

SIRTF Science Center

Downlink Segment

Subsystem Design Specification

AOT Products Subsystem:
LATIMREPORT

8 November 2000

California Institute of Technology
SIRTF Science Center



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Space Administration



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**THIS IS A PRELIMINARY DOCUMENT, the module described here may
or may not be utilized in the final pipelines as described.**

SIRTF Science Center

Subsystem Design Specification

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1 Revision History

Version	Description	Date
1.0	Initial version	September 26, 2000
2.0	(i) Memory allocation made more efficient: converted double precision FITS I/O to single precision. (ii) Get the UTCS-OBS keyword directly from the image header. (iii) IPAC table output now only reports pixel locations with latents and this output is now optional. (iv) Warning flag written to stdout if number of latent pixels in a plane exceeds 80% (user-specified) of the total number of pixels in an array specific to the instrument. (v) Default maximum number of single-plane images to process has been set to 2000 and this was rigorously tested.	November 8, 2000

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1. Introduction

1.1. Purpose and Scope

The Subsystem Design Specification is a document that describes the basic requirements, assumptions, definitions, software-design details and necessary interfaces for each subsystem. The document will be used to trace the incremental development of each subsystem and also to allow trace-back of levied requirements; this document should have sufficient detail to allow future modification or maintenance of the software by developers other than the original developers. This document is an evolving document as changes may occur in the course of science instrument hardware design and maturity of operational procedures. This document is not intended to repeat sections or chapters from other Project documents; when appropriate, references to proper sections of primary reference documents will be made.

1.2. Document Organization

This document is organized along the major themes of Requirements; Assumptions; Operational Concept; Functional Descriptions; Functional Dependencies; Input; Output; Other S/S Interfaces; Algorithm Descriptions (when applicable); and Major Liens.

The material contained in this document represent the current understanding of the capabilities of the major SIRTf systems. Areas that require further analysis are noted by TBD (To Be Determined) or TBR (To Be Resolved). TBD indicates missing data that are not yet available. TBR indicates preliminary data that are not firmly established and are subject to change.

1.3. Relationship to Other Documents

The requirements on the operation of SIRTf flow down from the Science Requirements Document (674-SN-100) and the Facility Requirements Document (674-FE-100). The Science Operations System is governed by the SOS Requirements Document (674-SO-100). The current document is also cognizant of the requirements that appear in the Observatory Performance and Interface Control Document (674-SEIT-100) as well as the Flight Ground Interface Control Document (674-FE-101). This document is also affected by the FOS/SOS Interface Control Document (674-FE-102) that governs interfaces between the Flight Operations System and the Science Operations System. Related Software Interface Specifications (SIS) will be as indicated in Section 2.2 of this document.

1.4. Change Procedure

This document is a level 4 document according to the SIRTf Project Documentation Plan (674-FE-103). Changes to this document after approval require the approval of the SOS Change Board (TBD). The process for change control is described in the SOS Configuration Management Plan.

2. Overview

The LATIMREPORT program reads in image data from a standard FITS file and performs latent image reporting using an input 'history' list of "persistence-time" FITS images generated by the LATIMDETECT program. The list of persistence time images correspond to image data taken prior to the image where latent reporting is performed. The persistence-time images and input FITS image can consist of different numbers of image planes and all must contain the UTCS-OBS and T_INT FITS header keywords generated by the TRANHEAD module.

The program sorts the images in time-order to determine which pixels in the history image list are likely to persist as latents in the final image. The software produces an 8-bit/pixel FITS image flagging latent pixels with the value of "1" or "0" otherwise. Optionally, a table in IPAC format can also be generated which reports latent-pixel locations. LATIMREPORT is written in standard C.

2.1. LATIMREPORT Requirements

LATIMREPORT is initiated by a startup script under the control of the pipeline executive and does its required functions for a given DCE image or pre-processed DCE image; this involves performing the following tasks.

- A.) Retrieve the command line parameters passed by the start up script and use them to run the program.
- B.) Read in as input a standard FITS file for which a latent-report is requested and a list of "persistence-time" images generated by the LATIMDETECT software.
- C.) Produce as primary output a latent-report FITS image and accompanying table in IPAC format.

D.) Provide exit codes to the pipeline executive and also provides logon and logoff messages identifying the version number and write any error messages to the standard output devices.

E.) Produce a processing summary.

2.2. Applicable Documents

The following documents are relevant to the LATIMREPORT program of the AOT PRODUCTS Subsystems.

A.) The SOS Requirements Document

B.) The SOS Downlink Requirements Document

C.) The SOS Downlink Software Development Guidelines

D.) The following Software Interface Specifications (SIS)

SOSDL-SIS-PD-3000 (real*4 DCE data input/output)

TBR...

2.3. Version History

2.3.1. Version 1.0

Initial version created on September 26, 2000.

2.3.2. Version 2.0

Upgraded on November 8, 2000.

2.4. Liens

It is yet to be decided whether the actual pixel strength (in DN) of a latent will be reported in the final latent-report image instead of a single “flag”. The strengths will also be reported in the table output. The actual final latent intensity will be the sum of all previous latent-producing intensities for that pixel that have decayed “into” the time of observation.

3. Input

3.1. LATIMREPORT Input

LATIMREPORT takes all of its input from either the command line or namelist file, which is set up by the startup script that is controlled by the pipeline executive or standalone. If the namelist is not specified, then all required inputs are expected from the command line. If both namelist and command-line inputs are specified, then the command-line inputs override the namelist values. Prior to reading namelist and/or command-line parameters, default values for the relevant parameters are assigned.

3.1.1. LATIMREPORT NAMELIST Input

LATIMREPORT reads the NAMELIST file whose name is passed to it by start-up script. The name of the NAMELIST is LATIMREPORTIN. The parameters that can be defined in the NAMELIST are listed in Table 1.

1 Namelist variable	Description	Dim.	Type	Units	Default
FITS_Image_List_Filename	Input list of persistence-time FITS-images	161	C	-	Null
FITS_Image_Filename	Input FITS-image filename where latent reporting is performed.	161	C	-	Null

FITS_Out_Filename	Required output FITS-image filename for pixel map of latent pixels	161	R*8	1 or 0 flag	Null
Data_Out_Filename	Optional output IPAC-table filename for latent pixel locations	161	C	-	Null
Log_Filename	Output log filename	161	C	-	Stdout
Ancillary_File_Path	Pathname where supporting source files are installed.	161	C	-	./ (current directory)
Data_Plane	Which FITS data planes to consider in the input list of persistence-time images: 1=All, 2=First, or 3=Last	1	I*4	-	1

Table 1. Namelist file

The following is an example of the contents of a LATIMREPORTIN NAMELIST file that might be used, where the values specified are not necessarily realistic.

```
&LATIMREPORTIN
  Comment = 'Generic namelist file for latimreport, default values.',
  Ancillary_File_Path = '../latimreport_v2',
  FITS_Image_List_Filename = 'latimreport_images.list',
  FITS_Image_Filename = '../test_imgs/TEST_4planes1.fits',
  FITS_Out_Filename = './testing/latent_testout.fits',
  Comment = 'Following is optional: exclude line for no table output',
  Data_Out_Filename = './testing/table_testout.tbl',
  Log_Filename = 'stdout',
  Comment = 'Data_Plane to sample in history images: 1=All, 2=First, 3=Last',
  Data_Plane = 1,
&END
```

3.1.2. LATIMREPORT Command-Line Input

Alternatively, all inputs can be specified via command line, in which case, a namelist file is not needed. Or, inputs can be provided with a hybrid of both namelist and command-line mechanisms, with the latter overriding the former. Table 2 lists the available command-line options associated with their

namelist-variable counterparts, as well as other options for specifying the namelist-file name and making the standard output more verbose.

3.1.3. LATIMREPORT FITS Input

LATIMREPORT uses the FITSIO library routines to read in the FITS-formatted input data file. The routines used are: fits_open_file, fits_read_keys_lng, fits_read_keys_dbl, fits_read_img, and fits_close_file.

Command-line option	Value
-n	Namelist_Filename
-f	FITS_Image_List_Filename
-i	FITS_Image_Filename
-o1	FITS_Out_Filename
-o2	Data_Out_Filename
-l	Log_Filename
-a	Ancillary_File_Path
-p	Data_Plane
-v (verbose switch)	-
-vv (super-verbose switch)	-
-d (debug switch)	-

Table 2. Command-line options

4. Processing

4.1. LATIMREPORT Processing

LATIMREPORT begins processing by writing its name and version number to standard output (verbose mode only), and then it initializes relevant variables with defaults values, and checks that the required namelist parameters and/or command-line parameters were passed to it. If this condition is not true, then it writes a message stating which parameters are missing, recommends a look at this document, and terminates by issuing an appropriate exit code to the pipeline executive; otherwise it proceeds as follows.

If an error occurs during processing, then an error message is written to standard output, a termination-status code is written to the log file, and an exit code to the pipeline executive issued.

After processing, the program name and version number, namelist filename (if used), input, and output filenames, values of other input parameters, date and time, processing time, and a termination-status code are written a log file.

4.2. LATIMREPORT Processing Phases

LATIMREPORT operates in six phases: initialization, data input, image start and end time computation, latent-pixel detection, results output, and termination. This processing level is depicted in Figure 1

4.2.1. LATIMREPORT Initialization

LATIMREPORT initializes itself by performing the following tasks.

- A.) A message is printed to STDOUT (verbose mode only), which includes the program name and version number.
- B.) If specified on the command line, the NAMELIST file is opened and read. If any errors are encountered, a message is printed, and execution aborts.

- C.) The remaining command-line inputs are read and checked for correct data range, consistency, etc. If any errors are encountered, a message is printed, and execution aborts.

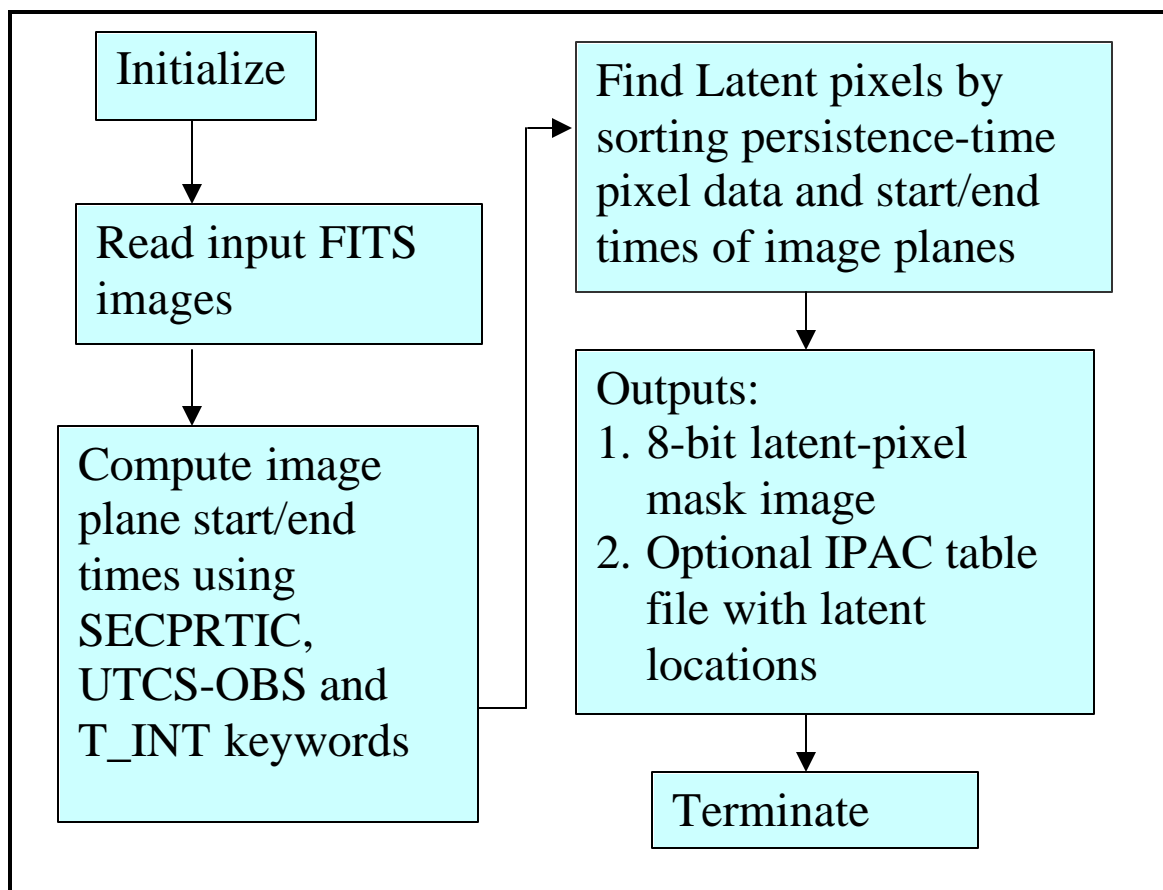


Figure 1. LATIMREPORT data and processing flow

4.2.2. FITS-Image Input

Images are read and stored using dynamic memory allocation. This includes all data planes in the input list of persistence-time images (depending on the p-option setting, not all planes will be processed) and the input image where latent-pixel reporting is performed.

4.2.3. Image Start/End Times

Start and end times in images between which a pixel intensity may persist as a latent are defined as follows: For the k^{th} plane in a “persistence-time” image data cube (p) and the l^{th} plane in an input image data cube (inp):

$$T_p(start) = T_p(UTCS-OBS) + k \ T_INT_p$$

$$T_{inp}(end) = T_{inp}(UTCS-OBS) + l \ T_INT_{inp},$$

where $T_p(UTCS-OBS)$ and $T_{inp}(UTCS-OBS)$ are the start times of the persistence and input image cubes respectively, i.e. the start observation date-time of the first planes where $(k,l) = (0,0)$. T_INT_p and T_INT_{inp} are the respective integration times given by the T_INT FITS header keyword. The value of T_INT must be the same for all planes in any one input image. A further requirement is that the UTCS-OBS keywords must satisfy:

$$T_p(UTCS-OBS) < T_{inp}(UTCS-OBS)$$

4.2.4. Latent-Pixel Reporting

Persistence-time images generated by the LATIMDETECT module (with pixel values in units of “ticks”) are first converted into images with pixel values units of seconds using the SECPRTIC keyword (the number of seconds per 16-bit tick) in the persistence-time image headers. The input persistence-time images for the LATIMREPORT program are based on a model of latent persistence-time versus input pixel strength from test data (see LATIMDETECT for more details).

Given the start time of a persistence-time image plane and the end time of an input image plane, a pixel at location (i, j) will persist as a latent (in the input image) if its corresponding persistence-time, $T_p(i, j)$, satisfies

$$T_p(i, j) > T_{inp}(end) - T_p(start)$$

All pixels in all planes which satisfy this inequality are tracked and reported as a flag with value “1” in the output latent mask image. The program also accounts for cases where bright pixels in the l^{th} plane of the input science image may persist as latents in the $(l + 1)^{th}$ image and beyond.

In a list of persistence time image cubes, one can also specify whether the first, last or all data planes should be included for latent-pixel detection. This is specified via the input parameter `Data_Plane`.

4.2.5. FITS-Image and IPAC-Table Output

The processing statistics are given in the standard output and log file. The calculation results are given in both (optional) IPAC-table and FITS files in different, useful formats. The primary product of this software is an 8-bit FITS image which flags those pixels containing latents to the value of “1” or “0” otherwise. Section 6.0 gives more details on the information included in the outputs.

4.2.6. Termination

Summary output is appended to the log file (the log file is created if previously non-existent), which includes diagnostic reports for the Q/A Subsystem and the appropriate exit code issued to be picked up by the pipeline executive. A detailed list of log file contents is given in Section 6.1.3.

5. Algorithm Specifics

The basics of the algorithm was discussed in the previous section. The following requirements however must be adhered to:

5.1. Assumptions and Requirements

- A.) All input images must have the T_INT and UTCS-OBS keywords in their FITS headers. These keywords are included via preprocessing through the TRANHEAD program.
- B.) All data planes within a single input image must have the same integration time as specified by a single FITS-image header keyword: T_INT. No “dead” (excess) time is assumed to exist between successive planes.
- C.) The start observation times of input list of persistence-time images must precede those of the input image where latent-pixel reporting is performed.
- D.) The input image FITS file where latent-reporting is requested must also have its corresponding persistence-time image included in the list of persistence-time images (namelist variable: FITS_Image_List_Filename).
- E.) The filename list of persistence-time images must list one FITS image filename per line in a single vertical column. They do not have to be listed in any time order as all sorting is done internally.

5.2 Algorithm-Implementation Details

NaN values, saturated and dead pixels, and radiation hits are removed by processing prior and during execution of the LATIMDETECT program which generates persistence-time images. The latent-pixel reporting will therefore not be affected by such artifacts.

The include file latimreport.h specifies parameters for the fraction of latent-pixels tolerated in each input image plane (relative to the total number of pixels in the instrument array). This parameter and its default setting is LATENTPIXFRAC=0.8. A warning message is printed to stdout if this fraction is exceeded and processing continues as normal. The default setting in latimreport.h for the maximum number of *single plane images* to process is 2000. This number can be changed by re-defining *both* the following parameters: MAX_NUMBER_IMAGES and MAX_NUM_PLANES_PER_IMAGE.

6. Output

6.1. LATIMREPORT Output

LATIMREPORT is capable of generating the following output:

- A.) Standard-output processing and status messages. All processing stages can be tracked by specifying the verbose (-v) switch on the command line.
- B.) An 8-bit FITS image representation of the latent pixels in terms of a flag value set to “1” if the pixel contains a latent, and “0” otherwise.
- C.) An optional IPAC-table file containing latent-pixel locations. Ancillary information on input parameters is given in the table header. See below for more details.
- D.) A log file (unless directed to “stdout”) containing processing statistics and status messages.

All LATIMREPORT disk output is written to the pathnames that are specified with the output filenames in the command-line or namelist inputs.

6.1.1 LATIMREPORT FITS Output

LATIMREPORT uses the FITSIO library routines to create FITS-formatted output data files. The routines used are: fits_read_key_lng, fits_insert_key_lng, fits_create_file, fits_open_file, fits_copy_hdu, fits_flush_file, fits_write_key, fits_update_key, fits_write_date, fits_write_key_str, fits_write_key_fixflt, fits_write_img, fits_get_hdrspace, fits_read_record, fits_write_record, and fits_close_file.

6.1.2 LATIMREPORT (Optional) IPAC-Table Output

Latimreport outputs an IPAC-table containing the following information in the header: program name and version number, date and time of calculation, input-image filename, input filename containing

persistence-time image list, persistence-time conversion factor in units of seconds per tick, input latent-reporting image integration time, its start observation time, number of planes, and number of latent pixels in each image plane. The table columns represent the following: Latent label number, plane number in input image to which this corresponds to and pixel coordinates of the latent.

Below is a snippet of an example table produced with inputs specified by the example namelist file given in Section 3.1.1.

```
\character comment = Output from latimreport, version 2.00
\character Date-Time = Wed Nov 1 12:03:31 2000
\character inputFITSfile = ../../test_imgs/TEST_4planes1.fits
\character inputFITSimageLIST = latimreport_images.list
\real SecondsPerTick = 0.050000
\real IntegrationTime = 100.000000
\real startTIME = 3204000.000000
\integer Number of Planes = 4
\integer Number_of_Latents_in_Plane 1 = 2
\integer Number_of_Latents_in_Plane 2 = 23
\integer Number_of_Latents_in_Plane 3 = 27
\integer Number_of_Latents_in_Plane 4 = 21
```

Latent_No.	Plane_No.	Column	Row
i	i	i	i
1	1	16	58
2	1	128	103
1	2	59	16
2	2	183	49
3	2	68	53
4	2	16	58
.	.	.	.
1	3	34	33
2	3	101	34
3	3	183	49
4	3	212	56
5	3	16	58
1	4	34	33
2	4	101	34
3	4	40	38

6.1.3 LATIMREPORT Log-File Output

The information stored in the log file at the output of this program includes: program name and version number, values of all namelist and/or command-line inputs, a message indicating the type of calculation performed, status code, processing time, date and time, and a message indicating program termination.

7. Testing

Latimreport has been successfully unit-tested as a stand-alone program for a variety of different input cases. The tests were designed to check latimreport robustness and capability of generating corrected results.

Here is a summary of the unit tests that were conducted:

1. Executed latimreport with inputs read from and output written to directories different from where the program was run. Both namelist and command-line input mechanisms were exercised.
2. Executed latimreport with input persistence images consisting of single planes as will apply to IRAC. Also executed with different numbers of planes for the input persistence images as will apply to MIPS.
3. Executed latimreport by using only specific planes in the input persistence images (the Data_Plane parameter).
4. Executed latimreport with a *single* persistence-time image data cube to test cases where latents persist between planes of a single cube.
5. Executed latimreport for all combinations of input parameters, in order to test that they function properly.
6. Executed latimreport on large 2048 x 2048 (COSMIC) images.

7. Tested with 2000 single plane (16-bit/pixel, 256x256) images, taking 20 min. processing on a 128MHz, 128MB RAM Ultra-10 workstation.

8. Usage Examples

Using a namelist file with verbose (-v) setting and re-directing verbose output messages to a file "out.log":

```
latimreport -n latimreport.nl -v | & tee out.log
```

Without using a namelist file:

```
latimreport -f persistence_image.list -i input.fits -v -a ../ancpath -  
o1 latent_image.fits -o2 latent_table.tbl
```

9. Glossary

DCE	Data Collection Event
DN	Data Number
IOC	In-Orbit Checkout
SDS	Subsystem Design Specification
SIS	Software Interface Specification
TBD	To Be Determined
TBR	To Be Resolved
UTCS	Universal Co-ordinated Time in Seconds