recipe Switching		√ **S**
JAC	OR 3.	In Off-line mode 16 hours of data shall be reducible in 24 hours, including calibration, but this can be implemented using multiple computers.	[6]	6.The Off-line Pipeline		√ **S**
	OR 4.	Off-line mode shall use all the calibration information obtained during the night (as opposed to the on-line mode which can only use calibration data taken prior to the observation).	[6]	6.The Off-line Pipeline		√ **D**

Requirement			Implementation of requirement			Level of compliance proven at given project stage
	OR 5.	The Software shall provide Recipes which are optimized for mosaicing large areas and for carefully combining images taken in the deepest fields.			The proposed rebin-ning algorithm, derived from SURF, will support large areas, assuming the memo-ry and CPU resour-ces are available, but won't necessarily do this in a manner suit-able for survey work.	√ **S**
	OR 6.	The Software shall be able to deal with at least $20^0 \times 20^0$ maps (where the pixel area distortion in the tangent plane projection exceeds 10%), subject to staying within the 2GB file size limit.	[6]	6.The Off-line Pipeline		√ **S**
	OR 7.	The Off-line DR Software shall allow users to include their own algorithms.	[3]	1. Introduction	Met by adoption of ORAC-DR	√ **D**
FPR 5.2.2.	OR 8.	The Off-line Software shall be executable by observers at their home institutions without access to commercial software or any restriction on the basis of software licenses.	[7]	Compliance with DR SW Requirements		√ **D**
Off-line Goals						
	OR 9.	Spectral index plots are not a DR requirement, but they should be easy for users to make in the Off-line System, using information generated by the Pipeline.				√ **C**
	OR 10.	The available Off-line Software should contain a decent, robust source extractor (similar to SEXTRACTOR [9,10] perhaps) which works well in uncrowded fields. This need not be optimized for use in very crowded fields, which is more complicated and research-area driven.				√ **S**
	OR 11.	The Off-line extraction Software also should report a measure of how extended vs. point-like each source is.				√ **S**
	OR. 12.	The available Off-line software should make it relatively straightforward to search for variable or moving objects off-line.				√ **S**
	OR 13.	A full pixel-pixel covariance is probably beyond the scope of the Pipeline Software. However the available tools should make it feasible for a dedicated user to calculate full pixel-pixel covariance themselves.				Not testable in the absence of dedicated user
Display Requirements						

Requirement			Implementation of requirement			Level of compl-iance proven at given project stage
FPR 5.2.5	DR 1.	There shall be a set of near real-time displays available to the observer. These displays may grab partially processed data from the Pipeline data reduction, but they shall not interfere with the running of the main Pipeline.	[4]	1.Introduction, 4.Quick Look Display		√√ **S**
FPR 3.6.3	DR 2.	An early version of the Data Display System shall be ready for use in testing the instrument.	[4]	4.1.2.DREAM and STARE		√ **I**
	DR 3.	A map of the currently taken data shall be displayed, available as fast as possible, but dependent on the observing mode. This will be in Nasmyth coordinates, but with an approximate (RA,Dec) overlay.	[4]	4.1.2.DREAM and STARE		√ **S**
	DR 4.	The most recently co-added map shall also be displayed separately. This shall be available in (RA,Dec) coordinates and be calibrated.	[4] [6]	5.Pipeline Display 4.2.Mosaicking and "Group"co-adding		√ **S**
	DR 5.	There shall be a means of viewing the array variations in near real-time during observing.	[4]	5.Movie Display on-line		√ **S**
ATC	DR 6.	There shall be an Off-line means of viewing the array variations (including the ability to combine data from multiple files).	[4]	5.Movie Display off-line		√ **S**
	DR 7.	For the DREAM mode, frames shall be updated at the same rate they are being written to disk (i.e. As fast as 1Hz), and with essentially no delay behind real-time.	[4]	4.1.2.DREAM and STARE		√ **S**
	Dr 8	The DREAM/STARE Quick Look system shall not fall behind in displaying frames, and should drop the smallest number of frames in order to keep up.	[4]	4.Quick Look Display		√ **S**
	DR 9.	For SCAN mode the image shall be updated every time an individual scan has been completed, with the display appear-ing before the next scan is complete.	[4]	4.1.3 SCAN		√ **S**
	DR 10.	There shall also be a plot of estimated noise in the co-added map. This will be estimated using knowledge of the detector variances and integration times in sub-images.	[6]	4.2.Mosaicking and "Group" co-adding		√ **S**
	DR 11.	A map of the noise of the detector elements measured over a fixed time interval shall be available (used for assessing which detector elements are misbehaving for example).	[4]	4.1. Quick Look Recipes		√ **S**

Requirement			Implementation of requirement			Level of compliance proven at given project stage
	DR 12.	A 'strip-chart' shall be used for displaying time varying data generated by the Pipeline	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 13.	It shall be possible to display multiple strip-charts in a single user interface.	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 14.	It shall be possible to display multiple data sets on the same strip-chart with shared x and y-axes.	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 15.	It shall be possible for the observer to adjust the time period covered by the strip-chart.	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 16.	The y-axis for the strip-chart shall be configurable to either autoscale or use values supplied by the user.	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 17.	It shall be possible to pre-configure the strip-chart so that it can automatically locate the type and location of data it is expected to display (e.g. data from log files, parameter systems etc).	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 18	It shall be possible for more than one strip-chart to be displayed. (e.g. one for the observer and one for the telescope operator).	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 19.	The strip-chart shall include a facility for displaying monitor information, including at least the median power across the array, FCF performance, opacity information (e.g. Water Vapour Radiometer,[12] the CSO tau meter[11] and skydips), and beam sizes.	[4]	6.Strip Chart Diagnostics		√ **S**
	DR 20.	Calibrated images of particular signify-cance (e.g. mosaics) shall be displayed on a separate window so that they remain visible for longer periods than the ongoing co-adds.	[4]	5.Pipeline Display		√ **S**
Display Goals						
	DR 21.	It should be possible to overlay catalo-gues of objects on the co-added images, or import other images to compare.	[4]	4.Quick Look Display 5.Pipeline Display	We will use GAIA for primary image display	√ **S**
	DR 22.	The display of a large area should allow the possibility of pan and zoom function.	[4]	4.Quick Look Display 5. Pipeline Display	We will use GAIA for primary image display	√ **S**
FTS and Polarimetry Requirements						
FPR 5.2.8	XR 1.	The FTS and polarimeter shall be incor-porated into the same reduction Pipeline, but shall require their own Recipes. The first steps in the reduction processes will produce images, which the FTS or polarimetry Recipes can then process.	[6]	3.10.FTS 3.11. Polarimetry observations		√ **D**
POL	XR 2.	Polarization magnitudes and orientations shall be calculated and displayed on the reduced total intensity image by the Pipeline.	[4] [6]	5.Pipeline Display 3.11.Polarimetry observations		√ **S**

Requirement			Implementation of requirement			Level of compliance proven at given project stage
POL	XR 3.	There shall be polarization histograms, along with magnitude and angle signal-to-noise estimates.	[4] [6]	5.Pipeline Display 3.11.Polarimetry observations		√ **S**
	XR 4.	Any Software explicitly needed for handling FTS and polarimetry shall be delivered when those parts of the instrument are delivered.	[7]	External Dependencies		√ **C**
FTS and Polarimetry Goals						
FTS	XR 5	The Display System should provide a means for viewing selected FTS interferograms, spectra, and spectral images.	[4] [6]	5. Pipeline Display Spectral Cubes 4.3.2.FTS		√ **S**
Simulation and Testing Requirements						
FPR 5.2.8 , 6.1	TR 1.	A full working Pipeline shall be available at commissioning for each of the anticipated observing modes.	[5] [7]	3.Reduction Algorithms 4.Schedule Work Breakdown Structure		√ **C**
FPR 5.2.8 , 6.1	TR 2.	Each observing mode shall be tested and documented.	[7]	Quality Assurance		√ **C**
FPR 4.2.1 .3, 4.3.2 .	TR 3.	Observing strategies for scanning the sky,similar to techniques used by other instruments, shall be carefully examined.	[5]	3.Reduction Algorithms		√ **C**
FPR 4.2.1 .3, 4.3.2 .	TR 4.	Several strategies shall be investigated for reducing SCAN data, in order to select the most appropriate one for building into the DR Software.	[5]	4.Schedule		√ **S**
	TR 5.	The testing of SCAN mode reduction shall be used to define specifications for improving the data simulator.	[5]	4.Schedule		√ **S**
External Requirement (the Data Reduction Pipeline Software imposes on other developments)						
	ER 1.	A standard polarization observing mode shall be defined.			Requirement on Polarimetry Work Package	**D**
	ER 2.	The DA System shall not write files larger than 2GB in size.				D
	ER 3.	A set of 200 Hz simulations of the entire array shall be generated in order to test the Software. These simulations shall include sources of noise and instrumental artifacts which are as realistic as possible.			Requirement on ATC	**D**
	ER 4.	The simulations shall generate data files which conform to the final SCUBA-2 DA/DR system interfaces so that they can be used for sub-system testing.				D

Requirement			Implementation of requirement			Level of compliance proven at given project stage
	ER 5.	Simulated skies shall include extended emission as well as point sources, and sources covering the anticipated range of brightness.			Requirement on ATC	**D**
FPR 4.2.1 .2, 4.2.2 .	ER 6.	STARE mode shall be investigated to determine how successful it might be in the presence of realistic atmospheric and instrumental noise and to determine which simple operations on the raw data result in the best images.			Requirement on ATC	**D**
FPR 4.2.1 .3	ER 7.	Further simulations of DREAM mode should be carried out in order to optimize the dither pattern and speed, and to make the algorithm as efficient as possible in the presence of realistic sources of noise.			Requirement on ATC	**D**
JAC	ER 8.	The FTS software shall be called from the Pipeline using a messaging system, and should be fully automated.	[3]			**D**
	ER 9.	There shall be no additional Requirements placed on the Data Reduction Software from the Archiving and Survey teams, without consultation and adequate additional effort to maintain the DR Software schedule.				**D**

Acronyms

ATC – Astronomy Technology Centre
DA – Data Acquisition
DR – Data Reduction
DREAM – Dutch REal-time Acquisition Mode
FITS – Flexible Image Transport System
FPR – Functional and Performance Requirements
FTS – Fourier Transform Spectrometer
MSB – Minimum Schedulable Block
OMP – Observation Management Project
ORAC-DR – JAC data reduction pipeline reducer
POL – Polarimetry
SCUBA – Submillimetre Common User Bolometer Array
SURF – SCUBA User Reduction Facility
WVM – Water Vapour Meter

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