MSI L1 PRODUCT DEFINITIONS

VOLUME A: NOMINAL PRODUCTS

ECGP

DRL REF: ECGP-TS-02

Prepared by: ECGP Team

Approved by: X

Juan Aguilar
Quality Manager

Authorized by: X

Manuel Ruiz
Project Manager

Code:	EC.ICD.GMV.MSI.00001
Version:	2.0 ESA redline version
Date:	13 Mar 2017
Internal code:	GMV 21585/15 V3/16

DOCUMENT STATUS SHEET

Version	Date	Pages	Changes
01.00	15/05/2015	27	Version for the TRR2 First issue of the document In the first draft of this docunment, information related to product definition has been extracted from the original ICD and included in this document. Following changes have been implemented: • L0 Product definition moved back to ICD • Support Files definition moved back to ICD • Intermediate Data Files definition moved back to ICD • Land/Water Mask is needed as input. • Calibration product split in three differenent products and definitions moved to volume B • New fields in output products for the height and land water mask • Band dimension removed from L1C fields that are corregistered (the information was redundant). • StateVector Quality added for all MSI L1 Products No bar changes are included because more than 30% of the document has been changed.
01.01	22/07/2015	22	Version for the TRR2 Close-out Following RIDs have been implemented: • RID-TRR2-43: Clarified that the headers are also included in the netCDF4/HDF5 datablock (sections 5.6, 5.7 and 5.8) • RID-TRR2-42: Sections 4 a 6 of version 01.00 removed. Subsections 7.x of version 01.00 reviewed. • RID-TRR2-47: Packaging of L0 and L1 products in a ZIP file. Additional changes: • CCDB_Redundancy field added for each acquisition time.
01.02	12/10/2016	23	Version for the AR2 Close-out Following RIDs have been implemented: DL-MSI-11: PixelQuality values defined.
02.00	13/03/2017	22	Interface change for the MSI Nominal L1b and MSI Regridded L1c products implementing EarthCARE metadata convention. Redline version generated by ESA

TABLE OF CONTENTS

1. INTRODUCTION 5
1.1. PURPOSE 5
1.2. SCOPE 5
2. APPLICABLE AND REFERENCE DOCUMENTS 6
2.1. APPLICABLE DOCUMENTS 6
2.2. REFERENCE DOCUMENTS 6
3. TERMS, DEFINITIONS AND ABBREVIATED TERMS 7
3.1. DEFINITIONS 7
3.2. ACRONYMS 7
4. MSI INSTRUMENT OVERVIEW 9
4.1. MSI OPTICS 9
5. MSI L1 NOMINAL PRODUCTS 17
5.1. TRANSFER MECHANISM 17
5.2. FILE NAMING CONVENTION 17
5.3. DIMENSIONS 17
5.4. SIZE AND FREQUENCY OF TRANSFERS 17
5.5. DATA DEFINITION 18
5.6. DATA STRUCTURE 18
5.7. MSI_NOM_1B 18
5.8. MSI_RGR_1C 20

LIST OF TABLES AND FIGURES

Table 2.1: Applicable Documents 6
Table 2.2: Reference Documents 6
Table 3.1: Definitions 7
Table 3.2: Acronyms 7
Table 5.1: MSI NetCDF Dimensions 17
Table 5.2: MSI L1 products size and frequency of transfers 17

Figure 4.1: VNS Optical Design 9
Figure 4.2: TIR Optical Design 10
Figure 4.3: Exagerated Spatial Distorsion 11
Figure 4.4: Aperture Error 12
Figure 4.5: VNS Detector Zone & Area Layout 13
Figure 4.6: TIR Detector Zone & Area Layout 14
Figure 4.7: TIR Reference Mask Layout 15

1. INTRODUCTION

1.1. PURPOSE

This document has been produced in the frame of the "EarthCARE Ground Processor" project and its purpose is to describe the format and content of the L1 nominal and regridded products for the MSI processor.

1.2. SCOPE

This document has been derived from the original ICD where all interfaces (commanding, monitoring, input and output data) were described. In this document, the information related to MSI L1B Nominal and MSI L1C Regridded Products has been extracted from the original ICD and has been included in this dedicated document.

2. APPLICABLE AND REFERENCE DOCUMENTS

2.1. APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form part of this document to the extent specified herein. Applicable documents are those referenced in the Contract or approved by the Approval Authority. They are referenced in this document in the form [AD.X]:

Table 2.1: Applicable Documents

Ref.	Title	Code	Version	Date
[AD.1]	Earth Observation Mission CFI Software - General Software User Manual	EO-MA-DMS-GS-0002	4.1	07/05/2010
[AD.2]	ECSIM Interface Control Document	ECSIM-DMS-TEC-ICD01-R	1.7	18/11/2008
[AD.3]	Architecture of the ESSS and ECGP	EC.TN.ASD.SY.00017	7	19/12/2014
[AD.4]	Volume 0 Products Definitions - Introduction	EC.ICD.ASD.SY.00004	8	12/12/2014
[AD.5]	Volume 1 Products Definitions - Common Products Definitions	EC.ICD.ASD.SY.00005	8	20/08/2014
[AD.6]	ESSS and ECGP Common Interface Control Document	EC.ICD.ASD.SY.00009	8	09/12/2014
[AD.7]	Requirements for the ESSS & ECGP	EC.RS.ASD.SYS.00007	8	26/05/2010
[AD.8]	MSI ECGP Algorithm Theoretical Baseline Document	EC.TN.SSTL.MSI.00014	14	31/10/2013
[AD.9]	Generic PDS-IPF Interface Guidelines	MMFI-GSEG-EOPG-TN-07-0003	1.8	03/08/2009
[AD.10]	Space Engineering - Software	ECSS-E-ST-40	C	06/03/2009
[AD.11]	Volume 4a Products Definitions – MSI L0 Products Definitions	EC.ICD.ASD.ATL.00020	6	11/12/2014
[AD.12]	Volume 6 Products Definitions – Auxiliary Data	EC.ICD.ASD.SY.00025	6	12/12/2014
[AD.13]	Earth Explorer Ground Segment File Format Standard	PE-TN-ESA-GS-0001	2.0	03/05/2012
[AD.14]	ECGP Interface Control Document (ICD)	EC.ICD.GMV.SY.00001	02.02	12/10/2016

2.2. REFERENCE DOCUMENTS

The following documents, although not part of this document, amplify or clarify its contents. Reference documents are those not applicable and referenced within this document. They are referenced in this document in the form [RD.X]:

Table 2.2: Reference Documents

Ref.	Title	Code	Version	Date
[RD.1]	List of Acronyms and Abbreviations	EC.LI.ASD.SY.00001	4	10/01/2013
[RD.2]	Volume 4b Products Definitions – MSI L1 Products Definitions	EC.ICD.ASD.ATL.00023	5	09/03/2012
[RD.3]	MSI L1 Product Definitions Volume A: Calibration Products	EC.ICD.GMV.MSI.00001	01.02	12/10/2016

3. TERMS, DEFINITIONS AND ABBREVIATED TERMS

3.1. DEFINITIONS

Concepts and terms used in this document and needing a definition are included in the following table:

Table 3.1: Definitions

Concept / Term	Definition

3.2. ACRONYMS

General EarthCARE abbreviations are in [RD.1]. Specific abbreviations used in this document are given below.

Acronyms used in this document and needing a definition are included in the following table:

Table 3.2: Acronyms

Acronym	Definition
ATLID	ATmospheric LIDar
BBR	EarthCARE Broadband Radiometer
CCDB	Characterisation/Calibration Database
ECGP	EarthCARE Level-1 Ground Processor
ESSS	EarthCARE Satellite System Simulator
FHN	Friedrichshafen – Germany
GERB	Geostationary Earth Radiation Budget
GUI	Graphical User Interface
HMI	Human-Machine Interface
H/W	Hardware
ICD	Interface Control Document
IMDD	Instrument Measurement Data Definition
ISP	Instrument Source Packet
LW	Long-Wave
MDS	Measurement Data Stream
MSI	MultiSpectral Imager
PCD	Product Confidence Data
PDD	Product Definition Document
PDGS	Payload Data Ground Segment
SCOE	Spacecraft Check-Out Equipment
SRDB	Spacecraft Reference Data Base
SW	Short-Wave
S/W	Software
TDS	Test Data Set
TOA	Top Of Atmosphere
TW	Total Wave
UV	Ultra-Violet
WGS	World Geodetic System

4. MSI INSTRUMENT OVERVIEW

The Multi-Spectral Imager (MSI) comprises two separate co-mounted instruments:

- The Thermal Infrared (TIR)
- The Visual, Near-Infrared and SWIR (VNS).

4.1. MSI OPTICS

4.1.1. VNS OPTICS

The diagram below shows the layout of the VNS optics.

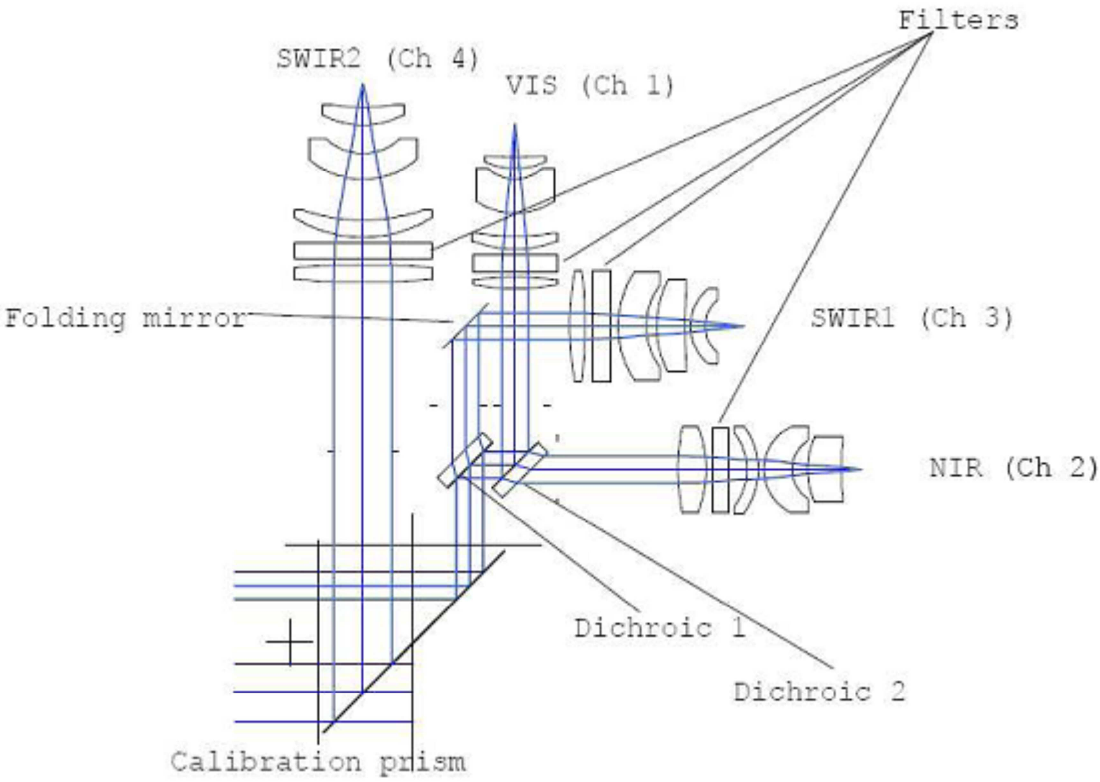

Figure 4.1: VNS Optical Design

The VNS optical section consists of four separate telescopes pointing through two apertures. One common aperture is provided for VIS, NIR and SWIR1 channels; plus a dedicated aperture for SWIR2. All channels share the same calibration source, using a shutter for dark calibration, and a diffuser prism for viewing sunlight for “sun” calibration.

4.1.2. VNS OPTICS

The diagram below displays the TIR instrument optical design.

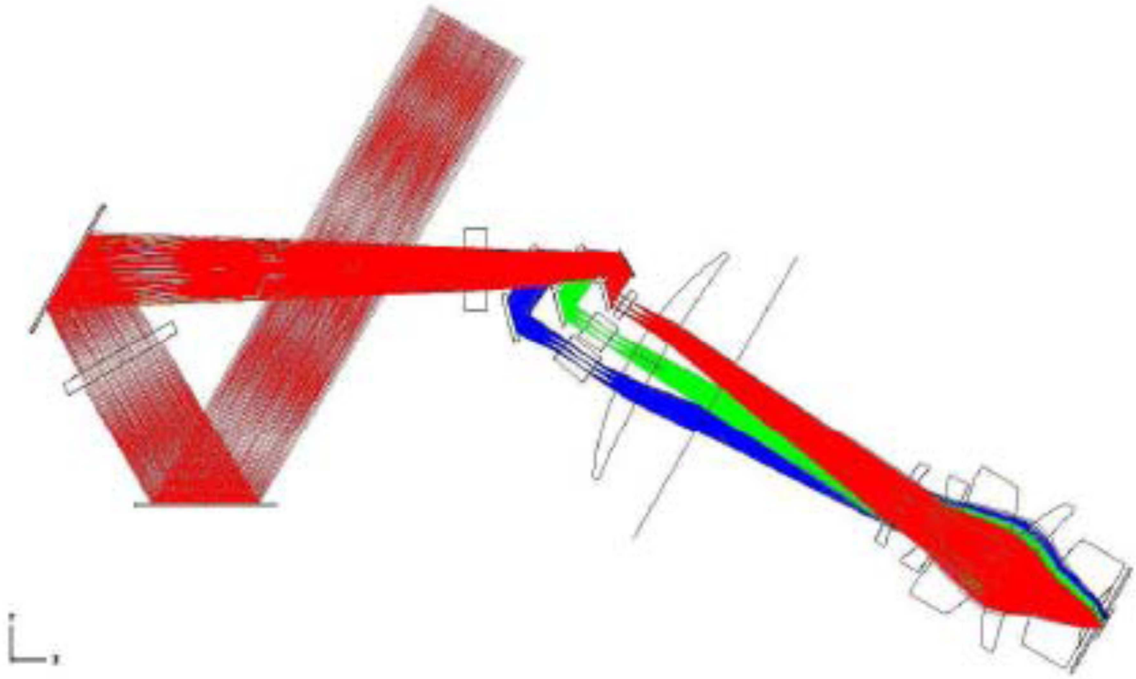

Figure 4.2: TIR Optical Design

All three TIR bands share signals from the same aperture, but they follow different optical pathways within the instrument (despite there being a single lens system). Also, they inhabit different spectral domains.

This also illustrates how the TIR optics also forms images on the detector array of various reference zones of the Filter Mask (in addition to the three filtered signal bands). The two sets of reference rows (Reference A and Reference B) will be imaged and combined by the FEE to create the Background Reference Band that forms an additional output channel. Because they are imaging a uniform flux field, any optical distortions in these reference areas are largely self-cancelling.

4.1.3. LENS DISTORSION

Slight aberrations in the optical pathways through the lens systems mean that at different radii from the optical axis images may be slightly displaced along the radial direction (Spatial Distortion).

They may also be brought to a focus at slightly different depths (Focal Distortion). When the focal point lies marginally in front of, or behind, the detector surface, the slight blurring of the image involves blending of adjacent ray-bundles.

For the VNS bands the detectors will always be centred across the optic axis of each telescope, thereby eliminating any along-track Spatial Distortion. There does however remain the problem of very slight nonuniform lateral displacement.

In the TIR, two of the bands are using detector rows situated some distance from the mid-line, so spatial distortions may involve both along-track and lateral displacement errors. The diagram below shows this effect (greatly exaggerated).

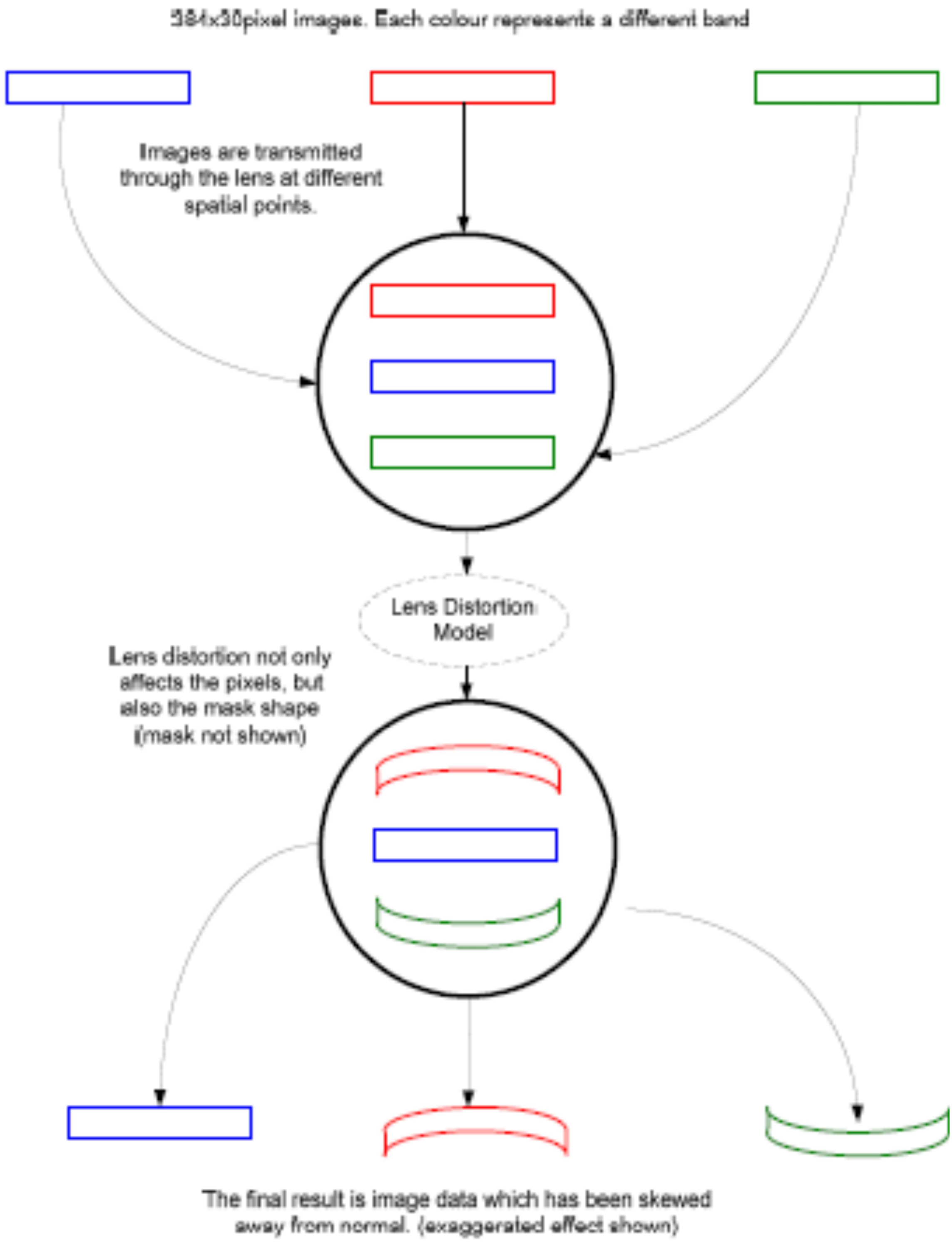

Figure 4.3: Exagerated Spatial Distorsion

The spatial displacement at a target pixel can be entirely defined (even for movements of several pixel widths) by its 2-D Transfer function.

4.1.4. APERTURE DIFFRACTION

Diffraction occurs when light waves are passed through an aperture, causing the appearance of an observed aperture image to change. Due to the far-field location of observation and the planar nature of un-stopped waves, these are diffracted as they pass through the aperture. The diagram below shows this effect:

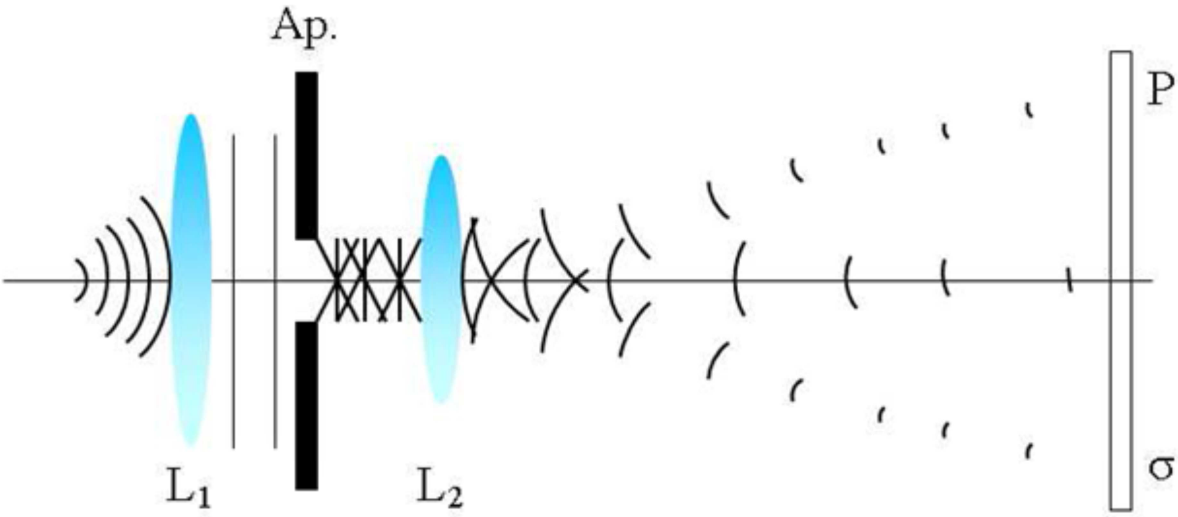

Figure 4.4: Aperture Error

It is believed that this effect will only be noticeable over a very small number of pixel rows/columns bordering the mask edge.

4.1.5. MULTIPLE REFLECTIONS

Any even number of reflections off optical surfaces can result in some flux taking unintended optical pathways and potentially falling on the wrong pixels, in some cases very distant from the nominal principal ray.

Although care has been taken to minimise multiple reflections by the use of various lens coatings, the process is imperfect. While successfully attenuating most of the more distant "ghost images" to a point where they can be ignored, there are still some low-level effects apparent in the optical modelling.

Lambertian (diffuse) stray light does not need to be specifically modelled, as it merely contributes to an elevated background illumination. This is explicitly detected in reference regions and used to correct signal readings.

4.1.6. SPECTRAL TRANSMISSION LOSS

Both the VNS and TIR instruments have been designed to incorporate a calibration mode that images explicit reference emitters. This allows the total effective sensitivity of each sensor pixel to be independently assessed (and regularly reassessed), so there is never any reason to directly compare their uncorrected outputs. It is assumed that any differences caused by transmission loss would in any case be only a few percent, and that the surviving flux at every sensor pixel would always be more than sufficient to allow for adequate measurement.

4.1.7. OUT-OF-BAND CROSS-TALK

For the VNS instrument, it is thought that this effect can be ignored, due to the high out-of-band rejection of the dichroic mirrors that split the optical path before any non-planar optical components, and the bandspecific filters that will further limit any cross-talk.

For the TIR there is a slight possibility that some out-of-band reflected energy might infiltrate a band sensor.

4.1.8. MSI DETECTORS

During the course of the conversion of the SFF via analogue electrical voltage readings into the digital data to be returned by the instrument there are various physical processes that degrade what would ideally be a simple linear transform.

For the different spectral bands of the MSI, the flux is detected by sensors employing widely different technologies. Within the VNS CMOS devices are used: the Visible and Near IR channels use linear Silicon arrays, while the SWIR channels use InGaAs. The TIR bands are all detected using a single 2-D microbolometer array.

The differing sensitivities, thermal behaviours and noise characteristics of these detectors demand different strategies in order to maximise the SNR of collected Signal Fields. This gives rise to a number of patterns of usage, such as: varying the integration time; averaging multiple readings (Oversampling); or, in the TIR, remeasuring a ground-line as it transits across several different sensor rows (a technique known as Time Delay & Integration, or TDI).

4.1.9. VNS DETECTOR

Each VNS detector contains 512 pixels. However, a maximum of 384 pixels can be accommodated in each ground-line ISP, so the outer 64 at each end are ignored. A physical mask is then applied to the next 20 pixels in from each end of the detector, providing zones of “blind” pixels that receive no incident flux. Within these zones, 16-pixel reference areas are defined, and are used to read out background offsets. To preclude fringing effects, a 6-pixel guard area is maintained between these reference areas and the central 336 image pixels.

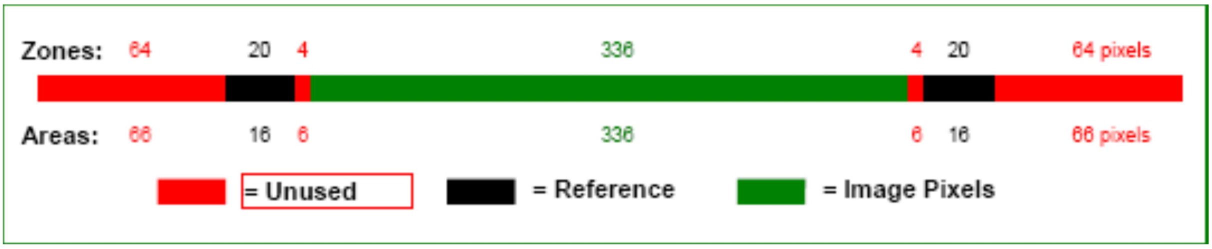

Figure 4.5: VNS Detector Zone & Area Layout

The Silicon detectors used for the VIS and NIR bands have fairly low dark-current noise but high read-out noise. This favours taking relatively long exposures to maximise SNR. By contrast to this, the InGaAs detectors used for the SWIR1 and SWIR2 bands are characterised by a high dark-current signal. This means that they tend to saturate quickly so can be used for only relatively short integration periods.

To overcome this problem, each detector is read out multiple times.

4.1.10. TIR DETECTOR

The exact layout (in terms of zones and detected areas within them) is illustrated below, using only the first 144 rows of the 288-row detector:

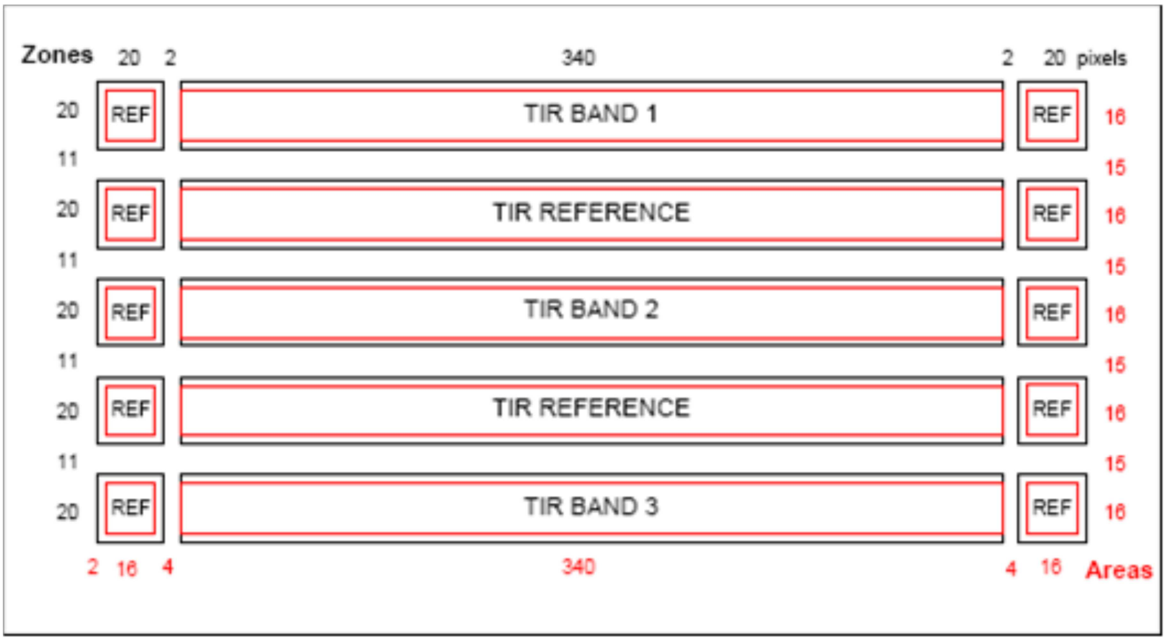

Figure 4.6: TIR Detector Zone & Area Layout

The TIR micro-bolometer has a number of characteristics that imposes constraints on acceptable patterns of reading.

Firstly, the thermal capacity of each sensor limits how fast it can follow changes in incident flux, incurring an unavoidable lag of a few milliseconds. Then there is the problem of readout-induced heat. The device is read out on a rolling-shutter basis, cycling through the 5 sets of 16 "useful" rows (3 signal bands and 2 reference bands), selecting one row at a time.

During the "exposure" time that each row is selected, its thermo-resistive current gets integrated after which all of its pixels are read-out in parallel. However, this integration current itself generates additional heat which must be discounted from the reading acquired. It also imposes limits on the acceptable integration period. No row can remain selected for too long or else thermal damage will result.

A degree of automatic compensation for local ambient temperature differences across the detector array is provided internally by comparing the reading from an exposed sensor element, with that of an internal "blind" partner element.

These factors guide the choice of regime for TIR detection, giving a maximum exposure time of around 10 ms iterating for 7 read cycles within each 70 ms dwell-time. Of these, some 4 or 5 readings are aggregated to improve the SNR of readings.

4.1.11. TIR REFERENCE AREAS

To ease thermal control and testing, the TIR instrument structure will be run at a constant warm temperature, typically 20°C (293K). This means that, at the detector, the images of band inputs will always be overlaid by the thermal emissions coming from the optical system itself. The spectral bandwidths of scene images (seen through their band-limiting filters) are two orders of magnitude smaller than the full spectral sensitivity range of the detector, so this background contribution will always dominate. Cold calibration mode will provide a measure of this contribution which can (and will) be subtracted electronically from readings to retrieve the much smaller residual scene image values.

If the temperature of the optical structure remained constant, this correction would suffice, but in practice this will be hard to achieve. Small fluctuations in structure temperatures will produce relatively large errors in apparently cold scene temperatures: the signal increase due to a 1K drift in background temperature at 293K would (if uncorrected) produce an apparent deviation of 3.6K in a Band 5 feature that is at 220K. It is therefore important to provide a runtime calibration mechanism to counter this effect.

This is achieved by always reading additional reference areas on the detector which will be imaging zones of the Filter Mask assembly that lie in-between, and at either end of, the filtered band apertures. The dielectric Filter Mask coatings are highly reflective out-of-band, so most of the radiation reaching the detector through the optics is an image of the surface of the Filter Mask assembly (with a much smaller contribution coming from other internal areas of the instrument due to double reflections in the relay lens).

It is arranged that both the filtered band apertures, and the reference structures beside and between them, will reflect (imaged onto the detector array) radiation coming from a common "internal reference" source area. This internal reference will be thermally isolated and controlled in temperature over the period between absolute calibrations.

The diagram below shows the proposed layout of the imaged Filter Mask zones on the detector array (measurements are in detector pixels). Within these zones lie the (smaller) regions that are actually to be read from the detector array. From the layout it can be seen that all captured regions will lie well within their Filter Mask zones. (Exact pixel dimensions are specified later, in Figure 12: TIR Detector Zone & Area Layout).

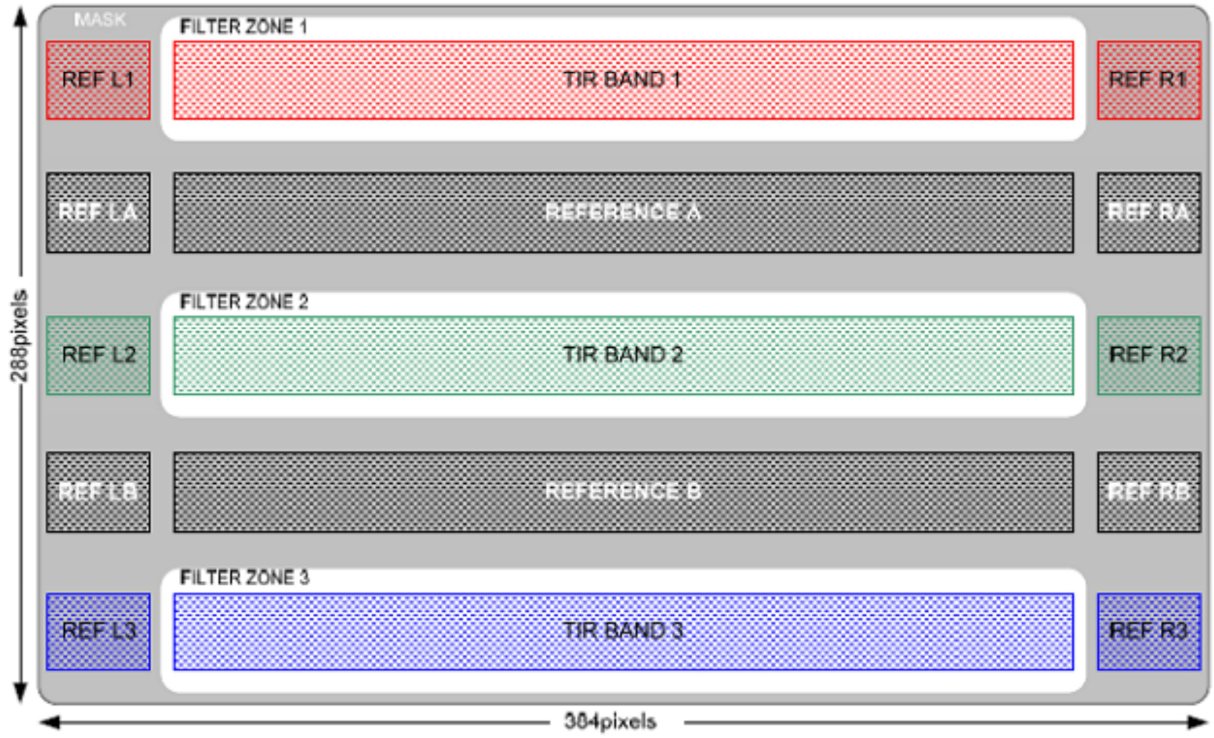

Figure 4.7: TIR Reference Mask Layout

4.1.12. CO-ALIGNMENT OF VNS AND TIR INSTRUMENTS.

To properly fulfil its function as a Multi-Spectral Imager, all sensor bands are nominally to be aligned onto the same ground-line. To assist in this, both TIR and VNS instruments are mounted on a shared Optical Bench Module (OBM) so that they can be carefully aligned pre-launch. However, due to mechanical tolerances in construction and assembly, there is the potential for minor misalignments between the fields of view.

These pointing discrepancies (a.k.a. co-alignment errors) between the optical pathways to each detector can give rise to horizontal and lateral relative mismatch between the detector centre-points, while any rotational (tilt) errors in mountings would cause bands to be no longer precisely parallel to each other.

Such mispointing errors are currently expected to result only in sub-pixel imaging displacements.

4.1.13. VNS BAND CALIBRATION MODES

The VNS Instrument is capable of being operated in two Calibration modes: (Dark and Sun).

For Dark Calibration, the sensors are shielded from all input radiation.

For Sun Calibration, a diffusing prism reflects sunlight onto the input aperture, which then passes through the filters to provide a known reference calibration signal for each band.

4.1.14. TIR BAND CALIBRATION MODES

The TIR Instrument will also support two Calibration modes: (Warm and Cold).

For Cold Calibration, the input aperture is pointed (via a rotatable mirror) at deep space (deemed to be close to 0 degrees Kelvin).

For Warm calibration, all bands are presented with a view of a blackbody reference source of known temperature.

Note: Content of current section (including text and figures) has been completely extracted from [RD.2]

5. MSI L1 NOMINAL PRODUCTS

MSI L1 Nominal Products are generated by the MSI L1 Processor.

5.1. TRANSFER MECHANISM

All EarthCARE Products are composed by two physical files:

- One XML for the headers (*filemane*.HDR)
- One binary file for the records containing the data (*filename*.h5)

Both files are located into a ZIP package with the same name (i.e. *filename.ZIP)*.

5.2. FILE NAMING CONVENTION

The file naming convention for the EarthCARE Products is described in [AD.5].

5.3. DIMENSIONS

Following table contains all dimensions used in the definition of the MSI L1 Nominal products.

"Name" is used in the description of the product datablock below (for brevity).

"Dimension label" is the actual name of the dimension in the NetCDF product.

Table 5.1: MSI NetCDF Dimensions

Name	Description	N Elements	Dimension label
t	Dimension used to define variables depending on the number of samples recorded during the measurement time	Variable	along_track
b	Dimension used to define variables that are Band dependant	7	band
pix	Dimension used to define variables that contain arrays of pixels	384	across_track

5.4. SIZE AND FREQUENCY OF TRANSFERS

Being 1/8 of orbit the nominal time frame for the EarthCARE L1 products, the size of the MSI L1 products is given for such time frame i.e. 1/8 of orbit. Following table summarises the sizes and frequency of generation of MSI L1 Nominal and Regridded products.

Sizes below are provided without margin and assume no compression (as reliable compression rates cannot be provided at this stage). For real products VNS bands will contain fill values during eclipse, which will allow for significant file size reductions when compressed.

Table 5.2: MSI L1 products size and frequency of transfers

MDS type	Size	Frequency of transfer	Comments
MSI_NOM_1B	1120 MB	8 per orbit.	Assuming 10.000 acquisition times at 14.49 Hz, there are 11,5 minutes of acquisition, i.e. 1/8 of 92 minutes (approximately one orbit).
MSI_RGR_1C	275 MB	8 per orbit.	Same as for MSI_NOM_1B, but latitude, longitude, surface_elevation, and land_flag are only provided for one band.

5.5. DATA DEFINITION

MSI L1 Products have different components, but there is a common structure for all of them. In this structure is included the Fixed Product Header and the main Product Header which are identical for all products and so it is described below.

5.6. DATA STRUCTURE

MSI L1 Products have different components, but there is a common structure for all of them. This structure is presented in the table below.

Table 5.3: L1 Product logical structure

HeaderData
FixedProductHeader
VariableProductHeader
MainProductHeader
SpecificProductHeader
ScienceData

According to the above structure, the products are physically composed by:

- Headers (FixedProductHeader and VariableProductHeader) included in the XML file
- ScienceData included in the netCDF4/HDF5 binary file (which also contains the headers)

There are two different MSI L1 Products, sharing this structure. In this structure it is included the FixedProductHeader and the MainProductHeader which are identical for all products and so it is described only once below.

5.7. MSI_NOM_1B

This is the Nominal MSI L1B product. It is separated in the four components described below.

5.7.1. MSI_NOM_1B FIXED PRODUCT HEADER

The FixedProductHeader is common for all ECGP products and is defined in Products Definitions Volume 1 [AD.5].

5.7.2. MSI_NOM_1B MAIN PRODUCT HEADER

The MainProductHeader for the MSI L1B Products is identical to the MainProductHeader defined in Products Definitions Volume 1 [AD.5] but with following predefined values specific to MSI L1B Nominal product:

- fileCategory = "MSI_"
- productType = "NOM_"
- productLevel = "1B"

5.7.3. MSI_NOM_1B SPECIFIC PRODUCT HEADER

This is the SpecificProductHeader for the Nominal MSI L1B Products.

Table 5.4: MSI_NOM_1B Specific Product Header

#	Field Name	Type	Total size	Description/Value
1	CCDBVersion	NC_BYTE	1	Reference to the CCDB version used to process this data

#	Field Name	Type	Total size	Description/Value
2	GroundLineCount	NC_INT	4	Total number of ground lines in this data set
3	InvalidGroundLineCount	NC_INT	4	Number of invalid ground lines in this data set
4	InvalidPixelCount	NC_INT	4	Total number of invalid or out of range pixels in the remaining valid ground lines

5.7.4. MSI_NOM_1B SCIENCE DATA

The Science Data of this product is formatted as NetCDF/HDF5 file and have following fields:

Table 5.5: MSI NOM L1B Datablock structure

Field Name	#Dims	Dimensions	Type	Units	Description
pixel_values	3	b, t,pix	NC_FLOAT	Wm-2sr-1 Or Kelvin	Corrected pixel values. Radiance in Wm-2sr-1 for bands VIS/NIR/SWIR1/SWIR 2 and Temperature in Kelvin for TIR channels
latitude	3	b, t, pix	NC_DOUBLE	deg	Latitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
longitude	3	b, t, pix	NC_DOUBLE	deg	Longitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
solar_azimuth_angle	3	b, t, pix	NC_FLOAT	deg	Solar azimuth angle per pixel
solar_elevation_angle	3	b, t, pix	NC_FLOAT	deg	Solar elevation angle per pixel
sensor_azimuth_angle	3	b, t, pix	NC_FLOAT	deg	Sensor azimuth angle per pixel
sensor_elevation_angle	3	b, t, pix	NC_FLOAT	deg	Sensor azimuth angle per pixel
surface_elevation	3	b, t, pix	NC_FLOAT	m	The height of this point
land_flag	3	b, t, pix	NC_BYTE	unitless	Flag which indicates if 1 = land 0 = water
pixel_quality_status	3	b, t, pix	NC_BYTE	unitless	MSIPixelQuality Enumeration

Field Name	#Dims	Dimensions	Type	Units	Description
					0: PIXEL_OK 1: PIXEL_DEAD 1: PIXEL_SATURATED 1: PIXEL_SUNGLINT 1: PIXEL_OTHER_ERROR 1: PIXEL_GUARD 1: PIXEL_DEGRADED
pixel_values_relative_error	2	b, t	NC_FLOAT	percent	Calculated error tolerance level for this dataset.
time	1	t	NC_DOUBLE	seconds since 1 Jan 2000 00:00:00 UTC	Sensing time
state_vector_quality_status	1	t	NC_INT	unitless	S/C State Vector Quality field copied from the ISP Private Science Data Header
ccdb_redundancy_flag	1	t	NC_BYTE	unitless	Flag to identify the redundancy configuration. 0=nominal chain 1=redundant chain

5.8. MSI_RGR_1C

This is the Regridded MSI L1C product. It is separated in the four components described below.

5.8.1. MSI_RGR_1C FIXED PRODUCT HEADER

The Fixed Product Header is common for all ECGP products and is defined in Products Definitions Volume 1 [AD.5].

5.8.2. MSI_RGR_1C MAIN PRODUCT HEADER

The Main Product Header for the MSI L1C Products is identical to the Main Product Header defined in Products Definitions Volume 1 [AD.5] but with following predefined values specific to MSI L1C Regridded product:

- fileCategory = "MSI_"
- productType = "RGR_"
- productLevel = "1C"

5.8.3. MSI_RGR_1C SPECIFIC PRODUCT HEADER

This is the Specific Product Header for the Regridded MSI L1C Products.

Table 5.6: MSI_RGR_1C Specific Product Header

#	Field Name	Type	Total size	Description/Value
1	CCDBVersion	NC_BYTE	1	Reference to the CCDB version used to process this data
2	GroundLineCount	NC_INT	4	Total number of ground lines in this data set
3	InvalidGroundLineCount	NC_INT	4	Number of invalid ground lines in this data set
4	InvalidPixelCount	NC_INT	4	Total number of invalid or out of range pixels in the remaining valid ground lines

5.8.4. MSI_RGR_1C SCIENCE DATA

The Science Data of this product is formatted as NetCDF/HDF5 file and have following fields:

Table 5.7: MSI RGR L1C Science Data structure

Field Name	#Dims	Dimensions	Type	Units	Description
pixel_values	3	b, t, pix	NC_FLOAT	Wm-2sr-1 Or Kelvin	Corrected pixel values. Radiance in Wm-2sr-1 for bands VIS/NIR/SWIR1/SWIR2 and Temperature in Kelvin for TIR channels
latitude	2	t, pix	NC_DOUBLE	deg	Latitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
longitude	2	t, pix	NC_DOUBLE	deg	Longitude per pixel. The reference height of this point will be the DEM if it is provided as input. Otherwise, the reference height will be the ellipsoid (i.e. h=0). The DEM is referenced to the ellipsoid WGS84.
solar_azimuth_angle	2	t, pix	NC_FLOAT	deg	Solar azimuth angle
solar_elevation_angle	2	t, pix	NC_FLOAT	deg	Solar elevation angle
sensor_azimuth_angle	2	t, pix	NC_FLOAT	deg	Sensor azimuth angle
sensor_elevation_angle	2	t, pix	NC_FLOAT	deg	Sensor azimuth angle
surface_elevation	2	t, pix	NC_FLOAT	m	The height of this point
land_flag	2	t, pix	NC_BYTE	unitless	1 = land 0 = water
pixel_quality_status	3	b, t, pix	NC_BYTE	unitless	MSIPixelQuality Enumeration 0: PIXEL_OK 1: PIXEL_DEAD 1: PIXEL_SATURATED 1: PIXEL_SUNGLINT 1: PIXEL_OTHER_ERROR 1: PIXEL_GUARD 1: PIXEL_DEGRADED
pixel_values_relative_error	2	b, t	NC_FLOAT	percent	Calculated error tolerance level for this dataset.
time	1	t	NC_DOUBLE	seconds since 1 Jan 2000 00:00:00 UTC	Sensing time
state_vector_quality_status	1	t	NC_INT	unitless	S/C State Vector Quality field copied from the ISP Private Science Data Header
ccdb_redundancy_flag	1	t	NC_BYTE	unitless	Flag to identify the redundancy configuration. 0=nominal chain 1=redundant chain