

# ***MSG Level 1.5 Image Data Format Description***

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## Document Change Record

<i>Issue / Revision</i>	<i>DCN. No</i>	<i>Changed Pages / Paragraphs</i>
1		New
2		Author changed from Y. Buhler and J. Flewin to C. Rogers. Sections 1, 2 and 7 updated.
3		Author changed from C. Rogers to K. Dammann and J. Mueller Section 2.2 rewritten. Section 3.1.5 on the alignment of the HRV and non-HRV images and their datums inserted. Note 3 in Section 3.1.7 deleted. Section on PSF deleted. Section 4.1 updated. General information in Section 5.2 deleted (now covered by Section 2.2). Information on temperature encoding included for "FCU temperatures" in Section 7. Instrument ground characterisation moved from Section 2 into Appendix A Table and text on the stability of interchannel spatial registration updated.
v4		Author changed from K. Dammann and J. Mueller to G. Fowler. Data in Appendix A transferred to separate Technical Note Section 7.1.3 addition of star ID table
V5		Update following the ECP 833, change to effective radiance: Author changed from G. Fowler to Johannes Müller - Section 1.2 Document Structure: Reference to section 3.1 deleted. - Section 1.4 Reference Documents Reference to "internal" ICDs removed Reference to [OGC] removed, because the document is not available Introduced reference to spectral and PSF characterisation TEN/0005-10 - Section 3.1 Receiving Level 1.5 Data:

<i>Issue / Revision</i>	<i>DCN. No</i>	<i>Changed Pages / Paragraphs</i>
		<p>Deleted, because outdated.</p> <ul style="list-style-type: none"> <li>- Section 3.2.7 Pixel Value Representation: Explains the difference between effective and spectral radiance.</li> <li>-Section 5.6 Where to Find Pixel and Data Representation Information? Reference to section 3.1 deleted.</li> <li>-Section 6.1 Level 1.5 Header Summary: “Header Version” parameter explained differently</li> <li>-Section 6.1.4 Image Description Record Summary: “Level1_5ImageProduction” parameter explanation updated.</li> <li>-Section 6.1.7 IMPF Configuration Record Summary: Added note that this is not disseminated.</li> <li>-Section 7.1 15HEADER Record Structure: Pointed out that 15HeaderVersion is not disseminated.</li> <li>-Section 7.1.4 Image Description Record: Change of PlannedChanProcessing from Boolean byte to enumerated byte.</li> <li>-Section: 7.1.7 IMPFConfiguration Record: Pointed out that IMPF configuration record is not disseminated Added recommendation not to use this record. Added information on “maxIncidentRadiance” Corrected information on “IncidenceRadiance”</li> </ul> <p>Appendix A: Fully removed</p>
V5A		Corrected editorial error in 7.1.4
V6		<p>Improved description on straylight processing:</p> <ul style="list-style-type: none"> <li>- 3.1.11 Updated for clarity</li> <li>- 7.2.5 Improved description of StraylightCorrectionFlag and StraylightCorrection</li> <li>- Appendix A, B, C added to illustrate the use of straylight information.</li> </ul>

<i>Issue / Revision</i>	<i>DCN. No</i>	<i>Changed Pages / Paragraphs</i>
v7		<p>Sections 6.1.5 and 7.2.5 updated to reflect the addition of GSICS information to:</p> <p>Radiometric Processing Record                      MPEFCalFeedback                      IMPF_CAL_Data</p> <p>This change consists of replacing:</p> <ul style="list-style-type: none"> <li>• CalMonBias by GSICSCalCoeff</li> <li>• CalMonRms by GSICSCalError</li> <li>• OffsetCount by GSICSOffsetCount</li> </ul> <p>N.B.: The first two of those three fields were not filled in the past, and the third one was statically set to 51.</p> <p>Sections 6.1.7 and 7.2.7 updated to include reprocessing version.</p> <p>Section 7.2: Description of NominalLongitude and LongitudeOfSSP updated, following misunderstandings by users.</p>
V8		<p>Sections 3.1.4 and 7.2.6 updated to reflect the fix of the geometric offset problem in 2017.</p>

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## **1 INTRODUCTION**

### **1.1 Purpose and Scope – Intended Readership**

Level 1.5 image data is the result of the processing of the satellite raw data (designated as Level 1.0 data) and constitutes one of the main products of the Meteosat Second Generation (MSG) system. The designation ‘Level 1.5’ corresponds to image data that has been corrected for all unwanted radiometric and geometric effects, has been geolocated using a standardised projection, and has been calibrated and radiance-linearised. The Level 1.5 data is suitable for the derivation of meteorological products and further meteorological processing.

Ancillary information is also available for Level 1.5 data in the form of a ‘Header’ and an ‘Trailer’ to the imagery data. These components provide valuable side-information necessary to allow full interpretation, validation and calibration of the imagery data to be made.

The purpose of this document is to:

- Provide an introduction to the MSG system to new users who wish to familiarise with the MSG imagery data.
- Act as a reference document for routine MSG data users who are considering to optimise the usage of the ancillary data, the extraction of new meteorological products from Level 1.5 data, or the generation of new applications based on it.
- Provide detailed explanatory text on the ancillary information to expert users with particular areas of specialisation such as image navigation, image radiometric & geometric quality, calibration, etc.

In short, the goal of the document is to ease the access to the information and therefore to promote the usage of Level 1.5 image data and its ancillary information.

The reader should be aware that this document describes the ‘native format’ of the Level 1.5 data, as explained further in the section on applicable documents. Depending on the type of data service and data product, the user may or may not have access to all the data described.

### **1.2 Document Structure**

The document is structured as follows:

- [This introduction](#) details the purpose and scope of this document and explains its relation to the other documents concerning the MSG System.
- [Section 2](#) presents an overview of the Level 1.0 image acquisition process by the instrument and provides an introduction to the SEVIRI instrument characteristics (acquisition, On-Board Calibration principle).
- [Section 3](#) presents the detailed overview of the Level 1.5 data. The most recent information on the basic characteristics and performance figures for the Level 1.5 image data are provided.
- [Section 4](#) defines the structure of the Level 1.5 dataset. A synoptic diagram shows the top-level organisation of the dataset in Records, and can be used as a navigation aid to the more

detailed Record information. The section also presents the rationale for defining the Level 1.5 dataset structure as it is.

- [Section 5](#) has the goal to provide the reader with a help to locate desired information in the numerous Records of the Level 1.5 dataset. It is organised by major topics and areas of expertise that can be of interest to the users (like “Where to find information on Calibration, Radiometry, Image Quality, etc...”). For each of these topics, the Records of the Level 1.5 dataset containing the relevant information are clearly identified.
- [Section 6](#) contains the list of Data Content Summary for all the Records of the Level 1.5 dataset. For each Record, the actual meaning and background of the information, its dynamics and its relation to the image data is presented.
- [Section 7](#) finally provides the most detailed information on the Level 1.5 Records, down to the format of the single variables and arrays. This section corresponds to the Detailed Data Content of the Level 1.5 dataset (at Interface Control Document Level). It is advisable to read also Section 5 and/or Section 6 before using this information to ensure correct understanding of the background and actual meaning of the data.

### 1.3 Applicable Documents

The following MSG documents are applicable to this document. They take precedence in case of conflict:

<b>[EURD]</b>	End Users Requirements Document, Issue 2.2, EUM/MSG/SPE/013.
<b>[GS]</b>	LRIT/HRIT Global Specification, Issue 2.6, August 1999.
<b>[MSI]</b>	MSG Ground Segment LRIT/HRIT Mission Specific Implementation, Issue 5, EUM/MSG/SPE/057.
<b>[GSDS]</b>	Ground Segment Design Specification, Volume F: Data Types and Encoding Rules. Issue 1.3, January 1999, EUM/MSG/SPE/055.

The [EURD] is a top-level document summarising the requirements on the MSG system, and in particular, the image quality requirements.

The [GS] is the basic document defining the transmission scheme used for the dissemination of the Level 1.5 data (for the users receiving the Level 1.5 data via the dissemination service).

The [MSI] is based on the previous document but provides the MSG-specific extensions to this transmission scheme.

The [GSDS] volume F contains the detailed information related to the representation of binary values for the different data types (INTEGER, REAL, TIME).

## 1.4 Reference Documents

The following documents provide additional information about ground characterisation data:

<b>[MET8PSF]</b>	MSG-1 SEVIRI Modulation Transfer Function Characterisation, EUM/MSG/TEN/06/0005, Issue 1, 19 January 2006.
<b>[MET9PSF]</b>	MSG-2 SEVIRI Modulation Transfer Function Characterisation, EUM/MSG/TEN/06/0006, Issue 1, 19 January 2006.
<b>[MSG3PSF]</b>	MSG-3 SEVIRI Modulation Transfer Function Characterisation, EUM/MSG/TEN/06/0007, Issue 1, 19 January 2006.
<b>[MSGSRC]</b>	MSG SEVIRI Spectral Response Characterisation, EUM/MSG/TEN/06/0010, Issue 1, 19 January 2006.

## 2 OVERVIEW OF LEVEL 1.0 DATA ACQUISITION

The Level 1.0 data correspond to the image data as acquired by the MSG satellite before any ground processing has taken place. The Level 1.0 image data are acquired by the Spinning Enhanced Visible and IR Imager (SEVIRI) of the MSG satellites.

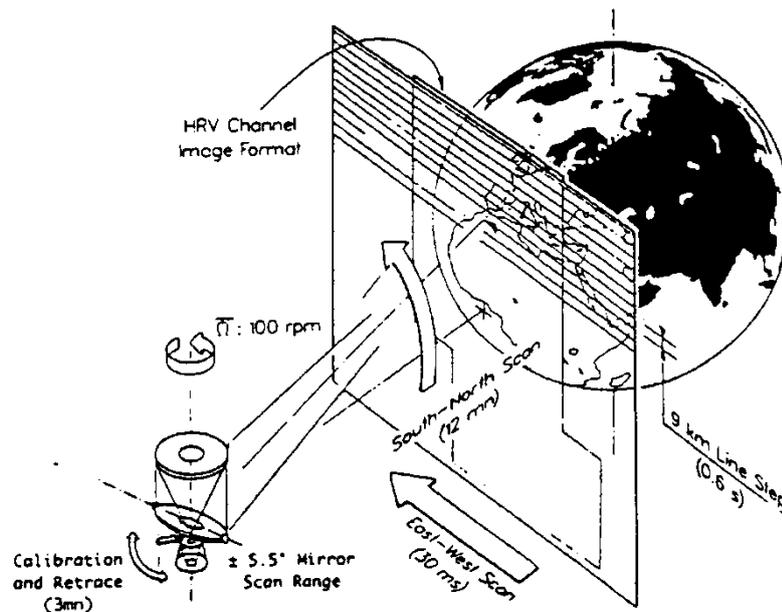
### 2.1 SEVIRI Description

#### 2.1.1 Image Acquisition Principle

The SEVIRI instrument is designed to produce the image of the Earth full disk from a spinning geostationary satellite.

The scanning of the Earth disk is obtained by using the satellite spin (100 rpm +/- 1%) in the East-West direction and by stepping a flat scan mirror in the South-North direction after each East-West line, to set up the instrument for acquiring the scan of image data.

Figure 1 shows the Earth imaging principle used by SEVIRI.



*Figure 1 – Earth imaging principle*

One complete revolution of the satellite lasts 0.6 seconds of which only about 30 milliseconds are available over the Earth disk to acquire one scan. After the 30ms spent imaging the Earth, the remaining 570ms are used mainly for scan mirror stepping, data transmission and deep space data acquisition for Direct Current Removal (DCR).

The image nominal repeat cycle is 15 minutes, including on-board radiometric calibration and scan mirror retrace. Shorter repeat cycles are programmable if an image of a reduced area of Earth is required (see also Section 3.1.2).

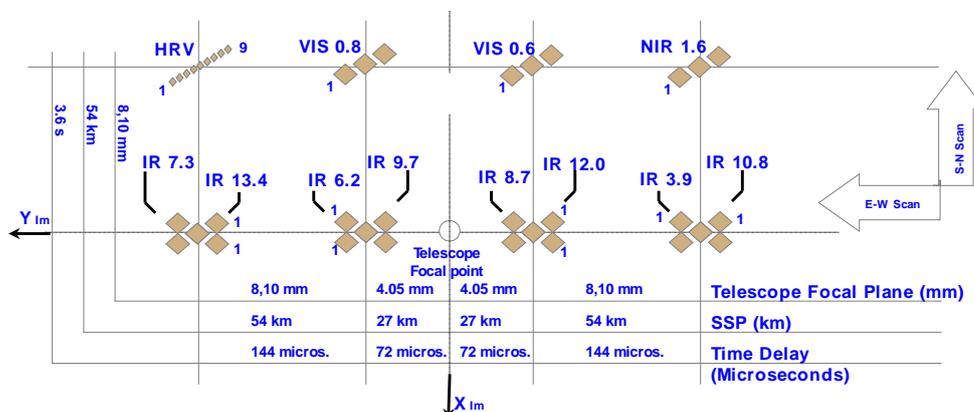
## 2.1.2 Focal Plane Arrangement

The instrument generates images of the Earth in 12 different spectral channels, from visible to infrared, with a sampling distance corresponding nominally to 3 km at Sub Satellite Point (1 km for High Resolution Visible channel on a reduced Earth area).

These channels are known as either 'cold' channels (IR3.9, IR6.2, IR7.3, IR8.7, IR9.7, IR10.8, IR12.0, IR13.4) or 'warm' or 'solar' channels: HRV, VIS0.6, VIS0.8, NIR1.6.

For each spectral channel there are three detectors, hence in one revolution of the satellite, three lines of image are acquired simultaneously. For the HRV channel there are 9 detectors and 9 lines are obtained per revolution.

The SEVIRI focal plane arrangement is shown in Figure 2.



**Figure 2 – SEVIRI focal plane arrangement**

The East-West alignment of the detectors in each channel is obtained by delaying the acquisition of the detectors according to their position in the focal plane. The East-West alignment of the channels is obtained by re-addressing the image rows (done by on-ground processing). The South-North alignment is obtained by re-addressing the image rows (this is also done by on-ground processing).

Note that for Level 1.0 (raw) data only, the '1' next to each set of detectors in the diagram indicates the order in which the data from the 3 (9 for HRV) detectors appears in the Level 1.0 data. Detector marked '1' appears first, followed by the centre detector of the group, then the detector furthest from the marked '1'. For HRV the detector marked '1' is first, followed by the other 8 up to the one marked '9'.

### 2.1.3 Channel Characteristics

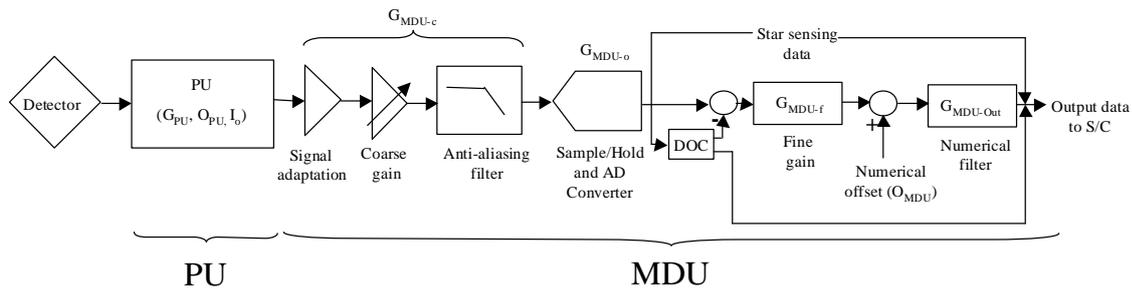
Channel ID	Absorption Band Channel Type	Nominal Centre Wavelength ( $\mu\text{m}$ )	Spectral Bandwidth ( $\mu\text{m}$ )	Spectral Bandwidth As % of energy actually detected within spectral band
HRV	Visible High Resolution	Nominally 0.75	0.6 to 0.9	Precise spectral characteristics not critical
VIS 0.6	VNIR Core Imager	0.635	0.56 to 0.71	98.0 %
VIS 0.8	VNIR Core Imager	0.81	0.74 to 0.88	99.0 %
IR 1.6	VNIR Core Imager	1.64	1.50 to 1.78	99.0 %
IR 3.9	IR / Window Core Imager	3.92	3.48 to 4.36	98.6 % <sup>(1)</sup>
IR 6.2	Water Vapour Core Imager	6.25	5.35 to 7.15	99.0 %
IR 7.3	Water Vapour Pseudo-Sounding	7.35	6.85 to 7.85	98.0 %
IR 8.7	IR / Window Core Imager	8.70	8.30 to 9.10	98.0 %
IR 9.7	IR / Ozone Pseudo-Sounding	9.66	9.38 to 9.94	99.0 %
IR 10.8	IR / Window Core Imager	10.80	9.80 to 11.80	98.0 %
IR 12.0	IR / Window Core Imager	12.00	11.00 to 13.00	98.0 %
IR 13.4	IR / Carbon Dioxide Pseudo-Sounding	13.40	12.40 to 14.40	96.0 %

### 2.1.4 Detection Chain Scheme

The amplification of the detector signal is done in two stages:

- a preamplifier unit (PU)
- and a main detection unit (MDU)

Each stage applies several amplification factors and offsets to the signal. The block diagram of the SEVIRI detection chain is shown in the following Figure:



**Figure 3 – SEVIRI detection chain**

The sequence of operations performed by the detection chain on the detector signal is described by the following equation.

$$C(E_L) \equiv G_{MDU-Out} \cdot \{ G_{MDU-f} \cdot [ G_{MDU-0} \cdot G_{MDU-c} \cdot (G_{PU} \cdot E_L - O_{PU} + I_0) - DO ] + O_{MDU} \}$$

- $C$  is the Counts at the instrument output
- $E_L$  is the signal coming from the detectors (it includes the dark signal  $E_D$ )
- $G_{PU}$  is the parameter called **PUGain** in the 1.5 header. There is one value of **PUGain** per detector (42 values). It is programmable by TC.
- $O_{PU}$  is the parameter called **PUOffset** in the 1.5 header. The **PUOffset** is programmable per detector except HRV, VIS0.6 and VIS0.8 (27 values). This offset is used to remove most of the dark current and the instrument self-emitted radiance in order to fully exploit the dynamic range for the Earth signal
- $I_0$  is a fixed current that is set to the appropriate value. It is not included in the 1.5 Header
- $G_{MDU-c}$  is the parameter called **MDUCoarseGain** in the 1.5 header. There is one value of **MDUCoarseGain** per detector (42 values). It is programmable by TC.
- $G_{MDU-0}$  is a fixed gain that is set to the appropriate value. It is not included in the 1.5 Header
- $DO$  is the parameter called **DCRValues** in the record “RadiometricProcessing” of the 1.5 header. There is one value of **DCRValues** per detector (42 values). Each value is obtained by averaging 2048 values acquired during Deep Space View.
- $G_{MDU-f}$  is the parameter called **MDUFineGain** in the 1.5 header. There is one value of **MDUFineGain** per detector (42 values). It is programmable by TC.
- $G_{MDU-Out}$  is the parameter called **MDUOutGain** in the 1.5 header. There is one value of **MDUOutGain** per detector (42 values). It is programmable by TC.

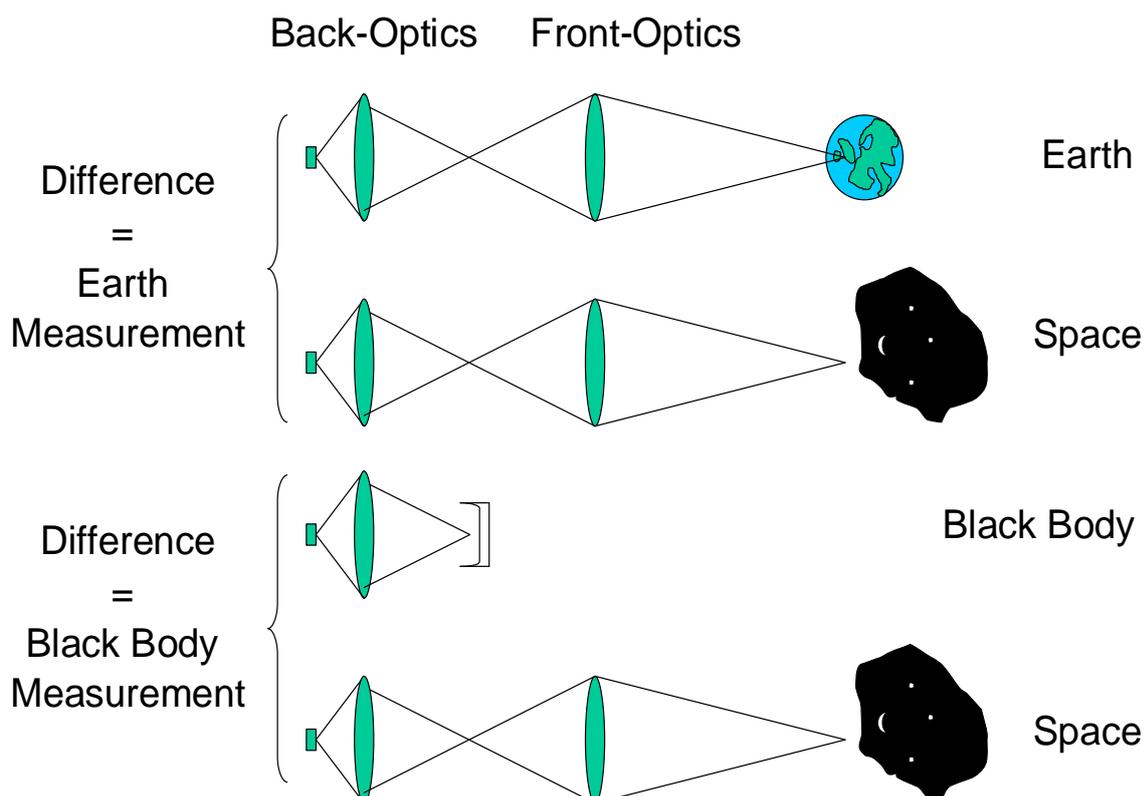
Note: all these parameters are calibrated out by the calibration procedure. A few parameters are not provided in the 1.5 level header because they are fixed. The variable ones are provided in the 1.5 header (see Sections 3, 4 and 5).

## 2.2 On-board Calibration Principle

In the SEVIRI 3-mirror telescope, the incoming Earth radiance is reflected on the primary telescope mirror M1 by a flat scan mirror that is used to adjust the line of sight in North-South direction for scanning. The primary mirror transfers the light through the central hole of the scan mirror onto the secondary and tertiary mirrors, M2 and M3, from where the light is focussed onto the detectors via a relay optic. A black baffle on the centre of the M1 mirror reduces the stray light that enters the telescope. The large size of the entrance aperture makes it impossible to put a calibration source there. However, a small black body source can be placed near the field stop in the intermediate focal plane between primary and secondary mirror. The "front optics" (scan mirror, mirror M1, M1 baffle) cannot be seen from the detector when the blackbody source is in place, whereas the "back optics" (M2, M3 and following relay optics) is the one behind the blackbody calibration source.

During each satellite rotation, deep space measurements are taken corresponding to zero input radiance. The irradiance at detector level now corresponds to the self-radiation of the instrument only.

The signal of the deep space measurements is subtracted on-board automatically from the Earth measurements after digitisation and sent as digital counts to the ground. When the blackbody is in place, the deep space measurements from the image line prior to the blackbody measurement are used. Hence, on the one hand, in all cases the contribution of thermal radiation of the full optical path is subtracted. On the other hand, the counts received during black body measurement contain information from the front optics obtained during the deep space measurements (Figure 4). With SEVIRI, the effect of the front optics on the Earth measurement and the black body measurement needs to be considered in a calibration model.



### *Figure 4 – Measurements and Direct Offset Correction*

Level 1.5 data are representing a fixed radiometric scale. This scale is provided to the user via two linear scaling parameters in the image header ("Cal\_Slope" and "Cal\_Offset"). From here, the user can reproduce the radiance for each spectral band by the relation:

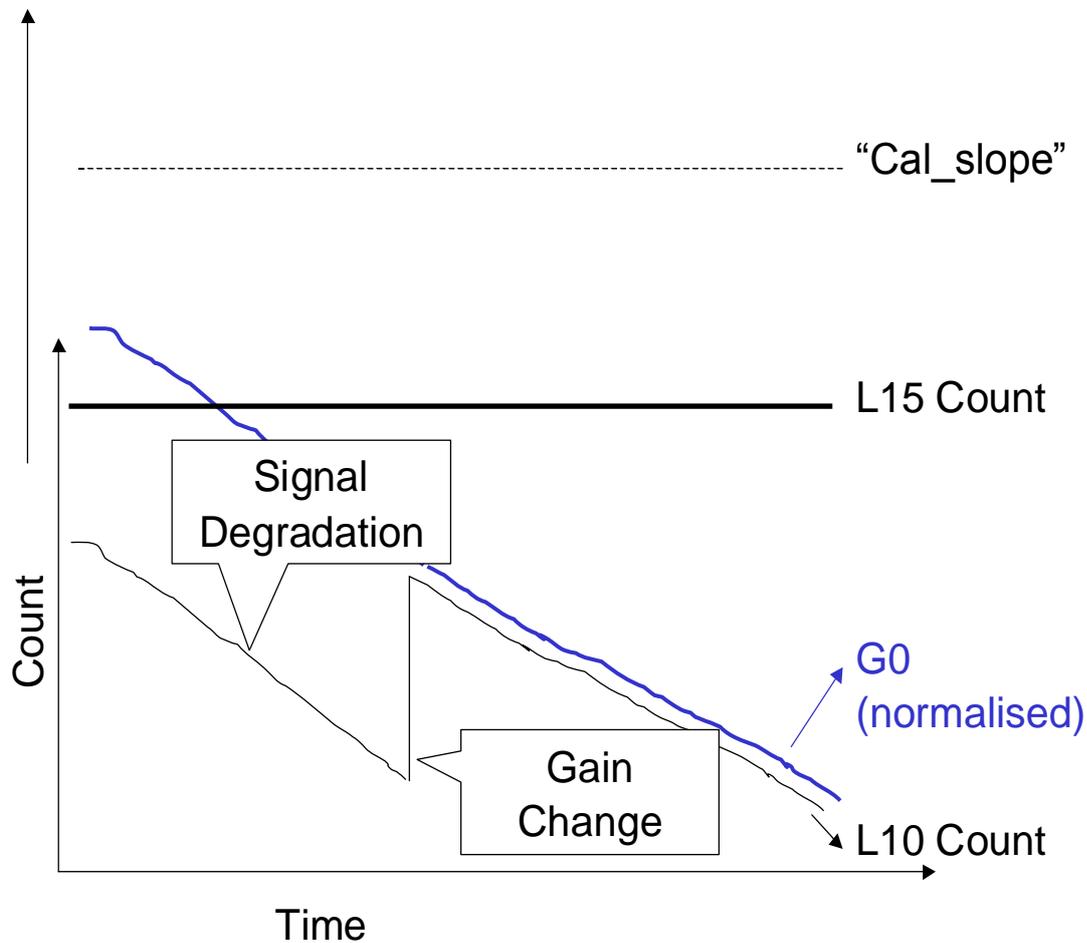
$$\text{Physical Units} = \text{Cal\_Offset} + (\text{Cal\_Slope} \times \text{Level 1.5 Pixel Count}) \text{ (expressed in } \text{mWm}^{-2} \text{ sr}^{-1} \text{ (cm}^{-1}\text{)}^{-1}\text{)}$$

The user must note that "Cal\_Slope" and "Cal\_Offset" are fixed scaling factors that will normally not change. They are not related to the calibration process performed to correct the image radiometrically.

The radiometric processing from Level 1.0 (raw data) to Level 1.5 is performed in four main steps:

1. **Linearisation.** The non-linearity of the detection chains has been established on ground. This information is used to remove the effects of non-linearity from the measurement.
2. **Conversion into radiances.** A preliminary conversion is performed to go from counts into radiances.
3. **Calibration.** The calibration allows correcting the preliminary estimate of the radiance into accurate numbers.
4. **Scaling.** To store the radiance values in the foreseen 10-bit integer format, a linear scaling is performed using "Cal\_Slope" and "Cal\_Offset". These are chosen so that the necessary dynamic range falls into the available interval [0, 1023]

The consequence of this approach is illustrated in Figure 5.



**Figure 5 – Schematic of the scaling of Level 1.5 counts**

Figure 5 shows the Level 1.0 count and the Level 1.5 count of an idealised stable target. The raw Level 1.0 count degrades in time as contamination increases. At some point, a gain change is performed to maintain image quality. During all this time, the Level 1.5 count remains stable as the instrument calibration is used to remove degradation effects from the Level 1.5 image. Also, a gain change is transparent to the user. "Cal\_Slope" represents a pure scaling constant for target radiances to Level 1.5 pixel counts, which is not affected by instrument degradation or gain changes.

## **Black Body Calibration**

The signal irradiance as received at the detector level is the product of three factors:

1. The target radiance, either from Earth or black body.
2. The total optical loss accrued during passage through the instrument.
3. The solid angle under which the detector collects the radiation. The opening cone for the incoming radiation is determined by the diameter and the focal length of the optical system.

The Calibration is performed in two steps: at ambient temperature plus a measurement with the blackbody heated to about 20K above ambient. The pair allows for the calibration of the "back optics" in a classic two-point measurement. Knowing the gain of the back optics, the self-radiation of the front optics can be measured when viewing cold space (= zero input). In fact, this needs only a single measurement with the blackbody at ambient because the space count is always subtracted. The assumption that the reflectance of the mirrors plus their emissivity equals 1 allows estimating the front optics transmittance from its temperature and its self-radiation. With the back optics responsivity and the front optics transmittance the full instrument gain can be calculated.

### **3 OVERVIEW OF LEVEL 1.5 DATA**

Level 1.5 data is derived from the Level 1.0 data that is acquired by the MSG satellite and received by EUMETSAT's ground segment. EUMETSAT corrects in real-time each received Level 1.0 image for all radiometric and geometric effects and geolocates it using a standardised projection. The resulting Level 1.5 image consists of Earth-located, calibrated and radiance-linearised information that is suitable for the derivation of meteorological products and other further meteorological processing.

#### **3.1 Characteristics of Level 1.5 Image Data**

This section introduces the reader to the basic characteristics of the Level 1.5 image, considering only the imagery-related aspects.

Important Note: The information given herein is provided with the goal to make available to a wide community of potential users the latest status of the knowledge within EUMETSAT. This knowledge will evolve over time when the characteristics of the satellite or the actual accuracy of the involved processing become more and more accurately known. It has to be stressed that this information does in no way represent formal requirements on the MSG System, as these formal requirements are documented in the [EURD]. In case of contradiction or inconsistency the [EURD] takes precedence.

##### **3.1.1 Spectral Bands**

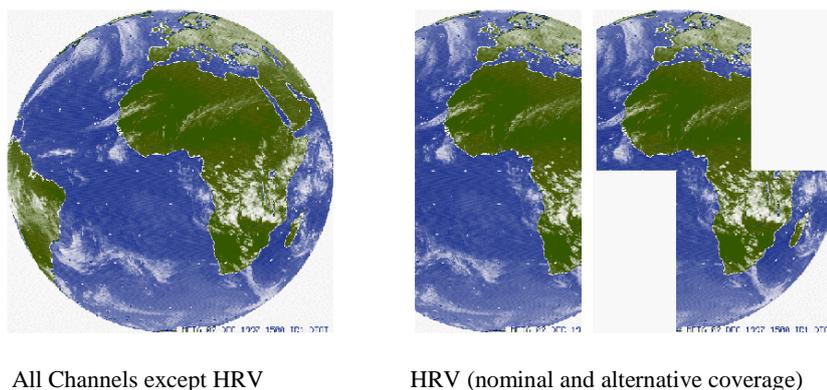
The 12 SEVIRI images channel correspond to the following spectral bands. The following table presents the spectral characteristics, the dynamic range, the operating temperature of the detectors, the number of detectors simultaneously acquiring image information during each satellite revolution and the sampling distance of the Level 1.0 image data:

Channel	Bands	Centre Wavel..	Spectral Band (99% energy limits)	Dynamic Range	Operating Temp.	Detectors per channel	Sample distance at SSP
		µm	µm		°K		
HRV	Visible &	(0.75)	broadband (peak within 0.6 - 0.9)	0 - 459 W/m <sup>2</sup> sr µm (scaled at centre frequency)	300	9	1
VIS0.6		0.635	0.56 - 0.71	0 - 533 W/m <sup>2</sup> sr µm		3	3
VIS0.8	Near	0.81	0.74 - 0.88	0 - 357 W/m <sup>2</sup> sr µm	85-95		
IR1.6	IR	1.64	1.50 - 1.78	0 - 75 W/m <sup>2</sup> sr µm			
IR3.9	Window	3.92	3.48 - 4.36 (98% energy limits)	0 - 335 K			
IR8.7		8.70	8.30 - 9.10 (98% energy limits)	0 - 300 K			
IR10.8		10.80	9.80 - 11.80 (98% energy limits)	0 - 335 K			
IR12.0		12.00	11.00 - 13.00 (98% energy limits)	0 - 335 K			
IR6.2	Water Vapour	6.25	5.35 - 7.15	0 - 300 K			
IR7.3		7.35	6.85 - 7.85 (98% energy limits)	0 - 300 K			
IR9.7	Ozone	9.66	9.38 - 9.94	0 - 310 K			
IR13.4	Carbon-dioxide	13.40	12.40 - 14.40 (96% energy limits)	0 - 300 K			

**Table 1 – MSG SEVIRI spectral channel definition**

### 3.1.2 Level 1.5 Image Coverage, Repeat Cycle Duration

Nominally the full Earth disk is covered for all image channels except HRV. For HRV only half Earth coverage in E-W is provided. The nominal repeat cycle duration providing this Earth coverage is 15 minutes. Below a visual representation of the full coverage of the Level 1.5 data:



**Figure 6 – Nominal Earth coverage of MSG image channels**

Note 1: Shorter repeat cycles with a correspondingly reduced coverage in North-South are technically possible and are supported by the image processing on ground, but are currently not considered for operational usage.

Note 2: The space area of the Level 1.5 image is set to a predefined binary value called the space mask. Further, any missing Level 1.5 image information will also be replaced by this predefined value (called “masked” in the following). In particular in the case of HRV, there will be masked pixels near the vertical edges: these account for the pixels that cannot mathematically be generated (due to the required Orbit and Attitude correction, the projection applied and the processing filter length).

Note 3: In the case of the HRV channel, the nominal coverage is only the central half of the full Earth disk in E-W. However, alternative coverages can be operated, with a southern and a northern part of the HRV image having different positions in E-W. The details about the planned HRV coverage in the Level 1.5 data can be found in the Header Record Image Description. Note also that some lines around the “break line” between the southern and northern parts might be masked out in the Level 1.5 data, the reasons being the possibility of loss/corruption of the Level 1.0 data during acquisition by the SEVIRI and/or the mathematical impossibility to derive correct values (due to the required Orbit and Attitude correction, the projection applied and the processing filter length).

### **3.1.3 Image Size**

For all channels except HRV, the nominal Level 1.5 image size is 3712 lines by 3712 columns (N-S by E-W), the sampling distance defined to be exactly 3 km by 3 km at the sub-satellite point.

For the HRV channel, the image size is 11136 lines by 5568 columns (N-S by E-W) with a sampling distance defined to be exactly 1 km by 1 km at the sub-satellite point.

Note: As mentioned earlier, it is technically possible to acquire and process shorter Repeat Cycles. Then the image size will be reduced. Full information about the image size can be found in the Record Image Description (see Section 7.2.4).

### **3.1.4 Image Projection and Relation to Geographical Coordinates**

#### **3.1.4.1 The GEOS Projection**

The level 1.5 image is provided in a geostationary projection (GEOS Projection), fully described in [GS]. For the 0 Degree Full Disk service, this is normally centred on 0° longitude, for Rapid Scan Service at 9.5 degrees East, and for the Indian Ocean Data Coverage, at 41.5 degrees East as this introduces the least distortions in the Level 1.5 image. Other projections are currently not foreseen. The actual longitude used is described by the parameter LongitudeOfSSP being part of the ProjectionDescription record (see Section 7.2.4).

The formulae providing the relation between a given pixel position (i, j) within the Level 1.5 image and the corresponding geographical coordinates (Longitude, Latitude) as well as the inverse relation, are fully described in [GS].

#### **3.1.4.2 Erroneous Georeferencing Offset**

Until 2017, the Level 1.5 image low resolution and HRV images of the MSG satellites were shifted by 1.5 km SSP North and West against the nominal GEOS projection. This was due to various small errors in the ground processor. This shift is still within the requirement of the

geometrical accuracy of 3.0 km. All MSG missions (0-Deg FES, RSS, and IODC) are affected. This problem was apparently present since the beginning of the MSG operations.

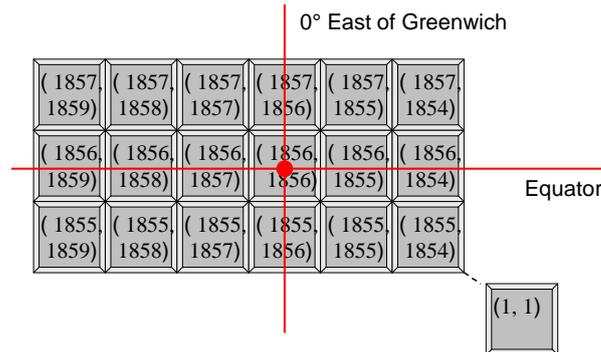
The problem is a constant shift of the image by 0.5 low resolution pixels North plus 0.5 low resolution pixels West. The HRV channel appears shifted by 1.5 HRV pixels North plus 1.5 HRV pixels West. A correction has been introduced in December 2017 to correct this error. After introduction of the correction, the disseminated images as well as the images in the data centre do not have this offset anymore. (Note that the correction has no effect of the natural variation in image quality, which are normally low but measurable.) The presence of the correction can be evaluated by inspecting the parameter `TypeOfEarthModel`, being parameter of the EarthModel record in the GeometricProcessing record (see Section 7.2.6). The interpretation is as follows:

<code>TypeOfEarthModel:= 1</code>	georeferencing offset present (i.e. image shifted wrt GEOS projection)
<code>TypeOfEarthModel:=2</code>	corrected data

### 3.1.5 Geographical Alignment of the Non-HRV and HRV images

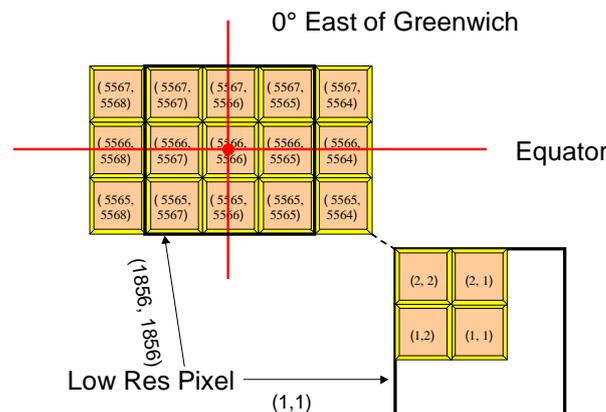
For the non-HRV images, the nominal geostationary projection centre (0° longitude, 0° latitude) coincides with the middle of the pixel that has the line and column number (1856,1856), where the pixel numbering starts in the South-Eastern corner of the image with line and column number (1,1), see Figure 7.

*Figure 7 – Alignment and numbering of the non-HRV pixels*

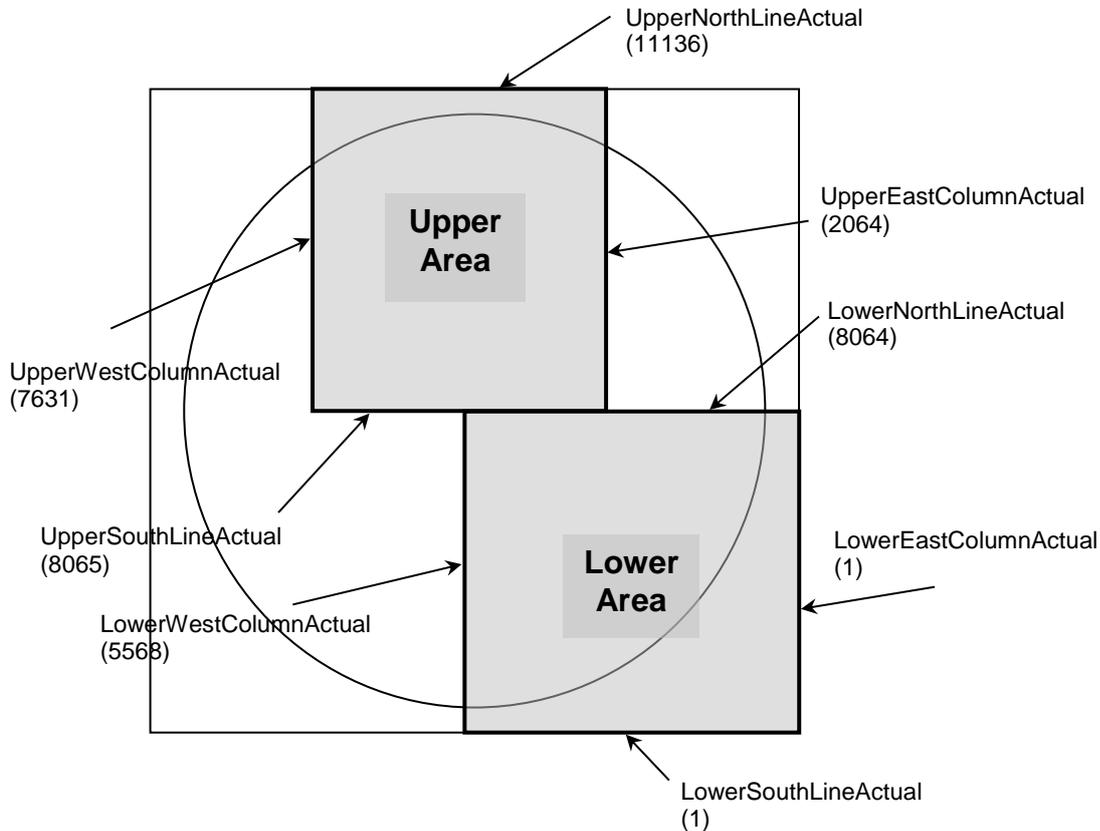


For the HRV image, the nominal geostationary position is the middle of the HRV-pixel with the line and column number (5566,5566), referenced to the HRV Reference Grid as shown in Figure 8. Note that nine HRV-pixels (3 by 3) cover one non-HRV pixel such that both non-HRV and HRV images are perfectly aligned with respect to the nominal geostationary position. However, the choice of image centres for the non-HRV and HRV images means that the datum pixel of the non-HRV image is not fully covered with HRV pixels as it is shown in Figure 8.

Note that the HRV Reference Grid normally consists of 11136 x 11136 pixels and is given in the **Image Description Record** as **ReferenceGridHRV** (see 7.2.4). Within the HRV Reference Grid the current HRV image (as shown i.e. in Figure 6) is given in the **Image Production Stats Record** (see Section 7.5.1) by the values of **LowerSouthLineActual**, **LowerNorthLineActual**, **LowerEastColumnActual**, **LowerWestColumnActual**, **UpperSouthLineActual**, **UpperNorthLineActual**, **UpperEastColumnActual** and **UpperWestColumnActual**, which are given the boundaries lines and columns of the HRV image referring to the Reference Grid and the datum of the image as shown in Figure 8 and Figure 9.



**Figure 8 – Alignment and numbering of the HRV-pixels with respect to non-HRV pixels and the HRV reference grid**

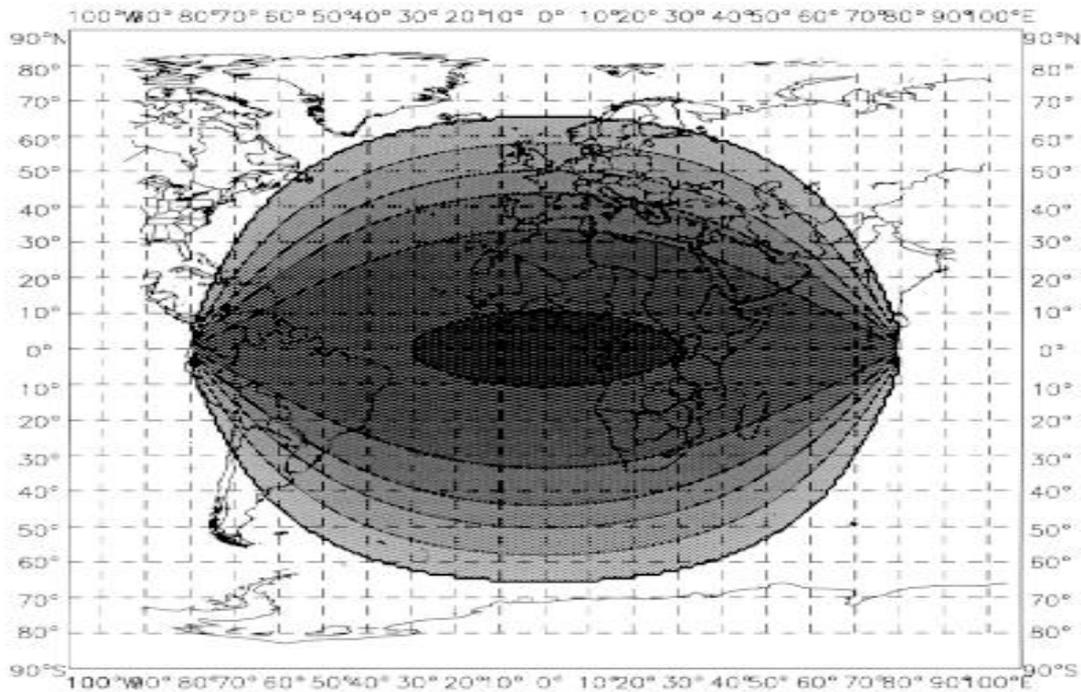


**Figure 9 – Example of the HRV alignment and numbering of the HRV offset scanning format with respect to the HRV reference grid**

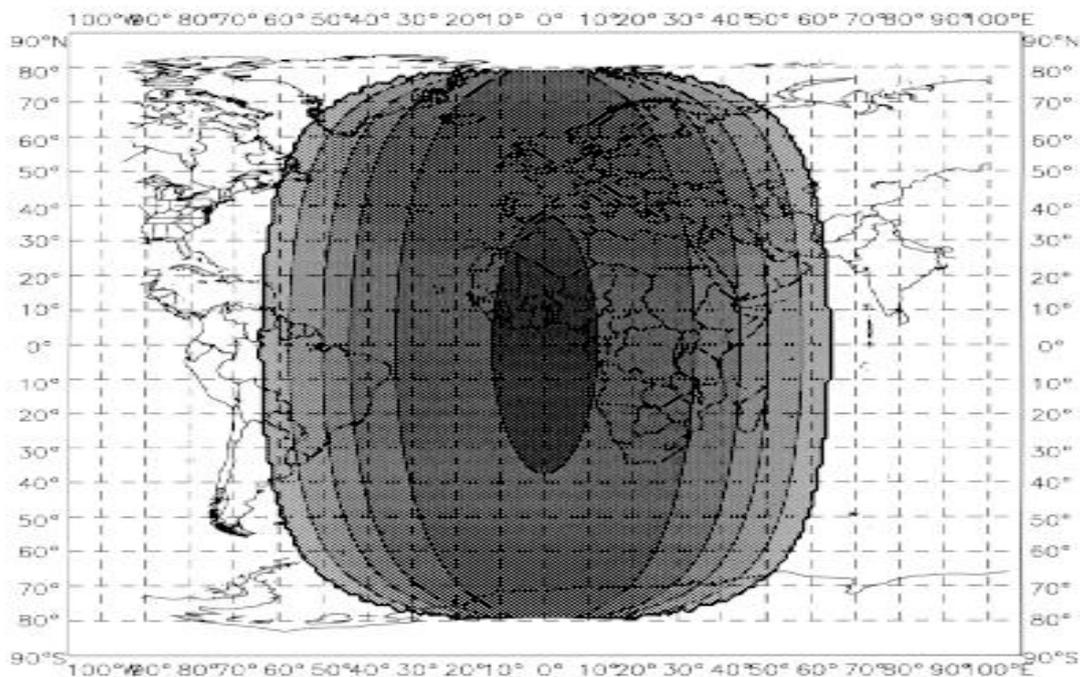
**3.1.6 On-Ground Resolution of Level 1.5 Images**

The following figures provide the map of the on-ground pixel resolution function of the geographical coordinates. This is a direct consequence of the image acquisition process by the MSG satellite based on constant angular steps seen from the geostationary orbit.

**Legend:** Darkest grey correspond to 3.1 km, lighter grey to 4 km, 5 km, 6 km, 8 km and 11km respectively

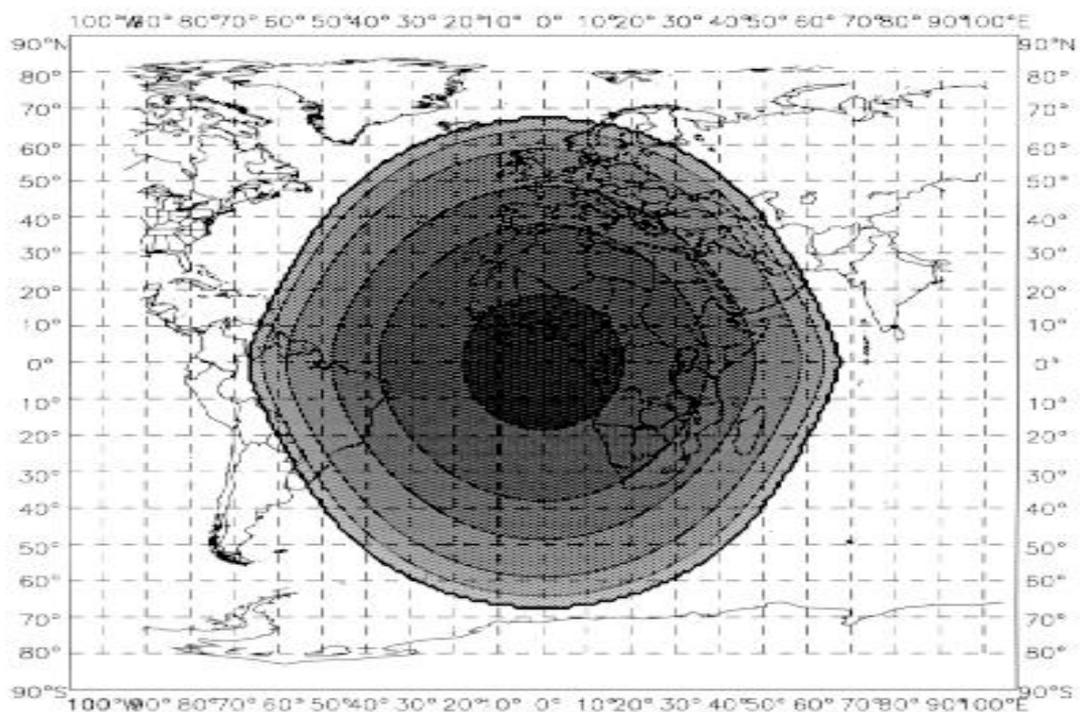


**Figure 10 – MSG Level 1.5 ground resolution map (N-S direction)**



**Figure 11 – MSG Level 1.5 ground resolution map (E-W direction)**

**Figure 12 – MSG Level 1.5 ground resolution (equivalent surface)**



### 3.1.7 Pixel Value Representation

The Level 1.5 pixel binary representation is 10-bit (8-bit for LRUS-received data), this corresponding to linearised and equalised image information (correcting for differences in response between the contributing detectors).

**Note 1:** As mentioned in the previous section, space pixels are “masked out”, i.e. set to a predefined value.

**Note 2:** The relation between the binary pixel value (the pixel count) and the physical radiance units (expressed in  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ ) is fully defined for each spectral band by the relation:

$$\text{Physical Units} = \text{Cal\_Offset} + (\text{Cal\_Slope} \cdot \text{Pixel Count})$$

More details can be found in the Level1\_5ImageCalibration Record. Concerning the accuracy of this calibration information, please refer to [EURD] for the specified figures.

Originally, the Level 1.5 image data were produced in terms of spectral radiance so that Level 1.5 product radiance  $\tilde{L}^{15}$  can be used to determine brightness temperatures  $T^{L15}$  using the following formula:

$$\frac{10^4}{\lambda_0} = \nu, T^{L15} = \frac{c_2 \nu}{\ln \left[ 1 + \nu^3 \frac{c_1}{\tilde{L}^{15}} \right]}$$

With  $\lambda_0$  the centre wavelength specified in Table 1,  $\nu$  wavenumber in  $\text{cm}^{-1}$ , and  $C_1=1.19104 \cdot 10^{-5} \text{ mW}(\text{cm}^{-1})^{-4}\text{m}^{-2}\text{sr}^{-1}$ ,  $C_2=1.43877 \text{ K cm}$ .

Following an update to the processing software, the Level 1.5 image data were produced in terms of effective radiance, defined by the following formula:

$$L^{15} = \frac{\int L_\nu r_\nu d\nu}{\int r_\nu d\nu}$$

With  $L$  target spectral radiance. In any case the unit would be  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ . Whether spectral or effective radiance is used, is indicated in the PlannedChanProcessing array in the Level 1\_5 ImageProduction record, being part of Image Description Record.

**Note:** The Level 1.5 pixels are the results of the resampling of Level 1.0 image data being acquired by several detectors (3 for all channels, except HRV where 9 detectors are used). For this reason, in order to apply a mathematically correct processing, the Level 1.0 detector information are first pre-processed for equalisation/linearisation of the detectors response before resampling to Level 1.5 is applied. The relative “weighting” put on the individual detectors is fully defined in the Record RadTransform.

### 3.1.8 Radiometric Quality

The radiometric quality presented in the table below corresponds to the Level 1.0 radiometric quality. For more details on the Level 1.0 radiometric quality, please refer to [EURD] or to §5.3 of this document.

The additional radiometric errors introduced by the processing to the Level 1.5 (due to the inaccuracies in the implementation of the operation performed on the pixels) can be characterised as follows:

- The radiometric errors due to the implementation of the processing functions that transform the Level 1.0 into Level 1.5 data in real-time are generally small to negligible. This is due to the fact that all operations that modify the pixel values are implemented in floating point with the resampling function (windowed function of size up to 9x9) providing an accuracy that is very close to the ideal resampler.
- The final rounding from this internal floating-point representation to the 10-bit representation of the Level 1.5 data is by far the largest contributor. The error characteristic is evenly distributed between  $-0.5$  and  $+0.5$  digital count (out of 1024).
- The radiometric errors related to the inaccuracies in the knowledge of the linearisation, equalisation, etc... corrections are covered by the absolute calibration accuracy figure [EURD] and are therefore not repeated here.
- The inaccuracies in the geolocation of the data will obviously as a side effect introduce also radiometric errors with respect to the expected radiance for a given location. These errors are however strongly scene-dependent. It is considered more appropriate to separate clearly these contributions and define them as the geometric quality figures.

CHANNEL		NOISE	MEDIUM-TERM DRIFT
HRV	Visible	S/N >4.3 for target of 0.1% dynamic range	<0.1% of Dyn. Range/Day (outside eclipse days & gain changes)
VIS0.6	&	SNR>10.1 for target of 1% dynamic range	
VIS0.8	Near	SNR>7.28 for target of 1% dynamic range	
IR1.6	IR	SNR>3 for target of 1% dynamic range	
IR3.8 (IR3.9)	Window	0.35 K @ 300 K	<10% of the long-term drift between two on-board calibration.
IR8.7		0.28 K @ 300 K	
IR10.8		0.25 K @ 300 K	
IR12.0		0.37 K @ 300 K	
WV6.2	Water Vapour	0.75 K @ 250 K	
WV7.3		0.75 K @ 250 K	
IR9.7	Ozone	1.50 K @ 255 K	
IR13.4	Carbon-dioxide	1.80 K @ 270 K	

*Table 2 – MSG SEVIRI radiometric quality*

### 3.1.9 Geometric Quality

The geometric quality budgets and estimated values are shown in the following figures. These values might be updated when the actual behaviour of the MSG satellite in orbit are better known (distances are in equivalent sub-satellite point (SSP) distances):

The geometric accuracy applies to the image after ground processing. The values given in this section are obtained with the Image Quality Ground Support Equipment (IQGSE) that has been developed by Alcatel Space to verify the MSG image geometry performances after ground processing. They are formulated in a statistical sense, either over 1 day (absolute error, error over 500 lines and error over 6 lines) or in a relative sense between two consecutive images.

The verification is based on the usage of IQGSE coupled with the knowledge of the satellite parameters as measured during the test campaign.

	NS		EW	
	Performance (km)	Specification (km) (SSP)	Performance (km)	Specification (km) (SSP)
<b>Absolute Error within One Image</b>	1.32	3.0	0.15	3.0
<b>Relative Accuracy (consecutive Images)</b>	0.33	1.2	0.12	1.2
<b>Relative Accuracy (500 Samples NS)</b>	0.42	3.0	0.09	3.0
<b>Relative Accuracy (500 Samples EW)</b>	0.42	3.0	0.09	3.0

**Error on 16 samples**

Requirement: 0.75km total error

	N/S error on N/S samples	E/W error on E/W samples	E/W error on N/S samples	N/S error on E/W samples
<b>Channel</b>	<b>Budget</b>	<b>Budget</b>	<b>Budget</b>	<b>Budget</b>
<b>All Channels</b>	223m	76m	236m	146m

The tables actually refer to the data before re-sampling. Estimates provided by the Image Processing Facility (IMPF) assume a contribution in terms of interpolation error in the order of .29 km at SSP.

Note 1: The Absolute accuracy corresponds to the RMS value (over one image) of the error between the actual position of a pixel in the image and its ideal position. It is verified using landmark deviation measurements with respect to the ideal position (defined by a high-accuracy digital map).

Note 2: The relative accuracy from image to image corresponds to the variation in the geographical location of a pixel from one repeat cycle to the next. It is a measure of the “stability” of the image navigation and this criterion is especially important when tracking *displacement* of features (like clouds) rather than *geolocating* them in the absolute sense. This error is measured by tracking the displacement of landmarks from one image to the next.

**Note 3:** The relative accuracy within an image (over 500 resp. 16 pixels) gives the variation in the location error between two pixels that are separated by up to 500 (resp. 16) sampling distances. This criterion can be considered as a measure of the local deformation within the image. Currently, no direct methods for regular verification of these criteria are validated, although functionality is foreseen.

**Note 4:** The specification figures (worst case for nominal image) given above will be replaced with figures that correspond to nominally achieved quality once the S/C and SEVIRI are better known and the image processing function is operational.

### 3.1.10 Interchannel Registration

The specified and expected registration errors for the same pixel positions in different spectral channels are shown in the following figures. Here also, the figures might need to be updated once the actual behaviour of the MSG S/C in orbit is better characterised. All channels are registered to a common grid with the following accuracy:

<b>Channel Groups</b>	<b>Residual Misregistration Requirement (km)</b>	<b>Residual Misregistration Budget (km)*</b>
<b>VNIR</b>	0.6	0.45
<b>Warm</b> <b>(HRV +VNIR)</b>	0.6	0.45
<b>Window</b> <b>(IR3.9/IR8.7/IR10.2/IR12.0)</b>	0.6	0.45
<b>Cold</b> <b>(All except HRV and VNIR)</b>	0.75	0.45
<b>ALL</b>	1.5	0.45

\*This is comprised of two summed errors, arising from 1) error in the interpolation methods used (0.27km) and 2) an error in the SEVIRI focal plane model (0.18km)

**Note 1:** Distances are at sub-satellite point (SSP).

**Note 2:** The grid of HRV images is such that 3x3 pixels of the HRV image are registered to 1 pixel of the VIS/IR channels.

**Note 3:** The phenomenon of misregistration is mainly due to the thermo-elastic variations within the SEVIRI (both between the cold & warm focal planes and to a lesser extent between channels within a given focal plane). The misregistrations characterised on ground are of limited value after the launch, due to its thermal and mechanical influences. Therefore, the on-ground processing is an auto-adaptive method that continuously re-estimates and corrects the focal plane misregistration based on the newest observations taken from the image. It has a typical integration time of one day, but shorter periods are considered following eclipse or manoeuvre situations.

### **3.1.11 Straylight Compensation Characteristics**

The stray light performance of the SEVIRI instrument is generally speaking very good. Only the solar channels (VIS06, VIS08, NIR16 and HRV) and the IR 3.9 channel are affected when the Sun is close to the Field of View of the instrument. This is only the case for a few hours around midnight during or close to eclipse season. Although the effect is largest for the solar channels, the illuminated part of the Earth is minimal and hence the usefulness of the solar channel data collected during this period is low. Since, the stray light dominates the image for the solar channels and is complex in nature, no correction can be applied. In the IR 3.9 channel, the effect is smaller and the Earth signal larger, a correction is normally applied based on the angular distance between the image pixel direction and the direction towards the Sun.

### **3.1.12 Timeliness and Availability of Level 1.5 Image Data**

Via the Dissemination Service, Level 1.5 image data of a given geographical area are available to the users within 5 minutes from the time of acquisition by the satellite of this area (for users having HRUS stations, 15 minutes in the case of users having LRUS stations). For users accessing Level 1.5 data via other services, the timeliness is defined by the service (refer to [EURD]).

Image of nominal quality, completeness, timeliness are provided by the Dissemination Service with an availability of better than 95% [See EURD].

## **4 STRUCTURE OF THE LEVEL 1.5 DATA**

This section presents the general structure of the Level 1.5 data, showing graphically how the data content is organised in 'Records'. Please note that if information is searched on specific areas of interest, but there is no familiarity with the Record content, the help provided in [Chapter 5](#) may be more adequate.

### **4.1 Data Formats**

Before the Structure of the Level 1.5 data is presented, it is important to note the following aspects:

The native Level 1.5 data, as produced and distributed within the MSG Ground Segment, is distributed as MSG Ground Segment packets. The actual data content of the Ground Segment packets is either:

1. **Level 1.5 Data Header**, holding the ancillary data that is known at the start of the repeat cycle.
2. **Level 1.5 Image Line**, comprising groups of image lines, with each group holding the scan-lines for the 12 spectral channels (3 for HRV, and one for each of the other 11 channels). This group is repeated (nominally) 3712 times.
3. **Level 1.5 Data Trailer**, holding the ancillary data that has been generated or only became known during the repeat cycle.

Note: Depending on the capabilities of the service used to access the information, the user may receive the image part of the Level 1.5 data in a structure that does not directly correspond the 'native format' (i.e. the one presented in this document), but which is a derived one, such as a continuous image array of a single spectral channel. The format of the Header and Trailer information is however fixed.

Example: For the users receiving the data via the Dissemination Service, the image information is grouped by 464 image lines in the so-called HRIT/LRIT Image Segment Files. The Level 1.5 Header and the Level 1.5 Trailer are disseminated as separate HRIT/LRIT files [MSI] called "Prologue" (Level 1.5 Header) and "Epilogue" (Level 1.5 Trailer).

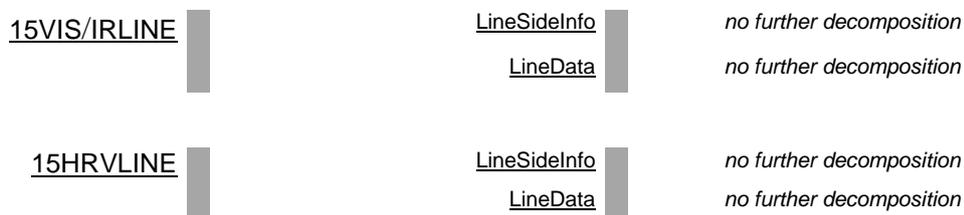
### **4.2 Detailed Level 1.5 Data Structure**

The following figures present the structure of the **Level 1.5 Data Header**, the **Level 1.5 Image Lines**, and the **Level 1.5 Data Trailer**.

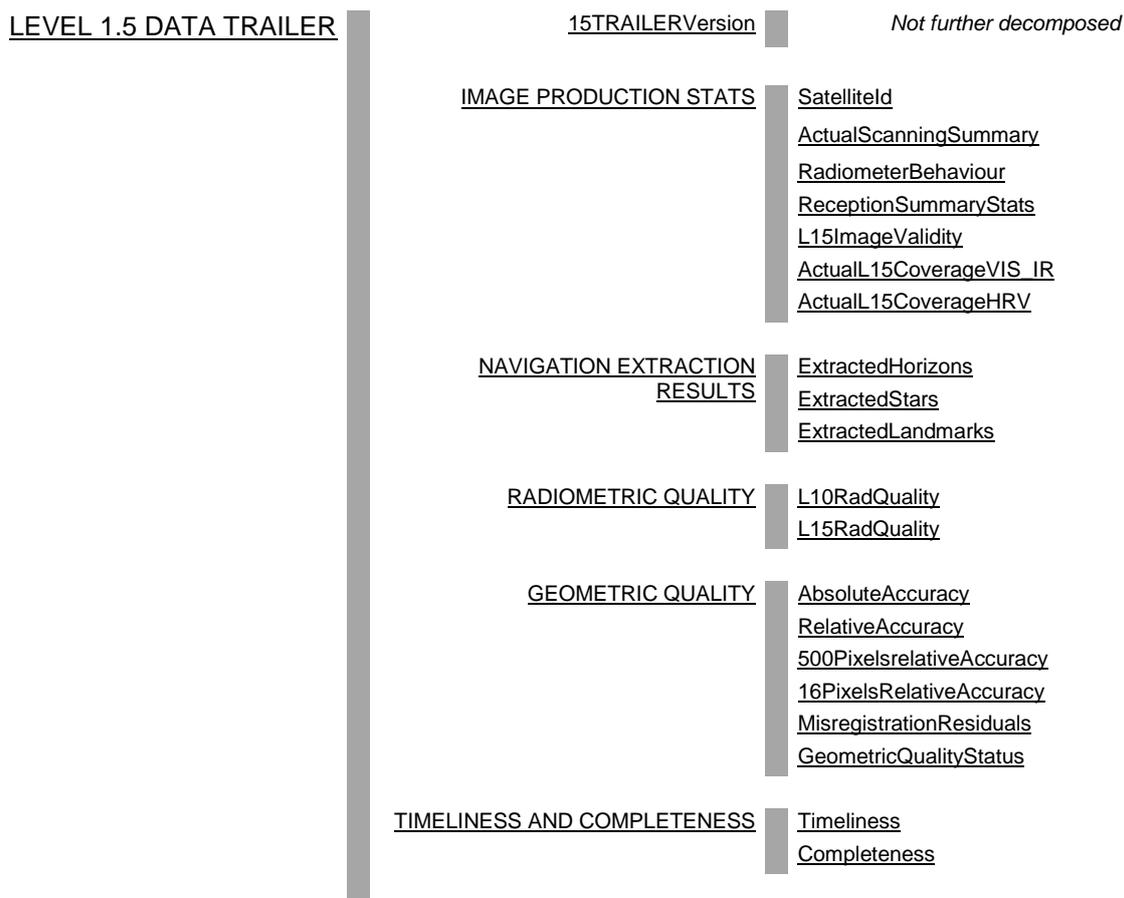
Note that the following figures have been prepared using 'hyperlinks'. To use these to their full extent on the electronic version of this document, enable the Web Toolbar in MS-Word (offered with version 7 onwards). Any underlined text which causes the cursor to change into a 'pointing finger' is a hyperlink that can be used to navigate to more detailed descriptions. When the cursor is positioned over a Record name of interest, click the left mouse-button to jump to the document section where the Record is described in detail. The 'Back' and 'Forward' arrows on the Web Toolbar allow the user to move between hyperlinks and associated texts.

<u>LEVEL 1.5 DATA HEADER</u>	<u>15HEADERVersion</u>	<i>no further decomposition</i>
	<u>SATELLITE STATUS</u>	<u>Satellite Definition</u> <u>Satellite Operations</u> <u>Orbit</u> <u>Attitude</u> <u>SpinRateatRCStart</u> <u>UTCCorrelation</u>
	<u>IMAGE ACQUISITION</u>	<u>PlannedAcquisitionTime</u> <u>RadiometerStatus</u> <u>RadiometerSettings</u> <u>RadiometerOperations</u>
	<u>CELESTIAL EVENTS</u>	<u>CelestialBodiesPosition</u> <u>RelationToImage</u>
	<u>IMAGE DESCRIPTION</u>	<u>ProjectionDescription</u> <u>ReferenceGridVIS_IR</u> <u>ReferenceGridHRV</u> <u>PlannedCoverageVIS_IR</u> <u>PlannedCoverageHRV</u> <u>Level1_5ImageProduction</u>
	<u>RADIOMETRIC PROCESSING</u>	<u>RPSummary</u> <u>Level1_5ImageCalibration</u> <u>BlackBodyDataUsed</u> <u>MPEFCalFeedback</u> <u>RadTransform</u> <u>RadProcMTFAdaptation</u> <u>StraylightCorrection</u>
	<u>GEOMETRIC PROCESSING</u>	<u>OptAxisDistances</u> <u>EarthModel</u> <u>AtmosphericModel</u> <u>ResamplingFunctions</u>
	<u>IMPF CONFIGURATION</u>	<u>OverallConfiguration</u> <u>SUDetails</u> <u>WarmStartParms</u>

**Figure 13 – Structure of Level 1.5 Header**

**MSG Level 1.5 Image Data Format Description**


**Figure 14 – Structure of Level 1.5 Image Lines**



**Figure 15 – Structure of Level 1.5 Trailer**

### **4.3 Rationale for the Level 1.5 Data Content and Structure**

The definition of the Level 1.5 data, both from structural and content points of view, was driven by a number of requirements or constraints but also by the goal to satisfy a large variety of users and potential applications. The rationale for the data structure/data content is presented here.

Stringent Timeliness Requirements & Real-time Product Extraction. The Level 1.5 data structure was adapted to the real-time extraction of meteorological products and to the stringent timeliness requirements. This resulted in the following:

- The selected structure with Header / Image Data / Trailer.
- A spectral channel-interleaved format allowing parallel transmission of all 12 spectral channels.
- The Header data content is fully describing the characteristics of the image data to follow, allowing to prepare the real-time meteorological processing.
- A line-by-line validity information is provided together with the image data, allowing real-time data acceptance by the subsequent meteorological processing.
- The Trailer data content corresponds to all the side-information that can only be derived after the completion of the image (e.g. actual Level 1.5 image quality, summary statistics).

Standardised Projection. In order to comply with the internationally accepted LRIT/HRIT Global Specification [GS], the projection used for the Level 1.5 data is the geostationary projection defined therein, allowing minimum distortion of the image data.

Full Calibration Information. With a high-accuracy imaging system, the accuracy and completeness of the calibration information plays a fundamental role. The Level 1.5 data provides the users of the data with complete calibration information.

Ancillary Information to support/allow/promote Product Extraction. The future MSG system will be the basis for the generation of an entire set of new meteorological products. The Level 1.5 data plays a central role in this system, and it is important that the image data is provided with sufficient ancillary information to promote its widespread use for product extraction. As an example, the following information is provided (see following sections for more details): Sun and Satellite exact positions during image acquisition, full calibration information, detail of all transformations actually applied to the pixel values, complete quality and validity information etc. Note that this amount of very detailed side information can be distributed to the users without noticeable impact on the transmission channel usage, as its volume is very small compared to the size of the complete image data.

Operational Flexibility. The structure of the Level 1.5 data includes many ‘self-describing’ features and this, coupled with the composition of the Header data, allows flexibility in the execution of operations (like e.g. reduced scanning with faster Repeat Cycles, scanning start/stop absolute time, etc...).

Historical Reprocessing Capability. This is due a EUMETSAT-internal constraint, allowing to reprocess the image data (from Level 1.0 to 1.5) during operations if, for example, real-time

image processing failed or if subsequent system improvements are desired to be applied to older datasets. To facilitate reprocessing, the initial conditions for the processing are forming part of the Level 1.5 Header.

Visibility of Actual Image Quality. Full details on the actual image quality (both radiometric and geometric) derived by the EUMETSAT real-time image quality assessment function is provided together with the Level 1.5 data, allowing the data user to characterise the image information used for the derivation of products.

## 5 LOCATING INFORMATION IN LEVEL 1.5 DATA

The purpose of this section is to provide the user with a fast guide for finding information in this document related to the most relevant areas of interest. High-level information for each of these areas of interest is provided below together with a pointer to the subsequent chapters where the details can be found.

### 5.1 Where to Find Image Size and Projection Information?

The Header of the Level 1.5 data provides all necessary data defining the size and projection of the Level 1.5 image. This information is provided in the Image Description Record (Section 6.1.4) of the Header. This information applies only to the corresponding image data and is updated for every image. This provides self-description of the image data in e.g. the case of reduced Earth scanning with shorter than nominal repeat cycles.

**Related information.** the Header Record Image Acquisition (Section 6.1.2) provides the full details of the commanded acquisition of the corresponding Level 1.0 data. The Trailer Records Image Production Stats (Section 6.3.1) provides the statistics on the actually performed Level 1.0 image acquisition and Level 1.5 generation.

### 5.2 Where to Find Image Calibration Information?

Providing accurate and unambiguous calibration information to the data users is one of the main objectives of the development and operation of the MSG system. For this reason a sophisticated calibration approach has been defined and the results are made available to the users in an unambiguous manner.

The Level 1.5 image data being provided to the users are corrected for non-linearity in the detector response, for differences in the detector response within a given channel, and are represented as 10 bit data with the linear (slope, offset) relation between binary counts and physical radiance being unambiguously defined in the Header Record Level 15ImageCalibration (Section 6.1.5).

**Related Information.** For users wishing full visibility of the way the provided calibration information is derived within the MSG System, the following additional information is provided:

- All data acquired by the instrument during blackbody viewing that are used by the processing are provided in the Header Record BlackBody Data Used (Section 6.1.5).
- The calibration feedback resulting from either vicarious methods or from the calibration monitoring function are provided in the Header Record MPEFCalfeedback (Section 6.1.5).
- The details of the look-up table used for transforming the Level 1.0 counts into the Level 1.5 radiometric data representation are provided for each detector in the Header Record RadTransform (Section 6.1.5). This information allows to fully relate the Level 1.5 data to the Level 1.0 data.

### 5.3 Where to Find Image Radiometry Information?

The radiometric quality of the image data has clearly been given careful attention during the definition of the MSG System. For this reason the Level 1.5 data includes numerous information on this aspect:

- The Header Record Image Acquisition (Section 6.1.2) provides all details about the radiometer settings (Gains, offset, etc.) actually used for the acquisition of the Level 1.0 data. In addition, the radiometer status information is provided, identifying any potential abnormalities in the acquisition process.
- The Header Record Radiometric Processing (Section 6.1.5) provides all the details of the transformations performed between the Level 1.0 and the Level 1.5 data from a radiometric point of view. This includes the calibration information (see above) the MTF adaptation that was performed and the straylight compensation that might have been applied.
- The Image Records 15VIS/IR Line (Section 6.2.1) and 15HRV Line (Section 6.2.2) are providing for every spectral channel and per line of the Level 1.5 data, the information about the radiometric validity of this line. This allows the Level 1.5 data users who intend to perform data acceptance on a line-per-line basis to implement such a mechanism.
- The Trailer Record Radiometric Quality (Section 6.3.3) provides all extracted Radiometric quality information for both the Level 1.0 (at detector level) and Level 1.5 (on a channel basis). This includes typical measures like Signal Noise ratios, histograms, entropy, etc.).

### 5.4 Where to Find Image Geometrical Accuracy Information?

The geometrical accuracy of the processed image is clearly an important aspect of the Level 1.5 data. The following information is provided:

- The Trailer Record Geometric Quality (Section 6.3.4) provides the summary results of the Geometric Quality Assessment function, for the different types of image accuracies that are considered (Absolute, Relative image to image, Relative within an image). This Geometric Quality Assessment function is based on the recognition and correlation of numerous landmarks and has the purpose to indicate the quality of the Level 1.5 image data being produced. This is also the tool used by EUMETSAT to optimise the image quality during the operational lifetime of the mission.
- The Header Record Geometric Processing (Section 6.1.6) describes the values used within the processing models (distances of detectors to the optical axis, The parameters of the Earth model, the parameters of the atmospheric model, and the resampling function being used.
- The Image Record 15VIS/IR Line (Section 6.2.1) and 15HRV Line (Section 6.2.2) are providing for every spectral channel and per line of the Level 1.5 data, information about the geometric validity of this line. This allows the Level 1.5 data users who intend to perform data acceptance on a line-per-line basis to implement such a mechanism.

## 5.5 Where to Find Inter-channel Registration Information?

A frequently expressed concern of the users is the quality/accuracy of the registration of image information between the different spectral channels. Information is provided in the Level 1.5 data in two manners:

- The Header Record OptAxisDistances (Section 6.1.6) gives the most up-to-date and accurate knowledge of the relative positions of the detectors in the focal plane of the instrument (“focal plane layout”). This is a useful information for a user wishing to know what are the differences in Line Of sight between any two channels / detector during the acquisition of the Level 1.0 data (if e.g. he/she wishes to relate Level 1.0 data acquired by different channels). In it important to note that these figures are the result of a constant re-estimation of the actual focal plane positions and are more accurate and relevant than on-ground characterised values.
- The Trailer Record MisregistrationResiduals (Section 6.3.4) provides the results of the Geometric Quality Assessment function with respect to the residual misregistration between channels in the Level 1.5 data. Note that the uncertainty radius on these measurements is much higher than the uncertainty on the focal plane layout for the following reason: the focal plane layout is derived for the accumulation of many measurements over a situation-adaptive period of time, whereas the misregistration residuals are only measured on the current image!

## 5.6 Where to Find Pixel and Data Representation Information?

The Level 1.5 image pixels are represented as 10 bit data, the relation between the digital value and physical units being as defined in the above section on calibration. Note that depending on the data service, the user might receive image data that are rounded to 8 bits. All the other information remains the same.

The representations used for the other types of data (Integers, Reals, Time codes, etc.) are all described in detail in [GSDS].

## 5.7 Where to Find Image Quality and Validity Information?

This area covers the following:

- Geometric Quality: please see “Where to find Image Geometrical Accuracy Information?” (Section 5.4).
- Radiometric Quality: please see “Where to find Image Radiometry Information?” (Section 5.3).
- Line-by Line Validity of the image data. For each line of the Level 1.5 data, validity information is provided within the Records LineSideInfo (VIS/IR) (Section 6.2.1) and Line Side Info (HRV) (Section 6.2.2). This information can be used as a criterion for the data acceptance within a meteorological product processing function.
- Timeliness and Completeness statistics can be found in the Trailer Record TimelinessAndCompleteness (Section 6.3.5).

## 5.8 Where to Find Image Acquisition & Scanning Conditions?

For Users wishing to know the exact conditions of the acquisition of the Level 1.0 image (on which the processing to Level 1.5 is based upon) by the instrument, there are two major sources of information:

- The Header Record Image Acquisition (Section 6.1.2) provides all the Radiometer settings and parameters that were active for the acquisition of the Level 1.0 image by the instrument and considered by the Image Processing function. In particular the scanning information is available there. Note that if one is interested in the coverage used for the Level 1.5 image the Header Record PlannedCoverage VIS\_IR (Section 6.1.4) and PlannedCoverage HRV (Section 6.1.4) are the best source of information.
- For the specific information related to the acquisition of the BlackBody data during the on-board calibration, this information can be found in the Header Record BlackBodyDataUsed (Section 6.1.5).

## 5.9 Where to Find Navigation Information?

Image navigation can be understood in several ways. We identify here where to find the related information for the different meanings of this term:

- If Navigation is understood as the way the image processing implements the geometrical transformation from Level 1.0 data to the Level 1.5 data, the following information is provided in the Level 1.5 data:
  1. In the Header Records Orbit /Attitude / SpinRateatRCStart (Section 6.1.1) the Flight Dynamics and satellite information used for the processing are provided.
  2. In the Header Record ProjectionDescription (Section 6.1.4) the projection applied by the resampling function is defined.
  3. In the Header Record Geometric Processing (Section 6.1.6) all the parameters / state of the main models used within the Image Processing function to derive the deformation to be applied to the Level 1.0 data in order to derive the Level 1.5 data are provided.
- If Navigation is meant as the information required to relate any Level 1.5 image data to the geographical coordinates, then this information can be found in Section 3 of this document and in [GS].
- Finally, the following information is also made available that can be useful in the context of navigation:
  1. The Trailer Record Navigation Extraction Results (Section 6.3.2) is providing all the image-based measurements (horizons, landmarks, and stars) that are performed by IMPF in order to support the estimation of Orbit & Attitude.
  2. Refer to Section 3 of this document for all aspects related to the accuracy of the navigation, i.e. to the geometric image accuracy.

## **5.10 Where to Find Satellite and Celestial Body Positions?**

It was generally found important to document within the Level 1.5 both the actual position of the satellite but also of relevant celestial bodies during the image acquisition. The reasons are twofold: the position of Sun relative to the S/C for a given geographical position can be important for the subsequent processing, e.g. involving bi-directional reflectance. Further, the presence of celestial bodies close to or within the field of view of the Level 1.0 image might have an impact on the image quality that is analysed by the Image Processing function.

The Header component record Satellite Status (Section 6.1.1) provides all the information on the position of the S/C with respect to the Earth at the moment of image acquisition.

The Header component record Celestial Events (Section 6.1.3) provides all the information on the position of Sun, Moon, Stars and provides the expected impact on the image data.

## 6 DATA CONTENT SUMMARY PER RECORD

Note that the headings for the following subsections correspond to the names of the highest-level component Records in the structure detailed in Section 7 of this document.

### 6.1 Level 1.5 Header Summary

The purpose of the **Level 1.5 header** which accompanies Level 1.5 imagery data is to supply ancillary information which is needed by the end-user for interpreting the image data and processing it further.

There is one header for each repeat cycle and it is produced, as its name implies, before the image data in each repeat cycle. The information it provides is that which is known at the time of the start of the repeat cycle. Information which becomes available at a later time during the repeat cycle is provided in the complementary Record, the Level 1.5 trailer, which is generated following the image data. This complementary Record is described later in the present chapter in Section 6.3 'Level 1.5 Trailer'.

The header comprises a number of component items which hold information relevant to the topics indicated below:

<b>Topic</b>	<b>Component Type</b>	<b>Details of Component</b>
<i>Header Version</i>	<i>Field</i>	<i>This field identifies the version of the header</i>
<i>Satellite Status</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>Image Acquisition</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>Celestial Events</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>Image Description</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>Radiometric Processing</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>Geometric Processing</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>
<i>IMPF Configuration</i>	<i>Record</i>	<i>See <u>corresponding subsection</u></i>

These topics are presented in the sub-sections below, in terms of the general data content and the relation that the information has to the image data.

Throughout these sub-sections, the data is described as though the users are receiving Level 1.5 image data via dissemination (in near real-time). The header, for example, is described in terms of it being received in advance of the imagery data which is yet to be acquired, processed and disseminated. Users who receive Level 1.5 data 'after the event', for example via offline Data Services such as retrieval from the EUMETSAT archive, should remember this when reading the text.

### 6.1.1 Satellite Status Record Summary

This first record of the Header provides the user with information on the status of the satellite which is producing the image. Along with the satellite's identification, information is given concerning the position of the satellite, its operational status, the last operation executed, the next operation planned for it, and the satellite's on-board time.

The satellite's 'onboard time' can be correlated with 'Universal Time' by using the UTC-correlation information provided, in order to match the satellite timestamps with the absolute time on the ground.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.1 [Satellite Status Record](#).

<b>Component Record</b>	<b>Description</b>
<i>SatelliteDefinition</i>	<p><b>Constituent Data.</b> Provides the identification of the satellite which produced the image, the longitude at which it is nominally stationed (this being the reference point from which the Orbit deviation is computed), and its operational status. Note that the longitude of the S/C should not be confused with the one used for the projection of the Level 1.5 data.</p> <p><b>Usage.</b> To identify the imaging satellite and to learn its current status.</p> <p><b>Data Constancy.</b> If the satellite is moved to a different geostationary location, or if its operational status changes, information in this Record will change. Examples of the latter are when a satellite enters operational use after commissioning is completed, or when a decontamination is performed.</p> <p>If there is a change in the imaging satellite used (e.g. if a switch to a spare satellite is effected for the prime imaging mission), this will also be reflected here.</p>

<b>Component Record</b>	<b>Description</b>
<i>SatelliteOperations</i>	<p><b>Constituent Data.</b> Information concerning the last and next manoeuvres of the satellite which are likely to have an impact on image quality.</p> <p><b>Usage.</b> Image quality impact is to be expected in the 3-hour period following a manoeuvre. Advance notice of the next manoeuvre allows the user to take this into account when planning his usage of the images. Knowledge that a manoeuvre took place in the recent past can help explaining deviations in the geometrical image quality (that will be reflected in the measured geometrical quality figures: see <u>Geometric Quality</u>).</p> <p><b>Data Constancy.</b> Manoeuvres that have taken place (or will take place) in the last (next) 48 hours are presented in this component Record. Attitude manoeuvres are conducted approximately every 2 months, as the need arises. Other manoeuvres (station keeping, spin-up) are generally performed as infrequently as possible to make best use of the available propellant and optimise the S/C lifetime.</p>

<b>Component Record</b>	<b>Description</b>
<i>Orbit</i>	<p><b>Constituent Data.</b> Provides the orbit offset of the satellite relative to its nominal position (as defined by the nominal longitude on the geostationary orbit). This is expressed as (X, Y, Z) plus velocities in an Earth-fixed frame. The information provided covers a defined period of time from past to future and consists of a set of polynomials which allow to obtain the position at any moment in time. Cartesian coordinates are obtained in a frame as defined in <a href="#">Section 7</a>. The information is the most accurate available in the MSG Ground Segment, and is exactly the information used by the processing to generate the Level 1.5 image data. The accuracy figures are currently specified to be:</p> <p>Better than 2000m/2000m/500m in the longitude/latitude/Altitude directions for the absolute accuracy.</p> <p>Better than 300m/300m/100m in the longitude/latitude/Altitude directions for the maximum difference between two successive orbit determinations.</p> <p>Note: As the orbit accuracy is of high importance for the image navigation, efforts are spent to get the best possible accuracy: In operations, the above figures (although sufficient to achieve nominal image quality) will need to be updated with the actually achieved accuracies.</p> <p><b>Usage.</b> Allows to define the position of the imaging satellite relative to its nominal position as a function of UTC time with the highest possible accuracy. The usage could be for GERB processing, accurate bi-directional reflectance calculations (in combination with Sun position), etc.</p> <p><b>Data Constancy.</b> Updated in case new orbit information is received and (after validation) used by the image processing function. This can be as frequently as every repeat cycle, but in practice it is influenced by the frequency of update in operations.</p>

<b>Component Record</b>	<b>Description</b>
<i>Attitude</i>	<p><b>Constituent Data.</b> Provides the attitude of the MSG imaging satellite. The information covers a defined period of time extending from past to future. After interpolation, (X, Y, Z) coordinates of the spin axis in an Earth-fixed frame are obtained that give the actual satellite attitude at any UTC time within this period. The information is the most accurate available and is exactly the information used by the processing to generate the Level 1.5 image data. The accuracy of the Attitude information is specified to be:</p> <p>Better than 0.0005 degrees in absolute sense.</p> <p>Better than 0.0002 degrees for the difference between two successive attitude determinations.</p> <p>As for the Orbit, efforts are spent to optimise the accuracy. In operations, the above figures are to be replaced by the achieved accuracy.</p> <p><b>Usage.</b> All applications requiring the satellite attitude information, either for investigations or for processing purpose. GERB processing can be an example.</p> <p><b>Data Constancy.</b> Updated as frequently as every repeat cycle. The update rate is higher than the one for the orbit information. However, only one attitude dataset is used per repeat cycle, and this is the one included in this record.</p>

<b>Component Record</b>	<b>Description</b>
<i>SpinRateatRCStart</i>	<p><b>Constituent Data.</b> Provides the spin-rate of the MSG imaging satellite at the start of the repeat cycle with a high accuracy. The accuracy is expected to be better than 2 in 100,000 (at the moment of the Repeat Cycle start). Note that during the Repeat Cycle, the spin rate will deviate from this figure due to the mirror motion and in case of eclipse, due to the thermal effects. The amplitude of the deviation to be expected will be provided after commissioning of the S/C and behaviour characterisation in actual eclipses.</p> <p><b>Usage.</b> The exact spin-rate can be computed at any moment from the 1.0 data by processing the Start-Of-Line datations. It was nevertheless found useful to provide the spin-rate at one characteristic moment in time for the information of the users. Usage of this information should take into account the operational situation, as spin-up manoeuvres or eclipse situations can affect the representativity of the value for the remainder of the Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every repeat cycle.</p>
<i>UTCCorrelation</i>	<p><b>Constituent Data.</b> Are all information required to relate the On-Board Time to the Universal Time Coordinated (UTC). The information covers a defined time period from past to future and is defined as polynomial coefficients of <math>UTC = f(\text{On-Board time})</math>.</p> <p><b>Usage.</b> All applications that need to relate On-Board Time information provided by the MSG Satellite to UTC. An example is processing of GERB data that might require accurate conversion of Start-Of-Line Datation to UTC transformation. Other examples are investigations or historical reprocessing, where the information is critical.</p> <p><b>Data Constancy.</b> Can be updated once per repeat cycle. The actual rate can be less frequent and depends on operational aspects. The information is exactly the one that is used for the processing of the Level 1.5 image of this repeat cycle.</p>

### 6.1.2 Image Acquisition Record Summary

This component record of the header holds information that has been used by EUMETSAT's image-processing system for the processing of the image data which the header precedes.

The information includes time delimiters for the start, end-of-forward-scan and end of the repeat cycle, and states and settings of the SEVIRI radiometer instrument. The majority of the values have been extracted from the satellite's housekeeping telemetry prior to the start of processing.

The status of the radiometer channels is given, along with various settings related to previous operations of the instrument such as gain changes, decontamination and blackbody calibration.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.2 [Image Acquisition Record](#).

<b>Component Record</b>	<b>Description</b>
<i>PlannedAcquisitionTime</i>	<p><b>Constituent Data.</b> These are the <u>actual</u> start-time of the repeat cycle, the <u>planned</u> time of forward scan end, and the <u>planned</u> Repeat Cycle end-time. Note: this is due to the fact that the actual end-times are not known (did not occur) at the moment the Header was created. – the actual times will only be known when real-time processing has completed, and thus they are held in the trailer. The planned information is generally so accurate (to less than 0.6 seconds) that it is sufficient for the Image Processing and therefore is probably sufficient for all derived applications.</p> <p><b>Usage.</b> To relate image data to the time &amp; date of observation. In the case of reduced scans, allows to identify the duration of the repeat cycle.</p> <p><b>Data Constancy.</b> Changes with each image.</p>

<b>Component Record</b>	<b>Description</b>
<i>RadiometerStatus</i>	<p><b>Constituent Data.</b> Status indicators for all channels and all detectors of the radiometer, showing which are switched on/off within the SEVIRI instrument.</p> <p><b>Usage.</b> In determining the status of the radiometer during image acquisition.</p> <p>Note 1: Users will normally not receive images which have been scanned by the radiometer operating in ‘test mode’ (unless specifically requested) – this information is generally for EUMETSAT’s reference only.</p> <p>Note 2: The information only relates to the SEVIRI status during Level 1.0 image acquisition This status information should not be confused with the presence or not of given image channels within the Level 1.5 data. For Level 1.5 channel information, the User should consider first the Record <u>Level 1_5 Image Production</u>.</p> <p><b>Data Constancy.</b> The status of each of the radiometer channels is nominally ‘on’, but during operations it might happen (e.g. during decontamination) that channels are switched “off”. Similarly for the status of each of the detectors. The status applies to the complete Repeat Cycle and can be updated each Repeat Cycle.</p>

<b>Component Record</b>	<b>Description</b>
<i>RadiometerSettings</i>	<p><b>Constituent Data.</b> Provides the basic parameters of the radiometer that apply for the acquisition of the repeat cycle and are used for the processing of the image. Of particular interest are the radiometric gains and offset settings used for Level 1.0 acquisition that will be used in the on-ground processing to derive (and calibrate) the Level 1.5 data.</p> <p>Also contained in this Record is the group of ‘Operation Parameters’ which shows the commanding of the radiometer just prior to the start of the repeat cycle (these commanded values are applicable to the Repeat cycle the Header belongs to).</p> <p><b>Usage.</b> Not only for internal operations of the Ground Segment, but also for system calibration activities that require the exact knowledge of the actual gains/offsets/temperature that were applicable during the acquisition of the image. Required also for EUMETSAT-internal activities like historical reprocessing.</p> <p><b>Data Constancy.</b> Detector gains are set according to radiometer channel to make best use of the dynamic range. In theory, gains can change from one repeat cycle to the next, but nevertheless stay constant for the duration of a repeat cycle.</p> <p>Operation parameters can also change for each repeat cycle, but many of them will be constant in operation (unless reduced scans are exercised for example).</p>

<b>Component Record</b>	<b>Description</b>
<i>RadiometerOperations</i>	<p><b>Constituent Data.</b> Information to show the time / duration / scope of the last gain-change, the last (or current) decontamination and the last blackbody calibration. Temperatures of the cold and warm focal planes are also given.</p> <p><b>Usage.</b> Activities such as decontamination and blackbody calibration, which affect the operation of the radiometer, have an influence on the image quality. The information here can help the understanding of variations in the image. In addition, the information is important for the monitoring of the calibration.</p> <p><b>Data Constancy.</b> The data provided here is the latest form of the information available within the MSG Ground Segment, and is updated as soon as newer information becomes available.</p>

### 6.1.3 Celestial Events Record Summary

This component record of the header holds information related to the position of the pertinent celestial bodies (i.e. the Earth, moon, sun and stars) and to the events which have effected the image, such as eclipses and appearances of bodies in the satellite's Field Of View (FOV).

Ephemeris information is mainly organised as time delimiters for the period concerned, and a set of coefficients for the Chebychev polynomials which describe the positions of the Earth, moon, sun and stars. For details on the coordinate frame and the polynomial computation see Section 7.2.3 Celestial Events Record.

The information concerning possible effect on an image includes the start and end times of eclipses, the type of eclipse, indicators for bodies either visible in the image or close to the satellite's FOV and an indication of the impact that might occur on image quality (e.g. horizons made indistinct by low illumination or stray light altering the radiometric quality within the Earth disc).

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.3 Celestial Events Record.

<b>Component Record</b>	<b>Description</b>
<i>CelestialBodiesPosition</i>	<p><b>Constituent Data.</b> Defines the position of the main celestial bodies as a function of time over a specified period of validity (covering past to future) including the current Repeat Cycle. The celestial bodies are the sun, the moon and an identified small set of bright stars. The positions of stars are primarily used for EUMETSAT-internal purposes, as a support for navigation.</p> <p><b>Usage.</b> The information is of interest to any user trying to relate the observation to the actual position of the sun / moon.</p> <p>The position of the sun is useful in defining the illumination situation for bi-directional reflectance computations (in conjunction with satellite longitude and orbit data), but also in defining whether flare and stray-light may affect the image (also see the next Component Record).</p> <p>The position of the moon is used to define whether or not the moon is within the field of view for the Level 1.0 image. The moon image will be masked out by the space-mask applied to the Level 1.5 image data, but if desired, it can be extracted (via a suitable data service) from the corresponding Level 1.0 data, e.g. for visible-channel calibration purposes.</p> <p><b>Data Constancy.</b> The data can be updated as frequently as once per repeat cycle. In practice, a lower rate of update will occur, depending on operational needs. The information is</p>

<b>Component Record</b>	<b>Description</b>
	<p>the latest available and is the one used for the image processing function.</p>
<p><i>RelationToImage</i></p>	<p><b>Constituent Data.</b> Provides the result of the analysis performed by the image-processing function on the positions of the celestial bodies. This covers the occurrences of eclipse, pre-eclipse, moon or sun in (or close to) the field of view w.r.t. the Level 1.0 data and the expected effect on the image data.</p> <p><b>Usage.</b> Mainly to determine whether the image data may be impacted or not by an eclipse or similar event. It also provides information on the type of expected impact. This information is useful for e.g. users wishing to find images that include the sun or the moon.</p> <p>Note 1: only Level 1.0 data contains such image data, however – as Level 1.5 normally has the space area masked out.</p> <p>Note 2: Celestial bodies that are identified as “close” to the Field Of View (FOV) are not actually visible in the Level 1.0 image but are sufficiently close to potentially impact radiometry, e.g. via straylight.</p> <p>Note 3: the type of impact is only estimated in the Header based on calculated positions. Please consider that the actually measured image quality (radiometry &amp; geometry) is only provided in the Trailer.</p> <p><b>Data Constancy.</b> Eclipses are frequent phenomena that affect the satellite every night (for a period of up to 80 minutes around midnight) during several weeks in spring and in autumn. The information here is updated every repeat cycle to indicate the conditions for the coming image acquisition.</p>

#### **6.1.4 Image Description Record Summary**

This component record of the header holds information which describes the image in terms of its projection, reference grids (one for HRV channel data, another for all other channels), planned-coverage mapping (one set of parameters for HRV channel data, another for all other channels), and an indication of the spectral channels for which it was foreseen to receive and process the image data. The information can be used to geographically locate the observed image. Please refer to Section 3.1.4.

The reference grids are defined in terms of numbers of lines and columns, grid-step sizes (in km equivalent Sub-Satellite Point) in the directions of lines of columns, and an indication of the position of the grid origin. One grid is present for VIS and IR data, another for HRV. The two grids are defined such that 3x3 HRV pixels are aligned with one VIS/IR pixel.

The planned-coverage mapping parameters include values for the planned southern and northern lines, the planned eastern and western columns. One set of parameters are present for VIS and IR data, another set for HRV. Note that for HRV, due to the capability to split the image in two parts (a Southern and a Northern) with different E-W positions (see Section 3.1.2), the planned coverage description is more complex.

The information about the planned production of the Level 1.5 data includes the indication if the processing is configured to generate or not the Level 1.5 image for any given channel.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.4 [Image Description Record](#).

<b>Component Record</b>	<b>Description</b>
<i>ProjectionDescription</i>	<p><b>Constituent Data.</b> Indicates the mathematical projection which will be used to generate the Level 1.5 data, and the longitude of the Sub-Satellite Point (SSP) that is used for the projection. Note: it is not foreseen currently to use other projections than the Geostationary one (see Section 3.1.4) The technical/mathematical details of the projection are fully defined in [GS].</p> <p>Note: The longitude of SSP defines from which point the projection is applied and should not be confused with the nominal satellite position (the longitude which is held in the Record ‘<u>Satellite Status</u>’). The ground processing is theoretically able to receive images acquired by a satellite located at any longitude and to process these to Level 1.5 using any (different) longitude for the projection. It is however of limited interest if the difference between the two longitudes is too high (e.g. above 10 degrees), as distortions appear and the actually useful Level 1.5 image surface is reduced.</p> <p><b>Usage.</b> This information, combined with the grid information, is used for relating pixels of Level 1.5 data to Earth coordinates (longitude and latitude).</p> <p><b>Data Constancy.</b> The information is unlikely to be modified, but it is foreseen that the longitude at SSP may be changed (infrequently) if the imaging satellite is moved to a position far away from the nominal 0° longitude in order to cover a different area of the globe.</p>
<i>ReferenceGridVIS_IR</i>	<p><b>Constituent Data.</b> Defines the grid used for the 11 VIS and IR channels which have 3-km pixel spacing. The size of the nominal Level 1.5 image area (in lines and columns), the origin of the grid and the actual pixel spacing (in line and column directions) are provided.</p> <p><b>Usage.</b> Facilitates the relating of pixel positions to Earth locations for the VIS and IR channels when combined with the projection information.</p> <p><b>Data Constancy.</b> Unlikely to change.</p>

<b>Component Record</b>	<b>Description</b>
<i>ReferenceGridHRV</i>	<p><b>Constituent Data.</b> Defines the grid used for the High Resolution Visible channel which has 1-km pixel-spacing. The size of the nominal Level 1.5 image area (in lines and columns), the origin of the grid and the actual pixel spacing (in line and column directions) are provided.</p> <p><b>Usage.</b> Same as for <u>ReferenceGridVIS_IR</u>, except for the HRV channel.</p> <p><b>Data Constancy.</b> Unlikely to change.</p>
<i>PlannedCoverageVIS_IR</i>	<p><b>Constituent Data.</b> Defines the coverage that is planned for the VIS and IR channels of the Level 1.5 image to come, w.r.t. the reference grid for those channels. For a nominal image, the coverage will be identical to the grid. For reduced scans, the information defines which subset of the Level 1.5 grid is actually generated. Note that the <u>actual</u> coverage is given in the Level 1.5 trailer. See also Section 3.1.2.</p> <p><b>Usage.</b> For advance knowledge of the intended Level 1.5 coverage for the VIS and IR channels - particularly of value in the case of reduced scanning.</p> <p><b>Data Constancy.</b> Can change from one repeat cycle to the next, but in practice should remain constant unless reduced scans are exercised.</p>
<i>PlannedCoverageHRV</i>	<p><b>Constituent Data.</b> HRV-specific data is similar to that for ‘PlannedCoverageVIS_IR’, but the number of parameters is extended to define the bounds of the two possible areas of coverage (northern part and Southern part) which may result from the alternative HRV coverage mode being operated (see also Section 3.1.2). Note that the <u>actual</u> coverage is given in the Level 1.5 trailer.</p> <p><b>Usage.</b> For advance knowledge of the intended Level 1.5 coverage for the HRV channel - particularly of value in the case of HRV alternative coverage mode.</p> <p><b>Data Constancy.</b> Can change from one repeat cycle to the next, but in practice should remain constant unless different than nominal scans are exercised (reduced scans or HRV alternative coverage).</p>

<b>Component Record</b>	<b>Description</b>
<i>Level1_5ImageProduction</i>	<p><b>Constituent Data.</b> Gives the directions of line- and pixel-generation of the Level 1.5 image data, and also identifies the channels for which Level 1.5 data will be generated (nominally all 12 channels).</p> <p><b>Usage.</b> To allow the user of the data (or more probably, the automated system receiving the data) to handle it in an appropriate manner. Storage, display and possibly processing functions will need to take account of the production information in order to perform their actions correctly.</p> <p><b>Data Constancy.</b> It is expected that the line- and pixel-generation directions will be set to ‘South-North’ and ‘East-West’ respectively, and will remain so permanently. It is also expected that Level 1.5 data will be produced for all 12 radiometer channels, except for when special operations (such as a radiometer decontamination) is performed. In the event of a malfunction of one or more of the channels, then it may be planned not to derive Level 1.5 data for particular channel(s) and the relevant indicators will then reflect this. Moreover, it is indicated whether the image is representing effective or spectral radiance.</p>

### 6.1.5 Radiometric Processing Record Summary

This component record of the header provides information related to the radiometric data processing applied to the Level 1.0 data but also information related to the calibration of the radiometer. This latter involves consideration of the self-emitted radiance of radiometer elements which affect the radiometer's infra-red measurements.

The information includes all 'Black Body' data last acquired (extracted from the SEVIRI Level 1.0 image data, and the housekeeping telemetry) that are used in the calibration process, the data which has been derived from it, and calibration feedback from EUMETSAT's meteorological product extraction facility. Data for the Modulation Transfer Function and 'stray-light' corrections is also included.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.5 [Radiometric Processing Record](#).

<b>Component Record</b>	<b>Description</b>
<i>RPSummary</i>	<p><b>Constituent Data.</b> Summarised details of radiometric processing per radiometer channel, indicating whether or not various aspects of radiometric processing have been applied or not to the data for each of the channels.</p> <p><b>Usage.</b> The summary indicators will show which of the detailed data following 'RPSummary' is valid to be used, depending on whether the relevant functions of radiometric processing have been applied (this per spectral channel). As can be seen from the component Records described below in this table, a large amount of detailed information is provided to allow the user to determine the scope of radiometric processing.</p> <p><b>Data Constancy.</b> Nominally, the summary indicators will always show that all radiometric processing functions have been applied for all channels for this Repeat cycle. The indicators may vary from one Repeat cycle to the next, as a function of the operational situation (e.g. if a BlackBody calibration provided or not new values, if the Calibration feedback was received or not, etc.).</p>

<b>Component Record</b>	<b>Description</b>
<i>Level1_5ImageCalibration</i>	<p><b>Constituent Data.</b> Calibration information for Level 1.5 data, for each of the 12 radiometric channels, comprising ‘slope’ coefficients and ‘offset’ constants which have been extracted from either on-board calibration data or from other sources such as MPEF calibration feedback data. It is the most accurate/up to date calibration information available within the MSG Ground Segment.</p> <p><u>Important Note:</u> This information is the primary calibration information that should be used when relating the Level 1.5 pixel count values to the physical radiance units.</p> <p>Note: the provision of one set of Slope/Offset coefficients per channel is sufficient for accurate calibration as the Level 1.5 data is produced after linearisation and equalisation of the radiance response of the single detectors (see Section 3.1.7).</p> <p><b>Usage.</b> To relate the Level 1.5 image pixel count values to physical radiance units.</p> <p><b>Data Constancy.</b> The data is (as all fundamental processing aspects) kept constant for an image but is likely to be updated from one image to the next (although it is expected to vary only slowly).</p>

<b>Component Record</b>	<b>Description</b>
<i>BlackBodyDataUsed</i>	<p><b>Constituent Data.</b> This record holds the values associated with the last blackbody calibration performed. This includes MDU and PU gains for each of the radiometer’s detectors, and the temperatures of the focal planes (warm and cold), scan mirror and the various sensors, such as these located on the baffle, the other mirrors and the black-body. Extracted black-body data (i.e. extracted from the image data acquired during black-body viewing) for each of the 12 radiometer channels is also included in this record, describing the set of pixels used in each case.</p> <p><b>Usage.</b> The purpose of the data is to provide full visibility of all data used as input to the blackbody processing in IMPF. This can be used for investigation, for historical reprocessing or for research/analysis purpose in order to optimise the processing.</p> <p><b>Data Constancy.</b> Blackbody calibration may be performed up to once per Repeat Cycle, although lower frequency of calibration may be applied when the instrument is known to be stable from a radiometric standpoint. The information presented is always the latest one, updated up to once per Repeat Cycle.</p>

<b>Component Record</b>	<b>Description</b>
<i>MPEFCalFeedback</i>	<p><b>Constituent Data.</b> This Record contains two types of information, the calibration feedback information from vicarious calibration against forecast and radiosondes and the cross-calibration against IASI according to the GSICS standards. The vicarious calibration information from MPEF is used for internal purposes as a feedback for the image-processing function. Flags for each of the 12 radiometer channels are provided, indicating whether or not MPEF considers that calibration performed by IMPF is of good quality, and if not, whether MPEF-supplied absolute calibration coefficients should be used by the automated image processing function. The absolute calibration data itself follows the quality flags in this Record, and includes details of the type of data, along with values for coefficients and biases.</p> <p>Important note: this information is normally already taken into account for the derivation of the <a href="#">Level1_5ImageCalibration</a>, so that the normal Level 1.5 data user does not need to analyse the present Record. In particular, differences between the information within the <a href="#">Level1_5ImageCalibration</a> and this one might have valid operational reasons, so that the information has to be used with extreme care.</p> <p>The GSICS cross-calibration part of the Record provides the results of the Near Real-Time (NRT) IASI-MSG cross-calibration to users. These data are updated usually once per day.</p> <p><b>Usage.</b> The vicarious calibration information is mainly for use within the MSG Ground Segment and should only be used for specific purposes by users external to the Ground Segment. It presents the insight on the MPEF feedback and can be used for specific investigations or research on calibration. The normal data user should always use the <a href="#">Level1_5ImageCalibration</a>, as this is the most accurate information available at the moment of processing within the Ground Segment.</p> <p>Users can optionally apply the GSICS cross-calibration coefficients instead of the <a href="#">Level1_5ImageCalibration</a> to ensure SEVIRI's calibration is consistent with that of the GSICS reference, and to correct for known radiometric biases, where these may affect their products.</p> <p><b>Data Constancy.</b> Indicators are included in the Record to show whether the calibration values have changed since the last repeat cycle. It is expected that MPEF will perform calibration cross-checking once every repeat cycle, and so variation may occur as frequently as that.</p>

<b>Component Record</b>	<b>Description</b>
<i>RadTransform</i>	<p><b>Constituent Data.</b> Holds the values of the Look-Up Tables (in steps of 64 counts) for each of the 42 detectors which are used for mapping the Level 1.0 digital counts to the floating point representation used for image-processing. For more details on these aspects see also Section 3.1.7 and Section 3.1.8.</p> <p><b>Usage.</b> The primary use is for the expert Users who desire to trace back very accurately all radiometric transformations applied to the Level 1.0 data. This is the case for example in the case of investigations on the end-to-end system calibration activities/campaigns.</p> <p><b>Data Constancy.</b> The look-up table values are likely to change from one repeat cycle to another as a result of dynamic calibration, equalisation, linearisation, etc.</p>
<i>RadProcMTFAdaptation</i>	<p><b>Constituent Data.</b> This Record contains the FIR filter sets of coefficients used for the MTF adaptation in N-S and E-W directions for each of the 42 detectors. The Level 1.5 impulse response (the inverse Fourier transform of the Level 1.5 MTF) is the result of the convolution of the initial Level 1.0 impulse response with the provided data.</p> <p><b>Usage.</b> To provide full trace of all applied transformation in the processing from Level 1.0 to Level 1.5. The usage is limited to expert users for specific investigations/research.</p> <p><b>Data Constancy.</b> The data is in practice constant over longer periods of time, but might be updated from one Repeat cycle to the next when a new set of MTF adaptation FIR is entering into operations (e.g. as a result of better characterisation).</p>
<i>StraylightCorrection</i>	<p><b>Constituent Data.</b> This Record holds Chebyshev coefficients of the straylight compensation which is a function of radiometer position and E-W Level 1.0 pixel location, and that can be applied in the production of the Level 1.5 image data (see also Section 3.1.11).</p> <p><b>Usage.</b> To provide full trace of the transformations applied to the Image data in order to derive the Level 1.5 image data.</p> <p><b>Data Constancy.</b> The data is by nature quasi-constant over time but can be updated from one Repeat Cycle to the next when more accurate information is provided.</p>

### **6.1.6 Geometric Processing Record Summary**

This component record of the header provides information for east-west and north-south focal plane layouts, the scanning law, the Earth and atmosphere models and the resampling functions.

Scanning law data consists of the angles corresponding to the steps of the radiometer which the latter takes in the course of its excursion between the lower and upper thresholds of the scanning.

The Earth model corresponds to the Earth Model used for the Horizons and Landmark processing as well as for the derivation of the relation of a given observation in the Level 1.0 image to physical geographical coordinates.

Note: This Earth Model is not the same than the one underlying the Level 1.5 Projection (that only defines the way the Level 1.5 data is projected on a surface, function of the geographical coordinates).

The atmospheric model gives values indicating the apparent limits of the atmosphere.

The resampling function defines what resampling kernel was used for the processing to Level 1.5.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.6 [Geometric Processing Record](#).

<b>Component Record</b>	<b>Description</b>
<i>OptAxisDistances</i>	<p><b>Constituent Data.</b> This is also sometimes referred to as the “Focal Plane layout”. It defines the latest and most accurate knowledge of the estimated relative locations of the detectors in the focal plane. The distances from the optical axis in both E-W and N-S directions are expressed for each of the detectors in terms of kilometres from SSP.</p> <p><b>Usage.</b> Provides expert users the knowledge of what was the focal plane misregistration that was corrected for in the processing to the Level 1.5. As the pre-launch characterisation of the Focal Plane is of limited value once in operations, the detector positions are regularly re-estimated (using horizons and landmarks measurements) by the automated processing. The information is therefore useful because it provides the most accurate knowledge available on the true misregistration in the Level 1.0 image data. It is used also in the case of historical reprocessing.</p> <p><b>Data Constancy.</b> The misregistration is accurately tracked and compensated for: the data is updated every Repeat Cycle (although only minor/slow modifications are expected). The values are used for the processing of the full Repeat Cycle.</p>
<i>EarthModel</i>	<p><b>Constituent Data.</b> Details of the earth model used by IMPF for navigation, and the sizes of the equatorial, northern polar and southern polar radii in kilometres, used by IMPF for the navigation of Level 1.0 to Level 1.5.</p> <p><b>Usage.</b> For EUMETSAT internal usage only. Note: this is only indicating how observations in the Level 1.0 image are related to geographical positions, it is not the way the Level 1.5 image pixels are related to geographical positions (for this see <a href="#">ProjectionDescription</a>).</p> <p><b>Data Constancy.</b> Foreseen to be constant over long periods of time. Can however change from one image to the next as a result of an update of the corresponding database (e.g. for improved accuracy).</p>

<b>Component Record</b>	<b>Description</b>
<i>AtmosphericModel</i>	<p><b>Constituent Data.</b> An array with elements for each of the channels and 360 elements per channel corresponding to the apparent atmosphere limit, sampled from South to North.</p> <p><b>Usage.</b> For EUMETSAT-internal purposes (e.g. historical reprocessing).</p> <p><b>Data Constancy.</b> Will change every Repeat Cycle.</p>
<i>ResamplingFunctions</i>	<p><b>Constituent Data.</b> Defines for each channel the type of Resampling used for the processing. The default (baseline) resampling function used in IMPF is a 9x9 FIR Shannon interpolation with a Kaiser window. Other resampling functions (Bicubic Splines 4x4 and Nearest Neighbour) are possible for specific use / reference.</p> <p><b>Usage.</b> Information on the applied interpolator for expert users. Used for historical reprocessing and for tracing the exact configuration of the applied processing.</p> <p><b>Data Constancy.</b> Likely to stay constant. However changes from one Repeat Cycle to the next can occur as a consequence of an upgrade or an improvement.</p>

### 6.1.7 IMPF Configuration Record Summary

This component record of the header provides information on the active configuration of the image processing function within the EUMETSAT MSG Ground Segment.

Information is also contained within this Record that facilitates the resumption of image-processing during a ‘warm-start’ of EUMETSAT’s image-processing system. The availability of such information means that image-processing can resume in a seamless manner after a restart/switch of the computer hosting the software system or in case of controlled historical reprocessing. The principle of this warm-start data is to save at a controlled breakpoint in the processing, the state of all basic internal variables/models that are required for the processing of the next Repeat Cycle.

As the information is really only of interest for the internal operations within EUMETSAT. Note: This record is not disseminated and externally only available via the UMARF.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.2.7 IMPF Configuration Record.

<b>Component Record</b>	<b>Description</b>
<i>OverallConfiguration</i>	<p><b>Constituent Data.</b> Gives the overall identification of processing history (in terms of real time processing and offline reprocessing of archived data).</p> <p><b>Usage.</b> To identify the real time processed and reprocessed data.</p> <p><b>Data Constancy.</b> The overall identification will change when data is re-processed offline.</p>

<b>Component Record</b>	<b>Description</b>
<i>SUDetails</i>	<p><b>Constituent Data.</b> Provides details of all ‘Software Units’ (SUs) and their associated ‘Information Bases’ that are in use on the EUMETSAT MSG computer system that processed the image.</p> <p>Each SU is identified uniquely within IMPF and according to its instantiation. Details of the processing modes and states of the (SUs) that were in use on the EUMETSAT MSG computer system that processed the image.</p> <p>Possible SU modes are OFF, ON/Non-Processing, ON/Real-Time Processing and ON/Analysis.</p> <p>The possible SU states are ERROR, NOMINAL and DEGRADED.</p> <p><b>Usage.</b> For EUMETSAT’s own use – the data is unlikely to be of value to users. EUMETSAT might require it in the case of image-data reprocessing being necessary, or possibly for problem diagnosis.</p> <p>It is not foreseen that this component Record will be disseminated with the other Records constituting the header via LRIT/HRIT, but it will be supplied with retrievals made from U-MARF.</p> <p><b>Data Constancy.</b> A SU will change when a new version of software is made operational. It is not expected that new versions would be introduced more than a few times in the course of a year. An ‘Information Base’ may also change at these times in accordance with the software, but may also change when special operational activities require it. The latter may occur from several times a year upwards to potentially several times on certain days.</p> <p>SU mode and state information is a snapshot at the start of image resampling. It is expected that, for images distributed to external users, the information will be constant for all SUs, each taking the nominal value. It should be noted that the snapshot information can become out of date in the course of the repeat cycle.</p>

<b>Component Record</b>	<b>Description</b>
<i>WarmStartParms</i>	<p><b>Constituent Data.</b> The states of all the models required for a warm start or the historical reprocessing of the image data.</p> <p><b>Usage.</b> Purely for EUMETSAT purposes like historical reprocessing, troubleshooting or on-going optimisation.</p> <p><b>Data Constancy.</b> Updated (in part at least) with each repeat cycle.</p>

## **6.2 Level 1.5 Image Data Summary**

For each scan of the earth disc by the MSG satellite, image data for 12 different spectral channels is produced in nominal operations. Each channel's line data is held in one of two different Record structures, depending on which spectral type it is.

One type of Record structure is designed to hold the data of the nominal line-size of 3712 pixels (i.e. the 11 types of visible (VIS) / infra-red (IR) data), and the other to hold the greater line-size of 5568 pixels (i.e. that of the high-resolution visible (HRV) channel).

The channel ordering of the image data constituting one scan line is as follows:

- VIS 0.6
- VIS 0.8
- NIR 1.6 (Near-Infra-Red)
- IR 3.9
- IR 6.2 (WV)
- IR 7.3 (WV)
- IR 8.7
- IR 9.7 (Ozone)
- IR 10.8
- IR 12.0
- IR 13.4 (CO<sub>2</sub>)
- HRV

### 6.2.1 15VIS/IR Image Line Record Summary

This record structure is the one used for holding data for any of the 11 VIS / IR image lines.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.3 [1.5 VIS/IR Line Record](#).

<b>Component Record</b>	<b>Description</b>
<i>LineSideInfo</i>	<p><b>Constituent Data.</b> The specification of the satellite which produced the data originally, the image-line and spectral channel context of the data, the acquisition time of that line, and various validity / quality indicators.</p> <p><b>Usage.</b> The side-information for the line allows the user to determine to which repeat cycle (and spectral channel thereof) the data belongs, and whether the data for the particular line is usable or not. The user is informed if the data present is non-nominal due to having been ‘missed’, ‘corrupted’, ‘replaced’, or ‘interpolated’, and a classification of ‘nominal’, ‘usable’, ‘suspect’ or ‘do not use’ is provided for both radiometric and geometric quality.</p> <p><b>Data Constancy.</b> While it is expected that the satellite id. and validity / quality indicators will normally stay constant, the remaining information will vary on a line-by-line basis.</p>
<i>LineData</i>	<p><b>Constituent Data.</b> The Level 1.5 pixel data for the spectral channel and line is indicated in ‘<i>LineSideInfo</i>’ above. For the number of pixels held in this component Record, and the number of these Records which together constitute an image, please refer to the Section 3.1.3.</p> <p><b>Usage.</b> The pixel data contained in this field is nominally used to build an image (for the indicated spectral-channel) corresponding to one scan of the earth.</p> <p><b>Data Constancy.</b> This is Image data, so no constancy. The only exception might be the lines of masked space that occur close to the South Pole or the North Pole.</p>

### 6.2.2 15HRV Image Line Record Summary

This record structure is that used for holding data for the HRV image line.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.4 [1.5 HRV Line Record](#).

Component Record	Description
<i>LineSideInfo</i>	<p><b>Constituent Data.</b> Same applies as for the field '<i>LineSideInfo</i>' of the Record structure '<i>VIS / IR Image Line</i>'.</p> <p><b>Usage.</b> Same applies as for the field '<i>LineSideInfo</i>' of the Record structure '<i>VIS / IR Image Line</i>'.</p> <p><b>Data Constancy.</b> Same applies as for the field '<i>LineSideInfo</i>' of the Record structure '<i>VIS / IR Image Line</i>'.</p>
<i>LineData</i>	<p><b>Constituent Data.</b> The Level 1.5 pixel data for the HRV line is indicated in '<i>LineSideInfo</i>' above. For the number of pixels held in this component Record, and the number of these Records which together constitute an image, please refer to the Section 3.1.3.</p> <p><b>Usage.</b> The pixel data contained in this field is nominally used to build an HRV image corresponding to one scan of the earth.</p> <p><b>Data Constancy.</b> This is Image data, so no constancy. The only exception might be the lines of masked space that occur close to the South Pole or the North Pole.</p>

### 6.3 Level 1.5 Trailer Summary

The purpose of the **trailer** which accompanies each Level 1.5 image is also to supply ancillary information needed by the end-user for interpreting the data and / or further processing the image.

In contrast to the header, the trailer contains information which is either accumulated during the processing of the image, or at its completion, and is generated at the end of the image repeat cycle, following the image data.

The trailer comprises a number of component items which hold information relevant to the topics indicated below:

<i>Topic</i>	<i>Component Type</i>	<i>Details of Component</i>
Trailer Version	Field	<i>This field identifies the version of the trailer – important when its format may have been upgraded</i>
Image Production Stats	Record	See <u>corresponding subsection</u>
Navigation Extraction Results	Record	See <u>corresponding subsection</u>
Radiometric Quality	Record	See <u>corresponding subsection</u>
Geometric Quality	Record	See <u>corresponding subsection</u>
Timeliness and Completeness	Record	See <u>corresponding subsection</u>

These topics are described in the sub-sections that follow, in terms of both the data content and the relation the information has to the image data.

### 6.3.1 Image Production Stats Record Summary

This component record of the trailer holds information on the actual image produced, providing details of its dimensions.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.5.1 Image Production Stats Record.

<b>Component Record</b>	<b>Description</b>
<i>SatelliteId</i>	<p><b>Constituent Data.</b> Indicator to show which of the satellites in the MSG series scanned the image.</p> <p><b>Usage.</b> Unambiguous relation of the present trailer to the image taking satellite.</p> <p><b>Data Constancy.</b> Might change as a consequence of a change in the imaging satellite. Note this can occur even if the disseminating satellite stays the same.</p>
<i>ActualScanningSummary</i>	<p><b>Constituent Data.</b> Summary details of image-taking for this repeat cycle, which include an indication of whether image-taking was performed in the nominal manner during the whole repeat cycle, whether it was a reduced scan, and the times of the first and last lines of forward scan.</p> <p><b>Usage.</b> Information about the actual image acquisition cycle (start and end of forward scan)</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>RadiometerBehaviour</i>	<p><b>Constituent Data.</b> Details of radiometer behaviour for this repeat cycle, which include indicators for nominal behaviour of the radiometer instrument during the whole of this repeat cycle, and whether any scan irregularity, radiometer stoppage or any other radiometer event has occurred which is considered abnormal behaviour.</p> <p><b>Usage.</b> Accurate information on the actual status at the end of the image acquisition for this Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated for every Repeat Cycle. Hopefully always nominal!</p>

<b>Component Record</b>	<b>Description</b>
<i>ReceptionSummaryStats</i>	<p><b>Constituent Data.</b> Statistics on a radiometer channel basis which give the number of corrupted Level 1.0 lines for this repeat cycle, the number of missing lines, the number of corrupt lines and the number of replaced lines.</p> <p><b>Usage.</b> Information on the actual status at the end of the Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every repeat cycle.</p>
<i>L15ImageValidity</i>	<p><b>Constituent Data.</b> A component sub-Record per radiometer channel which indicates the validity of the Level 1.5 image in terms of completeness, radiometric quality, geometric quality and timeliness.</p> <p><b>Usage.</b> Updated information on the actual status at the end of the Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>ActualL15CoverageVIS/IR</i>	<p><b>Constituent Data.</b> The line numbers of the actual bounds of this Level 1.5 image (i.e. the northern-, southern-, eastern- and western-most lines). These line numbers are within the limit of the planned-coverage information which was presented in the Level 1.5 header.</p> <p><b>Usage.</b> Updated information on the actual status at the end of the Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>ActualL15CoverageHRV</i>	<p><b>Constituent Data.</b> Similar to ‘<i>ActualL15CoverageVIS/IR</i>’ above, except that there are two line numbers given for the eastern and western bounds – these cater for the ‘upper’ and ‘lower’ areas of a alternative coverage HRV image. For an example of such an HRV image, please see the Section 3.1.2.</p> <p><b>Usage.</b> Updated information on the actual status at the end of the Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>

### 6.3.2 Navigation Extraction Results Record Summary

This component record of the trailer holds information containing all the image-based measurements (i.e. horizons, landmarks and stars) which have been made by IMPF to support navigation, and in particular the estimation of Orbit & Attitude.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.5.2 [Navigation Extraction Results Record](#).

<b>Component Record</b>	<b>Description</b>
<i>ExtractedHorizons</i>	<p><b>Constituent Data.</b> Alpha and beta angle measurements (in radians), accompanied by respective confidence intervals, the time of observation and the satellite spin-rate (in rpm.) for each of the 4 horizons (south, north, east &amp; west) for the present Repeat Cycle. For more details on the angles definition, see section <a href="#">Navigation Extraction Results Record</a>. Note: in case of miniscans, there might be only 2 horizons (East &amp; West) or none extracted.</p> <p><b>Usage.</b> Provides expert users the information about the observed, refined horizons extracted from the Level 1.0 image for the purpose of being used to derive the attitude/ (these data are passed together with other observations to the Flight Dynamics function of the Ground Segment for Attitude &amp; Orbit derivation).</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle and containing the information extracted during the Repeat Cycle.</p>
<i>ExtractedStars</i>	<p><b>Constituent Data.</b> The same information as for each of the '<a href="#">ExtractedHorizons</a>', but this time for each of the stars for which navigation information has been generated. Note that a unique EUMETSAT star identifier is held within the data for each star.</p> <p><b>Usage.</b> Same as for '<a href="#">ExtractedHorizons</a>', but this time for each of the stars used for navigation.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle and containing the information extracted during the Repeat Cycle.</p>

<b>Component Record</b>	<b>Description</b>
<i>ExtractedLandmarks</i>	<p><b>Constituent Data.</b> The same information as for each of the '<i>ExtractedHorizons</i>', but this time for each of the landmarks for which navigation information has been generated. Note that a unique EUMETSAT landmark identifier is held within the data for each landmark, along with the landmark's latitude and longitude.</p> <p><b>Usage.</b> of the '<i>ExtractedHorizons</i>', but this time for each of the landmarks used for navigation.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle and containing the information extracted during the Repeat Cycle.</p>

### 6.3.3 Radiometric Quality Record Summary

This component record of the trailer holds information.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.5.3 [Radiometric Quality Record](#).

Component Record	Description
<i>L10RadQuality</i>	<p><b>Constituent Data.</b> Details of the radiometric quality for each of the 42 detectors, in the form of a variety of statistical measures for the full image data, and also the Earth-disc, moon and space-region component data. Sampled versions of the accumulated Power Spectral Density (PSD) over all applicable E-W rows and over all applicable N-S columns are also included.</p> <p><b>Usage.</b> Full information on the actual radiometric image quality per detector of the Level 1.0 data</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>L15RadQuality</i>	<p><b>Constituent Data.</b> Details of the radiometric quality for each of the 12 channels, which includes a subset of the fields contained in '<i>L10RadQuality</i>' (but – note! – only per channels, not detectors, as the signal from the detectors of a given spectral channel has been combined during the production of the Level 1.5 data). Additional fields to those for Level 1.0 also provide the RMS and mean values respectively for the space corners of the Level 1.5 data (i.e. equivalent to the area that would have been produced had a space mask not been applied).</p> <p><b>Usage.</b> The values can be compared with the same information for Level 1.0 to assess the impact on the noise due to IMPF processing from Level 1.0 to Level 1.5.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>

### 6.3.4 Geometric Quality Record Summary

This component record of the trailer holds 4 sets of statistical information which describes the absolute accuracy of the image, the relative accuracy from image to image, and the relative accuracy within the image over 500-pixel and 16-pixel ranges, and this for each of the 12 radiometer channels. It also holds misregistration residual and geometric quality status information, again, on a radiometer channel basis.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.5.4 Geometric Quality Record.

<b>Component Record</b>	<b>Description</b>
<i>AbsoluteAccuracy</i>	<p><b>Constituent Data.</b> If derived, statistical information related to the overall absolute accuracy of the image data for each of the 12 radiometer channels, in both north-south and east-west directions. The metrics provided include magnitudes and uncertainties of accumulated RMS, deviations in image accuracy and maximum uncertainty factors in both.</p> <p><b>Usage.</b> Provides the data users with the actually measure absolute accuracy of the Level 1.5 image.</p> <p><b>Data Constancy.</b> Measured every Repeat Cycle.</p>
<i>RelativeAccuracy</i>	<p><b>Constituent Data.</b> Similar statistical information to that for '<i>AbsoluteAccuracy</i>', but this time related to the relative accuracy from image to image.</p> <p><b>Usage.</b> Provides the data users with the actually measured relative accuracy (a criterion of the “stability” over time of the image correction)</p> <p><b>Data Constancy.</b> Computed every Repeat Cycle, by comparing with the previous Level 1.5 image.</p>
<i>RelativeAccuracy500Pixels</i>	<p><b>Constituent Data.</b> Similar statistical information to that for '<i>RelativeAccuracy</i>', but this time related to the relative accuracy within an image over the range of 500 pixels.</p> <p><b>Usage.</b> Provides data users with the actually measured accuracy within 500 pixels (gives a measure of the “distortion” between pixels that are separated by up to 500 pixels).</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>

<b>Component Record</b>	<b>Description</b>
<i>RelativeAccuracy16Pixels</i>	<p><b>Constituent Data.</b> Similar statistical information to that for '<i>RelativeAccuracy500Pixels</i>', but this time for the relative accuracy within the image over the range of 16 pixels.</p> <p><b>Usage.</b> Currently, it is TBC if it is possible to measure these deviations in a reliable manner. If this is the case, the figures would be provided here.</p> <p><b>Data Constancy.</b> Updated every repeat Cycle.</p>
<i>MisregistrationResiduals</i>	<p><b>Constituent Data.</b> If derived, statistical information related to the misregistration residuals of the image data for each of the 12 radiometer channels, in both north-south and east-west directions. The metrics indicate magnitudes, uncertainty factors therein, and the RMS of misregistration.</p> <p><b>Usage.</b> Provides the actually measured residual misregistration once the <u>OptAxisDistance</u> has been compensated for. Note that the process of estimating the true focal plane distances is an extremely accurate one, based on the accumulation of hundreds of measurements from many Repeat cycles, whereas these measurements are only done within this Repeat cycle and therefore have a much higher uncertainty. Therefore it is advisable to consider the provided uncertainty radii for any work based on these values. For the most accurate knowledge related to the actual Focal Plane Layout, the information provided within the <u>OptAxisDistance</u> should be considered.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>GeometricQualityStatus</i>	<p><b>Constituent Data.</b> Geometric quality status information for each of the 12 radiometer channels, indicating whether overall quality is nominal, whether absolute image accuracy is nominal, whether relative image-to-image accuracy is nominal, whether relative accuracy within the image (for 16- and 500-pixel ranges) is nominal, and finally, whether image registration between spectral bands is nominal.</p> <p><b>Usage.</b> Provides a summary indicating to the Data Users if the image geometric quality is within specifications for the completed Repeat Cycle.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>

### 6.3.5 Timeliness and Completeness Record Summary

This component record of the trailer holds information.

The following table gives details of the likely usage of the data and its main characteristics. For full details on the Data Content see Section 7.5.5 Timeliness and Completeness Record.

<b>Component Record</b>	<b>Description</b>
<i>Timeliness</i>	<p><b>Constituent Data.</b> Minimum, maximum and mean delays in seconds for the whole image, between the Level 1.0 mean acquisition time and the time of the corresponding 1.5 image data output by EUMETSAT's image-processing facility.</p> <p><b>Usage.</b> Arguably of importance to EUMETSAT only, to provide a basis for statistics which will show the operational performance of its image-processing facility in terms of speed of the production of the Level 1.5 image.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>
<i>Completeness</i>	<p><b>Constituent Data.</b> Information showing the variation between the planned and the actual coverage of the Level 1.5 image (for each radiometer channel) in terms of the number of lines within each coverage, the number of Level 1.5 invalid lines, the number of dummy Level 1.5 image lines that were produced without corresponding Level 1.0 data (e.g. due to missing data) and the number of Level 1.5 image lines that were generated using corrupted Level 1.0 data.</p> <p><b>Usage.</b> Also of importance to EUMETSAT, to provide a basis for statistics which will show the operational performance of its image-processing facility in terms of its production of acceptable quality Level 1.5 image data.</p> <p><b>Data Constancy.</b> Updated every Repeat Cycle.</p>

## 7 DETAILED DATA CONTENT – APPLICATION DATA UNITS

Terms Used in the Level 1.5 Data Content definition:

*1.0 mean acquisition time:* the average acquisition time of the Level 1.0 data from which the 1.5 data item is derived (data from several scan lines is used to derive a 1.5 data item).

*Centre square:* the square area of pixels measuring 1024 by 1024 pixels located in the centre of the image square, as characterised by the coordinates (1344, 1344) and (2368, 2368) in the Level 1.5 reference grid.

*Earth disk:* the Earth disk part of the image for a particular spectral channel.

*Full image:* the full image array (including space) of the corresponding spectral channel.

*Lower area:* refers to the area of HRV image data that is scanned prior to the occurrence of a ‘break line’, i.e. the point in forward scan where the East-West offset is altered.

*Upper area:* refers to the area of HRV image data that is scanned subsequent to the occurrence of a ‘break line’, i.e. the point in forward scan where the East-West offset is altered.

*Space corner:* the square area of pixels measuring up to 500 by 500 pixels in either the SE, SW, NE or NW corner of the image square (the relevant 2-letter prefix used to identify which one). The expression “four space corners” is used to refer to the data from all four of the space corners.

Basic Data Structures

To be completed

The following data structures are used and not further detailed:

*GP\_SC\_ID*                      *Spacecraft identification. The spacecraft addressed through the MSGGS shall be uniquely identified. They concern the MSG spacecraft and simulators as well as spacecraft controlled by external ground segments interfaced to the MSGGS.*

Title: Spacecraft Identification	Id: GP_SC_ID	Area: general purpose
GP_SC_ID ::= ENUMERATED SHORT		

{NoSpacecraft	(0),	-- No specific satellite
METEOSAT-3	(16),	-- MOP spacecraft, ESA assigned ID
METEOSAT-4	(19),	
METEOSAT-5	(20),	
METEOSAT-6	(21),	
MTP-1	(150),	-- MTP spacecraft, ESA assigned ID
MTP-2	(151),	
MSG-1	(321),	-- MSG spacecraft, CCSDS assigned ID
MSG-2	(322),	
MSG-3	(323),	
MSG-4	(324),	
METOP-1	(11),	-- EPS, CCSDS assigned ID
METOP-2	(12),	
METOP-3	(13),	
NOAA-12	(17012),	-- NOAA polar, MSG GS assigned ID
NOAA-13	(17013),	
NOAA-14	(17014),	
NOAA-15	(17015),	
NOAA-16	(17016),	
NOAA-17	(17017),	
GOES-7	(18007),	-- GOES, MSG GS assigned ID
GOES-8	(18008),	
GOES-9	(18009),	
GOES-10	(18010),	
GOES-11	(18011),	
GOES-12	(18012),	
GOMS-1	(19001),	-- GOMS, MSG GS assigned ID
GOMS-2	(19002),	
GOMS-3	(19003),	
GMS-4	(20004),	-- GMS, MSG GS assigned ID
GMS-5	(20005),	
GMS-6	(20006),	
MTSAT-1	(21001),	-- MTSAT, MSG GS assigned ID
MTSAT-1R	(21003),	
MTSAT-2	(21002),	
UnknownSpacecraft	(OTHERS)}	

### 7.1.1 GP\_SC\_NAME: Spacecraft name

The spacecraft addressed through the MSGGS shall be assigned unique names.

Title: Spacecraft name	Id: GP_SC_NAME	Area: general purpose
GP_SC_NAME ::= CHARACTERSTRING SIZE (12)		
("NoSpacecraft"		-- No specific satellite
"METEOSAT3 "		-- MOP spacecraft
"METEOSAT4 "		
"METEOSAT5 "		

**MSG Level 1.5 Image Data Format Description**

"METEOSAT6	"		
"MTP1	"	-- MTP spacecraft	
"MTP2	"		
"MSG1	"	-- MSG spacecraft	
"MSG2	"		
"MSG3	"		
"METOP1	"	-- EPS	
"METOP2	"		
"NOAA12	"	-- NOAA polar	
"NOAA13	"		
"NOAA14	"		
"NOAA15	"		
"NOAA16	"		
"NOAA17	"		
"GOES7	"	-- GOES	
"GOES8	"		
"GOES9	"		
"GOES10	"		
"GOES11	"		
"GOES12	"	"GOMS1	"   -- GOMS
"GOMS2	"		
"GOMS3	"		
"GMS4	"	-- GMS	
"GMS5	"		
"GMS6	"		
"MTSAT1	"	-- MTSAT	
"MTSAT1R	"		
"MTSAT2	"		
"Unknown	")	-- Other	

**TIME CDS SHORT**

CCSDS Day Segmented time in its SHORT (6 bytes, day since epoch + number of milliseconds in day) format. For the CDS time, the epoch is 1958 January 1<sup>st</sup> starting with 0. The CDS time is UTC-based and takes into account leap second corrections.

Day	Milliseconds of day
UNSIGNED SHORT 2 bytes	UNSIGNED 4 bytes

Table 3 - Short CDS time

## 7.2 15HEADER Record Structure

The packet body assigned to the 15Header service subtype is defined as follows:

15HEADER ::= RECORD		
{	<b>15HEADERVersion</b>	UNSIGNED BYTE (0),
	<b>SatelliteStatus_Record</b>	SatelliteStatus, -- See below for definition
	<b>ImageAcquisition_Record</b>	ImageAcquisition, -- See below for definition
	<b>CelestialEvents_Record</b>	CelestialEvents, -- See below for definition
	<b>ImageDescription_Record</b>	ImageDescription, -- See below for definition
	<b>RadiometricProcessing_Record</b>	RadiometricProcessing, -- See below for definition
	<b>GeometricProcessing_Record</b>	GeometricProcessing, -- See below for definition
	<b>IMPFConfiguration_Record</b>	IMPFConfiguration} -- See below for definition

**15HEADERVersion** is used to identify the header version. Note: This parameter is not disseminated and externally only available via the UMARF.

### 7.2.1 SatelliteStatus Record

This is defined as follows:

SatelliteStatus ::= RECORD		
{	<b>SatelliteDefinition</b>	RECORD
	{	<b>SatelliteId</b> GP_SC_ID,
	<b>NominalLongitude</b>	REAL,
	<b>SatelliteStatus</b>	ENUMERATED BYTE
		{operational (1),
		standby (2),
		commissioning/test (3),
		manoeuvre (4),
		decontamination (5),
		safe mode (6),
		dissemination only (7)}},
	<b>SatelliteOperations</b>	RECORD
	{	<b>LastManoeuvreFlag</b> BOOLEAN BYTE,
	<b>LastManoeuvreStartTime</b>	TIME CDS SHORT,
	<b>LastManoeuvreEndTime</b>	TIME CDS SHORT,
	<b>LastManoeuvreType</b>	ENUMERATED BYTE
		{Spin-Up (0),
		Spin-Down (1),
		Attitude Slew (2),
		N-S Station-Keeping (3),
		E-W Station-Keeping (4),
		Station Relocation (5)}},
	<b>NextManoeuvreFlag</b>	BOOLEAN BYTE,
	<b>NextManoeuvreStartTime</b>	TIME CDS SHORT,
	<b>NextManoeuvreEndTime</b>	TIME CDS SHORT,
	<b>NextManoeuvreType</b>	ENUMERATED BYTE
		{Spin-Up (0),
		Spin-Down (1),
		Attitude Slew (2),
		N-S Station-Keeping (3),
		E-W Station-Keeping (4),
		Station Relocation (5)}},
	<b>Orbit</b>	ORBIT, -- See below for definition
	<b>Attitude</b>	ATTITUDE, -- See below for definition
	<b>SpinRateatRCStart</b>	REAL DOUBLE,
	<b>UTCCorrelation</b>	UTCCORRELATION} -- See below for definition

### **SatelliteDefinition:**

**SatelliteId** gives the satellite's identification. It is the ID received by IMPF in the GS packet sub-header of the 1.0 data used to produce the 1.5 data.

**NominalLongitude** gives the satellite nominal longitude in degrees.

It is important to understand that there is a difference between the satellite position and the L1.5 Image projection. The first is where the satellite physically is at any one time, whereas the latter is the projection (=map) to which the Level 1.5 image is rectified. In practise, if the user needs (e.g.) to find a location of a pixel on the Earth ellipsoid, he/she needs to refer to the image projection. If one needs to refer to (e.g) the satellite viewing angles, one needs to refer to the satellite position. The satellite is not exactly stationary on the geostationary ring. The true position of the satellite varies slightly with time because all the satellites are drifting from their nominal position. The station keeping is maintained actively by manoeuvres such that the satellite moves only in a confined area, the "station keeping box". The **NominalLongitude** is the position of the centre of satellite station keeping box on the geostationary ring. (Provided in degrees from the Greenwich Meridian and a positive value corresponds to a position East of it, a negative value to the West.) This is not to be confused with the real satellite position, which is described in the **Orbit** record, nor with the notional longitude used for image projection, which is described in the **Projection Description** record.

**SatelliteStatus** gives the status of the satellite.

### **SatelliteOperations:**

**LastManoeuvreFlag** is a flag that indicates if there has been a manoeuvre in the recent past (maximum 48 hours). A value of true indicates that there was a manoeuvre.

**LastManoeuvreStartTime** gives the start-time of the last manoeuvre.

**LastManoeuvreEndTime** gives the end-time of the last manoeuvre.

**LastManoeuvreType** gives the type of the last manoeuvre performed.

**NextManoeuvreFlag** indicates if a manoeuvre is planned for the near future (i.e. within 48 hours). 'TRUE' indicates that a manoeuvre is planned.

**NextManoeuvreStartTime** gives the foreseen start-time of the next planned manoeuvre.

**NextManoeuvreEndTime** gives the foreseen end-time of the next planned manoeuvre.

**NextManoeuvreType** gives the next planned manoeuvre type.

**SpinRateatRCStart** gives the spin rate in RPM at the start of the current repeat cycle.

**ORBIT** is defined as follows:

ORBIT ::= RECORD	
{ <b>PeriodStartTime</b>	TIME CDS SHORT,
<b>PeriodEndTime</b>	TIME CDS SHORT,
<b>OrbitPolynomial</b>	ARRAY SIZE (1..100) OF ORBITCOEF}

**PeriodStartTime** gives the start time of the coverage period.

**PeriodEndTime** gives the end time of the coverage period.

**OrbitPolynomial** is a fixed size array containing orbit coefficient sets. Unused array elements are filled with zeros.

**ORBITCOEF** is defined as follows:

ORBITCOEF ::= RECORD	
<b>StartTime</b>	TIME CDS SHORT,
<b>EndTime</b>	TIME CDS SHORT,
<b>X</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>Y</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>Z</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>VX</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>VY</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>VZ</b>	ARRAY SIZE (8) OF REAL DOUBLE}

**StartTime** gives the start time for the coefficient set validity. StartTime of set N is always greater than StartTime of set N-1.

**EndTime** gives the end time for the coefficient set validity. EndTime of set N is always greater than EndTime of set N-1).

**X, Y, Z** and **VX, VY** and **VZ** represent the spacecraft position and velocity in an Earth fixed coordinate frame. The relation between the spacecraft position or velocity and time is provided by a Chebychev polynomial. For each of the arrays, the index 0 coefficient contains the degree 0 coefficient of the Chebychev polynomial, the index 1 coefficient contains the degree 1 coefficient of the Chebychev polynomial, etc...

**ATTITUDE** is defined as follows:

ATTITUDE ::= RECORD	
<b>PeriodStartTime</b>	TIME CDS SHORT,
<b>PeriodEndTime</b>	TIME CDS SHORT,
<b>PrincipleAxisOffsetAngle</b>	REAL DOUBLE
<b>AttitudePolynomial</b>	ARRAY SIZE (1..100) OF ATTITUDECOEF}

**PeriodStartTime** gives the start time of the coverage period.

**PeriodEndTime** gives the end time of the coverage period.

**PrincipleAxisOffsetAngle** represents the angle, in radians, between the S/C principle axis and the geometrical axis perpendicular to the baseplate. It is derived from a model that predicts this angle based on the actual fuel status. This is valid for any time within the period covered by the file.

**AttitudePolynomial** is a fixed size array containing attitude coefficient sets. Unused array elements are filled with zeros.

**ATTITUDECOEF** is defined as follows:

ATTITUDECOEF ::= RECORD	
<b>StartTime</b>	TIME CDS SHORT,
<b>EndTime</b>	TIME CDS SHORT
<b>XofSpinAxis</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>YofSpinAxis</b>	ARRAY SIZE (8) OF REAL DOUBLE,
<b>ZofSpinAxis</b>	ARRAY SIZE (8) OF REAL DOUBLE}

**StartTime** gives the start time for the coefficient set validity. StartTime of set N is always greater than StartTime of set N-1.

**EndTime** gives the end time for the coefficient set validity. EndTime of set N is always greater than EndTime of set N-1).

**XOfSpinAxis, YOfSpinAxis** and **ZOfSpinAxis** represent the spacecraft spin axis in an Earth fixed coordinate frame. The relation between the spacecraft spin axis and time is provided by a Chebychev polynomial. For each

of the arrays, the index 0 coefficient contains the degree 0 coefficient of the Chebychev polynomial, the index 1 coefficient contains the degree 1 coefficient of the Chebychev polynomial, etc...

**UTCCORRELATION** is defined as follows:

<b>UTCCORRELATION ::= RECORD</b>	
<b>{PeriodStartTime</b>	TIME CDS SHORT,
<b>PeriodEndTime</b>	TIME CDS SHORT,
<b>OnBoardTimeStart</b>	CUC SIZE (4,3),
<b>VarOnBoardTimeStart</b>	REAL DOUBLE,
<b>A1</b>	REAL DOUBLE,
<b>VarA1</b>	REAL DOUBLE,
<b>A2</b>	REAL DOUBLE,
<b>VarA2</b>	REAL DOUBLE}

**PeriodStartTime** represents the time from which on the correlation becomes valid.

**PeriodEndTime** represents the time from which point onwards the accuracy of the correlation cannot be guaranteed.

**OnBoardTimeStart** is equivalent to **PeriodStartTime**, but from spacecraft epoch.

**VarOnBoardTimeStart**, **VarA1** and **VarA2** represent the variance (“the uncertainty”) of the coefficients **OnBoardTimeStart**, **A1** and **A2** respectively.

**OnBoardTimeStart**, **A1** and **A2** are the coefficients of the function:

$$UTC = OnBoardTimeStart + (1+A1) \times (OBT - OnBoardTimeStart) + A2 \times (OBT - OnBoardTimeStart)^2$$

OBT represents the On-board time as it is received from the S/C while the resulting UTC represents a corrected on-board time. It is a continuous and uniform time, but does not include leap second as UTC times expressed in CDS time format.

## 7.2.2 Image Acquisition Record

This is defined as follows:

<b>ImageAcquisition ::= RECORD</b>	
<b>{PlannedAcquisitionTime</b>	RECORD
<b>{TrueRepeatCycleStart</b>	TIME CDS EXPANDED,
<b>PlannedForwardScanEnd</b>	TIME CDS EXPANDED,
<b>PlannedRepeatCycleEnd</b>	TIME CDS EXPANDED},
<b>RadiometerStatus</b>	RECORD
<b>{ChannelStatus</b>	ARRAY SIZE (1..12) of ENUMERATED BYTE
	{OFF (0),
	ON (1)},
<b>DetectorStatus</b>	ARRAY SIZE (1..42) of ENUMERATED BYTE
	{OFF (0),
	ON (1)},
<b>RadiometerSettings</b>	RECORD
<b>{MDUSamplingDelays</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>HRVFrameOffsets</b>	RECORD
<b>{MDUNomHRVDelay1</b>	UNSIGNED SHORT,
<b>MDUNomHRVDelay2</b>	UNSIGNED SHORT,
<b>Spare</b>	BITSTRING SIZE(16), -- Set to 0x0000
<b>MDUNomHRVBreakline</b>	UNSIGNED SHORT},
<b>DHSSSynchSelection</b>	ENUMERATED BYTE
	{SUN (0),
	EARTH-NORTH (1),
	EARTH-SOUTH (2)},

<b>MDUOutGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>MDUCourseGain</b>	ARRAY SIZE (1..42) OF BYTE,
<b>MDUFineGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>MDUNumericalOffset</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>PUGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>PUOffset</b>	ARRAY SIZE (1..27) OF UNSIGNED SHORT,
<b>PUBias</b>	ARRAY SIZE (1..15) OF UNSIGNED SHORT,
<b>OperationParameters</b>	RECORD
<b>{L0_LineCounter</b>	UNSIGNED SHORT,
<b>K1_RetraceLines</b>	UNSIGNED SHORT,
<b>K2_PauseDeciseconds</b>	UNSIGNED SHORT,
<b>K3_RetraceLines</b>	UNSIGNED SHORT,
<b>K4_PauseDeciseconds</b>	UNSIGNED SHORT,
<b>K5_RetraceLines</b>	UNSIGNED SHORT,
<b>X_DeepSpaceWindowPosition</b>	ENUMERATED BYTE
	{no delay (0),
	predefined delay no. 1 (1),
	predefined delay no. 2 (2),
	predefined delay no. 3 (3)},
<b>RefocusingLines</b>	UNSIGNED SHORT
<b>RefocusingDirection</b>	ENUMERATED BYTE
	{Up (0),
	Down (1)},
<b>RefocusingPosition</b>	UNSIGNED SHORT,
<b>ScanRefPosFlag</b>	BOOLEAN BYTE,
<b>ScanRefPosNumber</b>	UNSIGNED SHORT,
<b>ScanRefPotVal</b>	REAL,
<b>ScanFirstLine</b>	UNSIGNED SHORT,
<b>ScanLastLine</b>	UNSIGNED SHORT,
<b>RetraceStartLine</b>	UNSIGNED SHORT},
<b>RadiometerOperations</b>	RECORD
<b>{LastGainChangeFlag</b>	BOOLEAN BYTE,
<b>LastGainChangeTime</b>	TIME CDS SHORT,
<b>Decontamination</b>	RECORD
<b>{DecontaminationNow</b>	BOOLEAN BYTE,
<b>DecontaminationStart</b>	TIME CDS SHORT,
<b>DecontaminationEnd</b>	TIME CDS SHORT},
<b>BBCalScheduled</b>	BOOLEAN BYTE,
<b>BBCalibrationType</b>	ENUMERATED BYTE
	{Hot (1),
	Ambient (2),
	Indeterminate (3)},
<b>BBFirstLine</b>	UNSIGNED SHORT,
<b>BBLastLine</b>	UNSIGNED SHORT,
<b>ColdFocalPlaneOpTemp</b>	UNSIGNED SHORT,
<b>WarmFocalPlaneOpTemp</b>	UNSIGNED SHORT}

### PlannedAcquisitionTime:

**TrueRepeatCycleStart** is the start time of the current repeat cycle, accurate to within  $10^{-6}$  seconds.

**PlannedForwardScanEnd** is the planned start time of the current repeat cycle, accurate to within 0.1 second.

**PlannedRepeatCycleEnd** is the planned end time of the current repeat cycle, accurate to within 0.1 second.

### RadiometerStatus:

**ChannelStatus** is an array with one element per channel that gives the status of each radiometer channel: OFF, ON.

**DetectorStatus** is an array with one element per detector that gives the status of each radiometer detector: OFF, ON.

### RadiometerSettings:

**MDUSamplingDelays** are the adjustment delays applied to each detection chain of the S/C in East-West to align the raw image pixels within a channel. It should be noted that these delays do not allow channel-to-channel alignment in the raw image. Units of 2 clock-pulses, as in the telemetry.

**MDUNomHRVDelay1** is the delay applied by the spacecraft to the southern part of the HRV raw image (i.e. the part of the image before the field **MDUNomHRVBreakline**). Units of 512 clock-pulses, as in the telemetry.

**MDUNomHRVDelay2** is the delay applied by the spacecraft to the northern part of the HRV raw image (i.e. the part of the image after the field **MDUNomHRVBreakline**). Units of 512 clock-pulses, as in the telemetry.

**Spare** is a spare field.

**MDUNomHRVBreakline** is the line in the HRV raw image at which the ‘upper area’ of the image begins (i.e. the image line at which the new East-West delay **MDUNomHRVDelay2** is applied).

**DHSSSynchSelection** indicates whether the synchronisation signal for the line events has been derived from the sun sensor unit (0), or the earth sensor unit (ESU). For the latter case the synchronisation pulse is either derived from the northern IR telescope (1) or the southern one (2) which are both part of the ESU (note that North and South refers to the ESU telescopes under nominal flight conditions).

The definition of the detection parameters can be understood from the following relationship:

$$C(E_L) \equiv G_{MDU-Out} \cdot \{ G_{MDU-f} \cdot [ G_{MDU-0} \cdot G_{MDU-c} \cdot ( G_{PU} \cdot E_L - O_{PU} + I_o ) - DO ] + O_{MDU} \}$$

$C$  are the Counts at the instrument output

$E_L$  is the signal coming from the detectors (it includes the dark signal  $E_D$ )

$G_{PU}$  is the parameter called **PUGain** in the 1.5 header. There is one value of **PUGain** per detector (42 values)

$O_{PU}$  is the parameter called **PUOffset** in the 1.5 header. There is one value of **PUOffset** per detector except HRV, VIS0.6 and VIS0.8 (27 values)

$I_0$	is a fixed current. It is not part of the 1.5 Header
$G_{MDU-c}$	is the parameter called <b>MDUCoarseGain</b> in the 1.5 header. There is one value of <b>MDUCoarseGain</b> per detector (42 values)
$G_{MDU-0}$	is a fixed gain. It is not part of the 1.5 Header
$DO$	is the parameter called <b>DCRValues</b> in the record “RadiometricProcessing” of the 1.5 header. There is one value of <b>DCRValues</b> per detector (42 values). Each value is obtained by averaging 2048 values acquired during Deep Space View.
$G_{MDU-f}$	is the parameter called <b>MDUFineGain</b> in the 1.5 header. There is one value of <b>MDUFineGain</b> per detector (42 values)
$G_{MDU-Out}$	is the parameter called <b>MDUOutGain</b> in the 1.5 header. There is one value of <b>MDUOutGain</b> per detector (42 values).

**MDUNumericalOffset** is the parameter  $O_{MDU}$  in the above equation. There is one such value per detector.

Note that all gains, bias and offset values take the same units as in the housekeeping telemetry.

**PUBias** is the bias current that is applied to the PhotoConductive detectors. It modifies their dark signal  $E_D$  according to a fixed relationship.

**L0\_LineCounter** gives the line counter value at which the forward scan will stop if CONFIGURATION mode is entered. It is not used in NOMINAL mode.

**K1\_RetraceLines** gives the first ‘retrace parameter’. The radiometer retraced ‘K1’ lines, at a rate of 1 line every 100msec.

**K2\_PauseDeciseconds** gives the second ‘retrace parameter’. The radiometer paused for ‘K2\*100’ msec, subsequent to the K1 retrace.

**K3\_RetraceLines** gives the third ‘retrace parameter’. The radiometer retraced ‘K3’ lines, at a rate of 1 line every 100msec.

**K4\_PauseDeciseconds** gives the fourth ‘retrace parameter’. The radiometer paused ‘K4\*100’ msec, subsequent to the K3 retrace.

**K5\_RetraceLines** gives the fifth ‘retrace parameter’. The radiometer retraced ‘K5’ lines, at a rate of 1 line every 100msec.

**X\_DeepSpaceWindowPosition** is the position in the backscan where the DCR values have been acquired. There are three possible windows which can be selected in order to avoid Sun or Moon interference; the positions of these three windows are defined as delays w.r.t. the Start-Of-Line.

**RefocusingLines** is the number of image lines during which one step of the refocusing mechanism is performed.

**RefocusingDirection** is the direction of the step performed by the refocusing mechanism.

**RefocusingPosition** is the absolute position of the refocusing mechanism at the start of the repeat cycle. Units are step counts.

**ScanRefPosFlag** indicates whether the radiometer went to the reference position before starting forward scan.

**ScanRefPosNumber** is the readout of the scan line counter value at the moment of the scan mirror being at reference position.

**ScanRefPotVal** is the potentiometer readout at the moment of the scan mirror being at reference position (as supplied by SEVIRI auxiliary data).

**ScanFirstLine** is the line counter value of the first line of the image.

**ScanLastLine** is the line counter value of the last line of the image.

**RetraceStartLine** is the line counter value at which the scan mechanism will start the retrace. Not to be confused with **ScanLastLine**.

### **Radiometer Operations:**

**LastGainChangeFlag** indicates if there has been a Gain Change in the recent past (i.e. within the last 48 hours). 'True' indicates that there has been a change.

**LastGainChangeTime** gives the time of the last gain change. Accuracy is to 64 seconds.

**DecontaminationNow** indicates whether a decontamination operation is currently taking place (true/false). Note that the operation is defined as the time from when the focal plane heater is first switched on until the point where the focal plane has cooled down to its nominal imaging temperature after the heater has been switched-off.

**DecontaminationStart** gives the start-time of the last decontamination operation, or of the current operation if one is currently taking place. Accuracy is of the order of 30 seconds.

**DecontaminationEnd** gives the end-time of the last decontamination operation that has been conducted. Accuracy is of the order of 30 seconds. Note that if a decontamination operation is currently taking place, this value will be undefined. If no decontamination operation is taking place, and the start- and end-time values are the same, then the system has no record of a decontamination operation having taken place.

**BBCalScheduled** indicates if BB Calibration foreseen in the coming repeat cycle (true/false).

**BBCalibrationType** gives the type of calibration planned.

**BBFirstLine** gives the line counter value of the first line of the image for which BB calibration is performed.

**BBLastLine** gives the line counter value of the last line of the image for which BB calibration is performed.

**ColdFocalPlaneOpTemp** is the temperature of the cold focal plane (i.e. also the temperature of the cold detectors). It is one of the fields **FCUNominalColdFocalPlaneTemp** or **FCURedundantColdFocalPlaneTemp** of the record "RadiometricProcessing", depending on whether the Nominal or Redundant electronics unit is selected.

**WarmFocalPlaneOpTemp** is the temperature of the warm focal plane (i.e. also the temperature of the warm detectors). It is either **FCUNominalWarmFocalPlaneVHROTemp** or **FCURedundantWarmFocalPlaneVHROTemp** (of the record "RadiometricProcessing"), depending whether the Nominal or Redundant electronics unit is selected.

### 7.2.3 Celestial Events Record

This is defined as follows:

CelestialEvents ::= RECORD		
{ CelestialBodiesPosition EPHEMERIS -- See below for definition		
RelationToImage RECORD		
{TypeofEclipse	ENUMERATED BYTE	
	{None	(0),
	Sun	(1),
	Moon	(2)},
EclipseStartTime	TIME CDS SHORT,	
EclipseEndTime	TIME CDS SHORT,	
VisibleBodiesInImage	ENUMERATED BYTE	
	{None	(0),
	Sun	(1),
	Moon	(2),
	Sun and Moon	(3)},
BodiesClosetoFOV	ENUMERATED BYTE	
	{None	(0),
	Sun	(1),
	Moon	(2),
	Sun and Moon	(3)},
ImpactOnImageQuality	ENUMERATED BYTE	
	{None	(0),
	Radiometric	(1),
	Geometric	(2)}} }

**TypeofEclipse** indicates if there has been or will be an Eclipse in the near past or the future (+/-12 Hours) and the type of eclipse if relevant ('Sun' or 'Moon'). If 'None', then the contents of the fields

**EclipseStartTime** and **EclipseEndTime** will be undefined.

**EclipseStartTime** gives the start time of the eclipse. If the eclipse was in the past then this will be the actual start time of the eclipse, and if in the future then it will be the predicted time. Time is accurate to better than 1 second.

**EclipseEndTime** gives the start time of the eclipse. If the eclipse was in the past then this will be the actual start time of the eclipse, and if in the future then it will be the predicted time. Time is accurate to better than 1 second.

**VisibleBodiesInImage** indicates which celestial bodies are visible in the image.

**BodiesClosetoFOV** indicates what bodies are close to the field of view.

**ImpactOnImageQuality** indicates possible impact on the image.

**EPHEMERIS** is defined as follows:

EPHEMERIS ::= RECORD	
{ PeriodStartTime	TIME CDS SHORT,
PeriodEndTime	TIME CDS SHORT,
RelatedOrbitFileTime	TIME GENERALIZED,
RelatedAttitudeFileTime	TIME GENERALIZED,
EarthEphemeris	ARRAY SIZE (1..100) OF EARTHMOONSUNCOEF
MoonEphemeris	ARRAY SIZE (1..100) OF EARTHMOONSUNCOEF
SunEphemeris	ARRAY SIZE (1..100) OF EARTHMOONSUNCOEF
StarEphemeris	ARRAY SIZE (1..100) OF STARCOEF }

**PeriodStartTime** gives the start time of the coverage for data in this record.

**PeriodEndTime** gives the end time of the coverage for data in this record.

**RelatedOrbitFileTime** gives the time of creation of corresponding orbit file.

**RelatedAttitudeFileTime** gives the time of creation of corresponding attitude file.

**EarthEphemeris** is a fixed length array containing Earth ephemeris data. Unused array elements are filled with zeros.

**MoonEphemeris** is a fixed length array containing Moon ephemeris data. Unused array elements are filled with zeros.

**SunEphemeris** is a fixed length array containing Sun ephemeris data. Unused array elements are filled with zeros.

**StarEphemeris** is a fixed length array containing Star ephemeris data. Unused array elements are filled with zeros.

**EARTHMOONSUNCOEF** is defined as follows:

```

EARTHMOONSUNCOEF ::= RECORD
{StartTime      TIME CDS SHORT,
 EndTime        TIME CDS SHORT,
  AlphaCoef     ARRAY SIZE (8) OF REAL DOUBLE,
  BetaCoef      ARRAY SIZE (8) OF REAL DOUBLE}
    
```

**StartTime** gives the start time for the coefficient set validity. StartTime of set N is always greater than StartTime of set N-1.

**EndTime** gives the end time for the coefficient set validity. EndTime of set N is always greater than EndTime of set N-1).

**AlphaCoef** and **BetaCoef** are the Chebychev polynomial coefficients that give the position of the Earth, Moon or Sun in the Spacecraft Frame. The relation between the Earth, Moon or Sun position and time is provided by a Chebychev polynomial. For each of the arrays, the index 0 coefficient contains the degree 0 coefficient of the Chebychev polynomial, the index 1 coefficient contains the degree 1 coefficient of the Chebychev polynomial, etc...

The alpha and beta coordinates of Earth and Moon are given relative to the spacecraft frame at the time of the predicted position.

The position of the Sun will be provided in a slightly modified alpha and beta format. The beta will be the declination in the satellite based coordinate frame as above. However, the alpha value given for the Sun position will, in this case, be the angle of rotation about the satellite spin axis (Z axis) from the Earth centre to the Sun centre.

**STARCOEF** is defined as follows:

```

STARCOEF ::= ARRAY SIZE (1..20) OF RECORD
{StarId         UNSIGNED SHORT
 StartTime      TIME CDS SHORT,
  EndTime       TIME CDS SHORT,
  AlphaCoef     ARRAY SIZE (8) OF REAL DOUBLE,
  BetaCoef      ARRAY SIZE (8) OF REAL DOUBLE}
    
```

**StarId** gives the ID of the star to which this record corresponds. The details of mapping this ID to a specific star are given in Table 4.

ID	Star
1	Rigel

2	Procyon
3	Betelgeuse
4	Alphard
5	Altair
6	Bellatrix
7	Alnilam
8	Alnitak
9	Yed Prior
10	Mintaka
11	53KapOri
12	Zubeneschamali
13	Sadalsuud
14	67BetEri
15	Porrima
16	Sadalmelik
17	Menkar
18	Cebelrai
19	Unukalhai
20	Enif

**Table 4 - Star Identifier Conversion**

**StartTime** gives the start time for the coefficient set validity. StartTime of set N is always greater than StartTime of set N-1

**EndTime** gives the end time for the coefficient set validity. EndTime of set N is always greater than EndTime of set N-1)

**AlphaCoef** and **BetaCoef** are the Chebychev polynomial coefficients that give the position of the stars in the Spacecraft Frame at the time of the predicted position. The relation between the stars position and time is provided by a Chebychev polynomial. For each of the arrays, the index 0 coefficient contains the degree 0 coefficient of the Chebychev polynomial, the index 1 coefficient contains the degree 1 coefficient of the Chebychev polynomial, etc...

### 7.2.4 Image Description Record

This is defined as follows:

ImageDescription ::= RECORD	
<b>{ProjectionDescription</b>	RECORD
<b>{TypeOfProjection</b>	ENUMERATED BYTE
	{Geostationary, Earth centred in grid (1)},
<b>LongitudeOfSSP</b>	REAL},
<b>ReferenceGridVIS_IR</b>	RECORD
<b>{NumberOfLines</b>	INTEGER,
<b>NumberOfColumns</b>	INTEGER,
<b>LineDirGridStep</b>	REAL,
<b>ColumnDirGridStep</b>	REAL,
<b>GridOrigin</b>	ENUMERATED BYTE
	{North-West corner (0),
	South-West corner (1),
	South-East corner (2),
	North-East corner (3)}},
<b>ReferenceGridHRV</b>	RECORD
<b>{NumberOfLines</b>	INTEGER,
<b>NumberOfColumns</b>	INTEGER,
<b>LineDirGridStep</b>	REAL,
<b>ColumnDirGridStep</b>	REAL,
<b>GridOrigin</b>	ENUMERATED BYTE

	{North-West corner	(0),
	South-West corner	(1),
	South-East corner	(2),
	North-East corner	(3)}},
<b>PlannedCoverageVIS_IR</b>	RECORD	
{SouthernLinePlanned	INTEGER,	
NorthernLinePlanned	INTEGER,	
EasternColumnPlanned	INTEGER,	
WesternColumnPlanned	INTEGER},	
<b>PlannedCoverageHRV</b>	RECORD	
{LowerSouthLinePlanned	INTEGER,	
LowerNorthLinePlanned	INTEGER,	
LowerEastColumnPlanned	INTEGER,	
LowerWestColumnPlanned	INTEGER,	
UpperSouthLinePlanned	INTEGER,	
UpperNorthLinePlanned	INTEGER,	
UpperEastColumnPlanned	INTEGER,	
UpperWestColumnPlanned	INTEGER},	
<b>Level 1_5 ImageProduction</b>	RECORD	
{ImageProcDirection	ENUMERATED BYTE	
	{North-South	(0),
	South-North	(1)},
PixelGenDirection	ENUMERATED BYTE	
	{East-West	(0),
	West-East	(1)},
PlannedChanProcessing	ARRAY SIZE (1..12) OF ENUMERATED BYTE	
	{Channel not processed	(0),
	Channel processed in spectral radiance	(1),
	Channel processed in effective radiance	(2)},
	}	

### **ProjectionDescription:**

**TypeOfProjection** gives the type of projection used for the Level 1.5 image generation. The type 'Enumerated Byte' has been used to allow future upgrades.

**LongitudeOfSSP** is notional longitude used for image projection. (Provided in degrees from the Greenwich Meridian and a positive value corresponds to a position East of it, a negative value to the West.). This is not to be confused with the real satellite position, nor with the position of the satellite station keeping box on the geostationary ring, both provided in the SatelliteStatus Record. Note, that **LongitudeOfSSP** indeed can be different from the nominal satellite longitude (e.g. a spare satellite located nominally at +3.5° might be used to generate the Level 1.5 image for the main mission, but the image would be projected to 0° longitude). **LongitudeOfSSP** field is only relevant to certain projection types (identified by **TypeOfProjection**).

### **ReferenceGridVIS IR:**

This record gives details of the reference grid for the VIS and IR channels.

**NumberOfLines** gives the number of lines in the reference grid for VIS and IR. Maximum possible value for VIS and IR is 3712.

**NumberOfColumns** gives the number of columns in the reference grid for VIS and IR. The **NumberOfColumns** has a fixed value of 3712.

**LineDirGridStep** gives the grid step size in km SSP in the line direction. Default value is 3km for VIS and IR, and 1km for HRV. The on-ground grid step size of 3 km at the SSP represents an instrument scan step of 251.53 microrad divided by 3.

**ColumnDirGridStep** gives the grid step size in km SSP in the column direction. Default value as for 'LineDirGridStep'.

**GridOrigin** gives the reference grid origin: North-West corner, South-West corner, South-East corner, North-East corner. Operations default is the South-East corner. The origin has the coordinates (1,1).

### **ReferenceGridHRV:**

This record gives details of the reference grid for the HRV channel. The individual fields in this record are the same as those in the **ReferenceGridVIS\_IR** record defined above.

### **PlannedCoverageVIS\_IR:**

This record gives details of the planned Level 1.5 coverage with respect to the grid definition for the VIS and IR channels. The details of each field are given below.

**SouthernLinePlanned** is the planned southern line number, taking a value in the range 1 to 3712.

**NorthernLinePlanned** is the planned northern line number, taking a value in the range 1 to 3712.

**EasternColumnPlanned** is the planned eastern column number, always taking the value 1.

**WesternColumnPlanned** is the planned western column number, always taking the value 3712.

Note that the number of column pixel per line for the VIS and IR channels is always 3712.

### **PlannedCoverageHRV:**

This record gives details of the planned coverage Level 1.5 coverage for the HRV channel. The component fields are the same as those for the record **PlannedCoverageVIS\_IR**, with the difference that the line and column bounds are given for each of the two areas constituting the scan, i.e. the **lower** and the **upper** areas. The terms 'lower' and 'upper' refer to the line numbering in respect to the reference grid, i.e. 'lower' means the area with the lower line numbers, 'upper' the one with higher line numbers.

**LowerSouthernLinePlanned** is the planned southern line number, taking a value in the range 1 to 11136.

**LowerNorthernLinePlanned** is the planned northern line number, taking a value in the range 1 to 11136.

**LowerEasternColumnPlanned** is the planned eastern column number, taking a value in the range 1 to 5569.

**LowerWesternColumnPlanned** is the planned western column number, taking a value in the range 5568 to 11136.

**UpperSouthernLinePlanned** is the planned southern line number, taking a value in the range 1 to 11136.

**UpperNorthernLinePlanned** is the planned northern line number, taking a value in the range 1 to 11136.

**UpperEasternColumnPlanned** is the planned eastern column number, taking a value in the range 1 to 5569.

**UpperWesternColumnPlanned** is the planned western column number, taking a value in the range 5568 to 11136.

Note, that the number of column pixel per line for the HRV channel is always 5568.

## Level 1 5 ImageProduction:

**ImageProcDirection** defines the direction of the production of the Level 1.5 image in real-time, this corresponding to the actual scanning direction by the Radiometer.

**PixelGenDirection** defines the direction of the generation of the pixels, therefore indicating if the first pixel in a line in the most Eastern or Western one. The default is the most Eastern pixel.

**PlannedChanProcessing** is an array whose elements indicate for each channel if it is planned to derive 1.5 data from the received data and what the representation of the data is. If a channel is not processed, this is indicated by a 0, if it is processed, but in spectral radiance, then it is set to 1, in effective radiance to 2. Users are reminded that information on radiometric processing is also provided in the RPSummary record of the Radiometric Processing record.

### 7.2.5 Radiometric Processing Record

This is defined as follows:

RadiometricProcessing ::= RECORD	
{ <b>RPSummary</b>	RECORD
{ <b>RadianceLinearization</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE,
<b>DetectorEqualization</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE,
<b>OnboardCalibrationResult</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE,
<b>MPEFCalFeedback</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE,
<b>MTFAdaptation</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE,
<b>StraylightCorrectionFlag</b>	ARRAY SIZE (1..12) OF BOOLEAN BYTE},
<b>Level1_5ImageCalibration</b>	ARRAY SIZE (1..12) OF RECORD
{ <b>Cal_Slope</b>	REAL DOUBLE,
<b>Cal_Offset</b>	REAL DOUBLE},
<b>BlackBodyDataUsed</b>	RECORD
{ <b>BBObservationUTC</b>	TIME CDS EXPANDED,
<b>BBRelatedData</b>	RECORD
{ <b>OnBoardBBTime</b>	TIME CUC SIZE (4,3),
<b>MDUOutGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT
<b>MDUCoarseGain</b>	ARRAY SIZE (1..42) OF BYTE,
<b>MDUFineGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>MDUNumericalOffset</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>PUGain</b>	ARRAY SIZE (1..42) OF UNSIGNED SHORT,
<b>PUOffset</b>	ARRAY SIZE (1..27) OF UNSIGNED SHORT,
<b>PUBias</b>	ARRAY SIZE (1..15) OF UNSIGNED SHORT,
<b>DCRValues</b>	ARRAY SIZE (1..42) OF BITSTRING SIZE (12),
<b>X_DeepSpaceWindowPosition</b>	ENUMERATED BYTE
	{no delay (0),
	predefined delay no. 1 (1),
	predefined delay no. 2 (2),
	predefined delay no. 3 (3)},
<b>ColdFPTemperature</b>	RECORD
{ <b>FCUNominalColdFocalPlaneTemp</b>	UNSIGNED SHORT,
<b>FCURedundantColdFocalPlaneTemp</b>	UNSIGNED SHORT},
<b>WarmFPTemperature</b>	RECORD
{ <b>FCUNominalWarmFocalPlaneVHROTemp</b>	UNSIGNED SHORT,
<b>FCURedundantWarmFocalPlaneVHROTemp</b>	UNSIGNED SHORT},
<b>ScanMirrorTemperature</b>	RECORD
{ <b>FCUNominalScanMirrorSensor1Temp</b>	UNSIGNED SHORT,
<b>FCURedundantScanMirrorSensor1Temp</b>	UNSIGNED SHORT,
<b>FCUNominalScanMirrorSensor2Temp</b>	UNSIGNED SHORT,
<b>FCURedundantScanMirrorSensor2Temp</b>	UNSIGNED SHORT},

<b>M1M2M3Temperature</b>	RECORD	
{FCUNominalM1MirrorSensor1Temp		UNSIGNED SHORT,
FCURedundantM1MirrorSensor1Temp		UNSIGNED SHORT,
FCUNominalM1MirrorSensor2Temp		UNSIGNED SHORT,
FCURedundantM1MirrorSensor2Temp		UNSIGNED SHORT,
FCUNominalM23AssemblySensor1Temp		BYTE,
FCURedundantM23AssemblySensor1Temp		BYTE,
FCUNominalM23AssemblySensor2Temp		BYTE,
FCURedundantM23AssemblySensor2Temp		BYTE},
<b>BaffleTemperature</b>	RECORD	
{FCUNominalM1BaffleTemp		UNSIGNED SHORT,
FCURedundantM1BaffleTemp		UNSIGNED SHORT},
<b>BlackBodyTemperature</b>	RECORD	
{FCUNominalBlackBodySensorTemp		UNSIGNED SHORT,
FCURedundantBlackBodySensorTemp		UNSIGNED SHORT},
<b>FCUMode</b>	RECORD	
{FCUNominalSMMStatus		BITSTRING SIZE (16),
FCURedundantSMMStatus		BITSTRING SIZE (16)},
<b>ExtractedBBData</b>	ARRAY SIZE (1..12) of RECORD	
{NumberOfPixelsUsed		UNSIGNED,
MeanCount		REAL,
RMS		REAL,
MaxCount		UNSIGNED SHORT,
MinCount		UNSIGNED SHORT,
BB_Processing_Slope		REAL DOUBLE,
BB_Processing_Offset		REAL DOUBLE}},
<b>MPEFCalFeedback</b>	IMPF_CAL_Data,	-- See below for definition
<b>RadTransform</b>	ARRAY SIZE (1..42) of ARRAY SIZE (1..64) of REAL,	
<b>RadProcMTFAdaptation</b>	RECORD	
{VIS_IRMTFCorrectionE_W	ARRAY SIZE (1..33) OF	
	ARRAY SIZE (1..16) of REAL,	
VIS_IRMTFCorrectionN_S	ARRAY SIZE (1..33) OF	
	ARRAY SIZE (1..16) of REAL,	
HRVMTFCorrectionE_W	ARRAY SIZE (34..42) OF	
	ARRAY SIZE (1..16) of REAL,	
HRVMTFCorrectionN_S	ARRAY SIZE (34..42) OF	
	ARRAY SIZE (1..16) of REAL,	
StraylightCorrection	ARRAY SIZE (1..12) OF	
	ARRAY SIZE (1..8) OF	
	ARRAY SIZE (1..8) of REAL}	

### RPSummary:

**RadianceLinearization** is an array with one element per channel indicating if the linearization of the radiance response has been applied to the channel. 'True' indicates it has been applied.

**DetectorEqualization** is an array with one element per channel indicating if the equalization of the detector responses within the channel has been applied to the channel. 'True' indicates it has been applied.

**OnboardCalibrationResult** is an array with one element per channel indicating if the results of the on-board black-body calibration have been applied to the channel. 'True' indicates it has been applied.

**MPEFCalFeedback** is an array with one element per channel indicating if the calibration feedback information provided by MPEF has been applied to the channel. 'True' indicates it has been applied.

**MTFAdaptation** is an array with one element per channel indicating if MTF adaptation has been applied to the channel. 'True' indicates it has been applied.

**StraylightCorrectionFlag** is an array with one element per channel indicating whether the straylight correction algorithm is activated for this channel. i.e. whether the image processing system has been configured to make an attempt at correcting for straylight in that channel. Since the straylight correction is usually permanently activated for the 3.9 channel this flag is normally set to TRUE for this channel and to FALSE for all the other channels. To find out whether a straylight correction has actually be applied for the current image, the StraylightCorrection array in the RadProcMTFAdaptation record (see below) should be checked,

### **Level1\_5ImageCalibration:**

An array of records providing calibration information for the Level 1.5 image data, one record per channel.

**Cal\_Slope** is the derived linear calibration coefficient extracted either from the on-board calibration (for IR channels) or from other sources (e.g. MPEF feedback or external data). The units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}\text{count}^{-1}$ .

**Cal\_Offset** is the offset constant between the pixel count and physical radiance extracted either from the on-board calibration (for IR channels) or from other sources (e.g. MPEF feedback or external data). The units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ .

(Physical\_Unit = Cal\_Offset + Cal\_Slope x pixel count). Units are spectral radiance i.e. the units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ .

### **BlackbodyDataUsed:**

This record defines all parameters used for the blackbody calibration.

**OnBoardBBTime** gives the on-board time at which blackbody calibration was started. Accuracy is 0.6 seconds.

**BBObservationUTC** is the UTC time at which calibration was started. Accuracy is 0.6 seconds.

The definition of the detection parameters can be understood from the following relationship:

$$C(E_L) \equiv G_{MDU-Out} \cdot \left\{ G_{MDU-f} \cdot \left[ G_{MDU-0} \cdot G_{MDU-c} \cdot (G_{PU} \cdot E_L - O_{PU} + I_o) - DO \right] + O_{MDU} \right\}$$

$C$  is the Counts at the instrument output

$E_L$  is the signal coming from the detectors (it includes the dark signal  $E_D$ )

$G_{PU}$  is the parameter called PUGain in the 1.5 header. There is one value of PUGain per detector (42 values)

$O_{PU}$  is the parameter called PUOffset in the 1.5 header. There is one value of PUOffset per detector except HRV, VIS0.6 and VIS0.8 (27 values)

$I_0$  is a fixed current.

$G_{MDU-c}$  is the parameter called MDUCoarseGain in the 1.5 header. There is one value of MDUCoarseGain per detector (42 values)

$G_{MDU-0}$  is a fixed gain.

**DO** is the parameter called DCRValues in the 1.5 header. There is one value of DCRValues per detector (42 values). Each value is obtained by averaging 2048 values acquired during Deep Space View.

**G<sub>MDU-f</sub>** is the parameter called MDUFineGain in the 1.5 header. There is one value of MDUFineGain per detector (42 values)

**G<sub>MDU-Out</sub>** is the parameter called MDUOutGain in the 1.5 header. There is one value of MDUOutGain per detector (42 values).

**MDUNumericalOffset** is the parameter O<sub>MDU</sub> in the above equation. There is one such value per detector.

**PUBias** is the bias current that is applied to the Photo Conductive detectors. It modifies their dark signal E<sub>D</sub> according to a fixed relationship.

**X\_DeepSpaceWindow Position** is the position in the backscan where the **DCRValues** have been acquired. There are three possible positions available, from which one can be selected in order to avoid Sun or Moon interference; these three windows are defined as delays w.r.t. Start-Of-Line.

**FCU temperatures:** field names are self-explanatory, and the temperatures are encoded as follows:

ColdFocalPlaneTemp	=(float_Temp_in_K *100)
WarmFocalPlaneVHROTemp	=(float_Temp_in_K - 250.0K) *100)
ScanMirrorSensor1Temp	=(float_Temp_in_K - 250.0K) *100)
ScanMirrorSensor2Temp	=(float_Temp_in_K - 250.0K) *100)
M1MirrorSensor1Temp	=(float_Temp_in_K - 250.0K) *100)
M1MirrorSensor2Temp	=(float_Temp_in_K - 250.0K) *100)
M1BaffleTemp	=(float_Temp_in_K - 250.0K) *100)
M23AssemblySensor1Temp	=(float_Temp_in_K - 265.0K) *4)
M23AssemblySensor2Temp	=(float_Temp_in_K - 265.0K) *4)
BlackBodySensorTemp	=(float_Temp_in_K - 250.0K) *100)

**FCUNominalSMMStatus** is the SEVIRI general status word related to the nominal electronics. It gives the evidence if during the blackbody calibration and the related image data acquisition there was an event affecting the image validity or quality. It is generated by IMPF using the TM and the SEVIRI status word contained in the SEVIRI AUX data at the start of the Repeat Cycle (first line of forward scan).

**FCURedundantSMMStatus** is the same as **FCUNominalSMMStatus**, but it applies to the redundant electronics.

### **ExtractedBBData:**

**NumberOfPixelsUsed** is the number of the pixels used to calculate the calibration mean counts.

**MeanCount** is the average fractional counts over the number of pixels used.

**RMS** is the RMS of the set of pixels used.

**MaxCount** is the maximum pixel count of the set of pixels used.

**MinCount** is the minimum pixel count of the set of pixels used.

**BB\_Processing\_Slope** is the “raw” linear calibration coefficient derived from the processing of the data acquired during BB viewing, without any further adaptations or inclusion of feedback. Units are the same as for **Cal\_Slope**.

**BB\_Processing\_Offset** is the “raw” offset constant between the pixel count and physical radiance, which results from the execution of the BB processing, without any further adaptation or inclusion of feedback. Units are the same as for **Cal\_Offset**.

### **MPEFCalFeedback:**

This record holds calibration information provided by MPEF for image-processing purposes. The structure of the record and the definition of individual fields can be found below.

**RadTransform** is an array of elements, each of which holds 64 equally spaced steps for each of the 42 detectors, mapping the Level 1.0 digital counts (0-1023) to the REAL (4-byte) representation of the pixel used for the online processing.

### **RadProcMTFAdaptation:**

**VIS\_IRMTFCorrectionE\_W** is the FIR filter set of coefficients used for MTF adaptation in E-W for each VIS/IR detector.

**VIS\_IRMTFCorrectionN\_S** is the FIR filter set of coefficients used for MTF adaptation in N-S for each VIS/IR detector.

**HRVMTFCorrectionE\_W** is the FIR filter set of coefficients used for MTF adaptation in E-W for each HRV detector.

**HRVMTFCorrectionN\_S** is the FIR filter set of coefficients used for MTF adaptation in N-S for each HRV detector.

**StraylightCorrection** is an 8x8 array of Chebyshev coefficients  $C_k^l$  that define a 2D Chebyshev polynomial for the stray light correction as a function of the radiometer position and the E-W Level 1.0 pixel location (so called Level 1.0 Coordinate Frame, see Appendix C). The array describes the correction that is actually applied. Hence, if the image processing system is not configured to perform a correction for the channel or if the channel is believed to be free of straylight then, the coefficients are zero. To just find out whether any straylight correction is actually applied; it is sufficient check whether the first Chebyshev is different from zero. For details on the decoding, refer to the Appendix.

**IMPF\_CAL\_Data** is defined as follows:

<b>IMPF_CAL_Data ::= ARRAY SIZE (1..12) OF RECORD</b>	
<b>{ImageQualityFlag</b>	ENUMERATED BYTE {IMPF Cal OK (0), Dubious IMPF Cal (1), Use MPEF Cal (2)},
<b>ReferenceDataFlag</b>	ENUMERATED BYTE {Not calculated (0), Met data (1), FSD (2), Mixed MET and FSD (3)},
<b>AbsCalMethod</b>	ENUMERATED BYTE {Not changed (0), External (1), Vicarious (2), Cross-satellite (3), Mixed vic & xsat (4)},
<b>Pad1</b>	CHARACTERSTRING SIZE(1),
<b>AbsCalWeightVic</b>	REAL,
<b>AbsCalWeightXsat</b>	REAL,
<b>AbsCalCoeff</b>	REAL,
<b>AbsCalError</b>	REAL,
<b>GSICSCalCoeff</b>	REAL,
<b>GSICSCalError</b>	REAL,

<b>GSICSOffsetCount</b> REAL}
-------------------------------

Unused array elements of IMPF\_CAL\_Data are filled with zeros.

**ImageQualityFlag** indicates whether or not the calibration of the Level 1.5 Data is considered good, i.e. whether the MPEF supplied absolute calibration coefficients should be substituted for those being used by the IMPF.

**ReferenceDataFlag** indicates the data source for the absolute calibration e.g. meteorological forecast (for the window channels) or observation (non-windows) data, foreign satellite data, or a mixture of meteorological and FSD data.

**AbsCalWeightVic** and **AbsCalWeightXsat** are normalised coefficients.

**AbsCalMethod** defines the method used for instantaneous absolute calibration. When absolute calibration has not been performed for a specific channel during the repeat cycle the **AbsCalMethod** will be set to (Not changed) and **AbsCalCoeff** will retain its most recently derived value. If VIS/NIR/HRVIS coefficients have been manually input to the system at the start of the repeat cycle the **AbsCalMethod** will be set to (External).

**AbsCalCoeff** represents the absolute calibration coefficient determined by MPEF. The units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}\text{count}^{-1}$ .

**AbsCalError** represents the accuracy of the absolute calibration coefficient determined by MPEF. The units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}\text{count}^{-1}$ .

**GSICSCalCoeff** represents the calibration derived from the cross-calibration according to the GSICS NRT requirements. The units are  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ .

**GSICSCalError** represents the RMSE of the GSICS cross calibration coefficient in units of  $\text{mWm}^{-2}\text{sr}^{-1}(\text{cm}^{-1})^{-1}$ .

**GSICSOffsetCount** is equivalent to the calibration offset derived from the GSICS cross-calibration, converted to counts. The sign convention is so that **GSICSOffsetCount** is equal to the NEGATIVE value of the level 1.5 count corresponding to zero radiance.

## 7.2.6 GeometricProcessing Record

This is defined as follows:

GeometricProcessing ::= RECORD	
{ <b>OptAxisDistances</b>	RECORD
<b>E-WFocalPlane</b>	ARRAY SIZE (1..42) OF REAL,
<b>N-SfocalPlane</b>	ARRAY SIZE (1..42) OF REAL},
<b>EarthModel</b>	RECORD
{ <b>TypeOfEarthModel</b>	ENUMERATED BYTE
	{Ellipsoid with Rpn Rps Req      (1)},
<b>EquatorialRadius</b>	REAL DOUBLE,
<b>NorthPolarRadius</b>	REAL DOUBLE,
<b>SouthPolarRadius</b>	REAL DOUBLE},
<b>AtmosphericModel</b>	ARRAY SIZE (1..12) of ARRAY SIZE (1..360) of REAL,
<b>ResamplingFunctions</b>	ARRAY SIZE (1..12) of ENUMERATED BYTE
	{ Windowed Shannon              (1),
	Bicubic Splines                (2),
	Nearest Neighbour            (3)} }

### OptAxisDistances:

**E-WFocalPlane** gives the distance of the detectors from the optical axis in the East-West direction in km from the SSP.

**N-SFocalPlane** gives the distance of the detectors from the optical axis in the North-South direction in km from the SSP.

### EarthModel:

**TypeOfEarthModel** gives details of the earth model used by IMPF for navigation. The parameter was only changed once to indicate the removal of the georeferencing offset (see Section 3.1.4.2).

TypeOfEarthModel:=1            georeferencing offset present (i.e. image shifted wrt GEOS projection)  
 TypeOfEarthModel:=2            corrected data

**EquatorialRadius** gives the size of the equatorial radius used by IMPF for the navigation of Level 1.0 to Level 1.5. Units are km.

**NorthPolarRadius** gives the size of the northern polar radius used by IMPF for the navigation of Level 1.0 to Level 1.5.. Units are km.

**SouthPolarRadius** gives the size of the southern polar radius used by IMPF for the navigation of Level 1.0 to Level 1.5.. Units are km.

### AtmosphericModel:

This is a two dimensional array with elements for each of the channels and 360 elements per channel corresponding to the apparent atmospheric variation relative to the Earth model, sampled every 10 detector line.

### ResamplingFunctions:

This is an array with one element per channel giving the type of Resampling used for the processing. The default (baseline) resampling function used in IMPF is a 9x9 FIR Shannon interpolation with a Kaiser window. Other resampling functions (Bicubic Splines 4x4 and Nearest Neighbour) are available for specific use / reference.

## 7.2.7 IMPFConfiguration Record

Note: This record is not disseminated and externally only available via the UMARF. It is defined as follows:

IMPFConfiguration::=RECORD	
{OverallConfiguration	RECORD
{Issue	UNSIGNED SHORT
Revision	UNSIGNED SHORT},
SUDetails	ARRAY SIZE (1..50) OF RECORD
{SUId	GP_SU_ID,
SUIdInstance	BYTE,
SUMode	ENUMERATED BYTE
	{OFF (0),
	ON/Non-Processing (1),
	ON/Real-Time Processing (2),
	ON/Analysis Mode (3)},
SUState	ENUMERATED BYTE
	{Error (0),
	Nominal (1),
	Degraded (2)},
SUConfiguration	RECORD
{SWVersion	RECORD
{Issue	UNSIGNED SHORT
Revision	UNSIGNED SHORT},

<b>InfoBaseVersions</b>	ARRAY SIZE (1..10) OF RECORD
{ <b>Issue</b>	UNSIGNED SHORT
<b>Revision</b>	UNSIGNED SHORT}}
<b>WarmStartParms</b>	RECORD
{ <b>ScanningLaw</b>	ARRAY SIZE (1..1527) OF REAL DOUBLE,
<b>RadFramesAlignment</b>	ARRAY SIZE (1..3) OF REAL DOUBLE,
<b>ScanningLawVariation</b>	ARRAY SIZE (1..2) OF REAL,
<b>EqualisationParms</b>	ARRAY SIZE (1..42) OF RECORD
{ <b>ConstCoef</b>	REAL,
<b>LinearCoef</b>	REAL,
<b>QuadraticCoef</b>	REAL},
<b>BlackBodyDataForWarmStart</b>	RECORD
{ <b>GTotForMethod1</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GTotForMethod2</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GTotForMethod3</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GBackForMethod1</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GBackForMethod2</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GBackForMethod3</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>RatioGTotToGBack</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>GainInFrontOpticsCont</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>CalibrationConstants</b>	ARRAY SIZE (1..12) OF REAL,
<b>maxIncidentRadiance</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>TimeOfColdObsSeconds</b>	REAL DOUBLE,
<b>TimeOfColdObsNanoSecs</b>	REAL DOUBLE,
<b>IncidenceRadiance</b>	ARRAY SIZE (1..12) REAL DOUBLE,
<b>TempCal</b>	REAL DOUBLE,
<b>TempM1</b>	REAL DOUBLE,
<b>TempScan</b>	REAL DOUBLE,
<b>TempM1Baf</b>	REAL DOUBLE,
<b>TempCalSurround</b>	REAL DOUBLE},
<b>MirrorParameters</b>	RECORD
{ <b>MaxFeedbackVoltage</b>	REAL DOUBLE,
<b>MinFeedbackVoltage</b>	REAL DOUBLE,
<b>MirrorSlipEstimate</b>	REAL DOUBLE},
<b>LastSpinPeriod</b>	REAL DOUBLE,
<b>HKTMPParameters</b>	RECORD
{ <b>TimeS0Packet</b>	TIME CDS SHORT,
<b>TimeS1Packet</b>	TIME CDS SHORT,
<b>TimeS2Packet</b>	TIME CDS SHORT,
<b>TimeS3Packet</b>	TIME CDS SHORT,
<b>TimeS4Packet</b>	TIME CDS SHORT,
<b>TimeS5Packet</b>	TIME CDS SHORT,
<b>TimeS6Packet</b>	TIME CDS SHORT,
<b>TimeS7Packet</b>	TIME CDS SHORT,
<b>TimeS8Packet</b>	TIME CDS SHORT,
<b>TimeS9Packet</b>	TIME CDS SHORT,
<b>TimeSYPacket</b>	TIME CDS SHORT,
<b>TimePSPacket</b>	TIME CDS SHORT},
<b>WSPReserved</b>	OCTETSTRING SIZE (3408)}}}

This record is intended to hold all data pertinent to the production and internal use of Level 1.5 data.

### OverallConfiguration

**OverallConfiguration** is the overall configuration number of IMPF. The following values are used:

Issue	1 = real-time data; 2 = reprocessed data
Revision	0 for real-time data; >0 corresponds to reprocessing run number

### **SUDetails:**

A fixed length array with one element for each SU/SUInstance in the IMPF processing instance which performed the processing of the image. The table below provides the mapping between the array indices and the SUs. The unused array elements are filled with zeros.

Index	SU Name
1	SW_Instance_M&C_SU
2	Accept_Data_SEVIRI_SU
3	Accept_Data_HKTM_SU
4	Accept_Data_GERB_SU
5	Accept_Data_FTP_Server_SU
6	RCal_GCal_SU
7	RQA_SU
8	GQA_SU
9	Requantize_Resample_VIS06_SU
10	Requantize_Resample_VIS08_SU
11	Requantize_Resample_IR16_SU
12	Requantize_Resample_IR38_SU
13	Requantize_Resample_WV62_SU
14	Requantize_Resample_WV73_SU
15	Requantize_Resample_IR87_SU
16	Requantize_Resample_IR97_SU
17	Requantize_Resample_IR108_SU
18	Requantize_Resample_IR120_SU
19	Requantize_Resample_IR134_SU
20	Requantize_Resample_HRV_SU
21	Produce_Quicklook_Data_SU
22	Send_Data_SEVIRI_1pt0_SU
23	Send_Data_SEVIRI_1pt5_SU
24	Send_Data_HKTM_SU
25	Send_Data_Raw_GERB_SU
26	Send_Data_Validated_GERB_SU
27	Send_Data_Generated_FD_SU
28	Send_Data_FTP_Client_Put_SU
29	Object_Store_Server_SU

**SUIid** is a unique id used to identify an SU within the IMPF.

**SUIidInstance** allows to identify uniquely an instantiation of an SU within IMPF.

**SUMode** gives the mode of the SU at the start of image resampling.

**SUState** gives the state of the SU at the start of image resampling.

**SWVersion** gives the software version number of the SU identified by the **SUIid/SUIidInstance** which was running during this repeat cycle. Note that it is possible to change the versions of SUs during a repeat cycle (by stopping/starting) the SU so this version may not be the one running at the end of the repeat cycle.

**InfoBaseVersions** is a fixed length array giving the version numbers for each information base used by the

**SUIid/ SUIidInstance**. If an SU uses less information bases than allowed by the size of this array then, the unused elements will be filled with zeros

**WarmStartParms:**

Contains the state of all the models required for a warm start or the historical reprocessing of the image data. This is purely internal for image processing facility and is not recommended to be used.

**ScanningLaw** is an array with one element per number of steps giving the angle of the instrument absolute step. Units are radians, and possible values are  $-0.192$  to  $+0.192$ .

**RadFramesAlignment** is an array of three elements giving the alignment of the SEVIRI axis to the spin axis.

**ScanningLawVariation** is an array of two elements, the linear and quadratic coefficients of the Radiometer Scan Law.

**EqualisationParms** is an array of 42 records, one per detector.

**ConstCoef** is the constant coefficient used for equalisation

**LinearCoef** is the linear coefficient used for equalisation

**QuadraticCoef** is the quadratic coefficient used for equalisation

**BlackBodyDataForWarmStart** is an array of 12 records, one for each channel

**GTotForMethod1** is the overall SEVIRI instrument gain for Method1 calibration,  $G_{total}$ .

**GTotForMethod2** is the overall SEVIRI instrument gain for Method2 calibration,  $G_{total}$ .

**GTotForMethod3** is the overall SEVIRI instrument gain for Method3 calibration,  $G_{total}$ .

**GBackForMethod1** is the instrument and processing gain as seen by the Black Body for Method 1,  $G_{back}$ .

**GBackForMethod2** is the instrument and processing gain as seen by the Black Body for Method 2,  $G_{back}$

**GBackForMethod3** is the instrument and processing gain as seen by the Black Body for Method 3,  $G_{back}$ .

**RatioGTotToGBack** is the ratio of  $G_{total}$  to  $G_{back}$  used for Method 3.

**GainInFrontOpticsCont** is the current estimate of the front optics contribution ( $g_f$ ) used in Method 2.

**CalibrationConstants** are the value of  $K_{cal}$  used,  $K_{cal} = 1/G_{total}$  for the selected Method.

**MaxIncidenceRadiance** is an array of 12 elements, the mean linearised channel output corresponding to the maximum temperature.

**TimeOfColdObsSeconds** is the start time of the preceding cold Black Body observation.

**TimeOfColdObsNanoSecs** is nano-second portion of the start time.

**IncidenceRadiance** is the mean linearised channel output for Black Body cold reading,  $R_{cal}(T_{cold})$ .

**TempCal** is the temperature of Black Body for cold reading,  $T_{cold}$ .

**TempM1** is the temperature of the primary mirror for Black Body cold reading,  $T_{M1}$ .

**TempScan** is the temperature of the scan mirror for Black Body cold reading,  $T_{scan}$ .

**TempM1Baf** is the temperature of the primary mirror baffle for Black Body cold reading,  $T_{M1baf}$ .

**TempCalSurround** is the temperature is the temperature of the black body surroundings for Black Body cold reading,  $T^*_{cal}$ .

**MaxFeedbackVoltage** is the initial value of the mirror potentiometer maximum feedback voltage.

**MinFeedbackVoltage** is the initial value of the mirror potentiometer minimum feedback voltage.

**MirrorSlipEstimate** is the initial value of the mirror slip.

**LastSpinPeriod** is the initial value of spin period.

**TimeS0Packet** is the time of first S0 packet received for this repeat cycle.

**TimeS1Packet** is the time of first S1 packet received for this repeat cycle.

**TimeS2Packet** is the time of first S2 packet received for this repeat cycle.

**TimeS3Packet** is the time of first S3 packet received for this repeat cycle.

**TimeS4Packet** is the time of first S4 packet received for this repeat cycle.

**TimeS5Packet** is the time of first S5 packet received for this repeat cycle.

**TimeS6Packet** is the time of first S6 packet received for this repeat cycle.

**TimeS7Packet** is the time of first S7 packet received for this repeat cycle.

**TimeS8Packet** is the time of first S8 packet received for this repeat cycle.

**TimeS9Packet** is the time of first S9 packet received for this repeat cycle.

**TimeSYPacket** is the time of first SY packet received for this repeat cycle.

**TimePSPacket** is the time of first PS packet received for this repeat cycle.

**WSPReserved** is reserved space for further Warm-Start Parameters.

### 7.3 1.5 VIS/IR Line Record Structure

The packet body assigned to the 15VIS/IRLine service subtype is defined as follows:

15VIS/IRLINE::=RECORD		
{15VIS/IRLINEVersion	UNSIGNED BYTE (0),	
<b>LineSideInfo</b>	RECORD	
{SatelliteId	GP_SC_ID,	
<b>TrueRepeatCycleStart</b>	TIME CDS EXPANDED,	
<b>LineNumberInVIS_IRGrid</b>	INTEGER,	
<b>ChannelId</b>	GP_SC_CHAN_ID,	
<b>L10LineMeanAcquisitionTime</b>	TIME CDS SHORT,	
<b>LineValidity</b>	ENUMERATED BYTE	
	{Not Derived	(0),
	Nominal	(1),
	Based on missing data	(2),
	Based on corrupted data	(3),
	Based on replaced or interpolated data	(4)},
<b>LineRadiometricQuality</b>	ENUMERATED BYTE	
	{Not Derived	(0),
	Nominal	(1),
	Usable	(2),
	Suspect	(3),
	Do not use	(4)},
<b>LineGeometricQuality</b>	ENUMERATED BYTE	
	{Not Derived	(0),
	Nominal	(1),
	Usable	(2),
	Suspect	(3),
	Do not use	(4)}},
<b>LineData</b>	ARRAY SIZE (1..3712) OF UNSIGNED (10)}	

**15VIS/IRLINEVersion** is set to zero initially and is used to identify possible future upgrades of this record.

#### LineSideInfo:

**SatelliteId** gives the identification of the satellite whose 1.0 data was used to produce this 1.5 data. This ID is copied by IMPF from the packet sub header of the 1.0 data. Therefore its reliability depends on the configuration of the PGS when the data was acquired.

**TrueRepeatCycleStart** is the start time of the current repeat cycle, accurate to within  $10^{-6}$ seconds.

**LineNumberInVIS\_IRGrid** gives the line number in the VIS/IR grid. Possible value lies in the range 1 to planned number of lines constituting the planned coverage.

**ChannelId** gives the channel id to which this line belongs. Possible value lies in the range 1..11 for VIS and IR.

**L10LineMeanAcquisitionTime** gives the acquisition time of the Level 1.0 image line used to construct this Level 1.5 line. This field contains the mean time of constituent lines when more than one Level 1.0 line was used.

**LineValidity** indicates the validity of the Level 1.5 line. ‘*Based on missing data*’ means that a block of missing data at Level 1.0 intersects this Level 1.5 line and has not been replaced. ‘*Based on corrupt data*’ means similar, but the data was corrupt. ‘*Based on replaced or interpolated data*’ means that a block of missing or corrupt data at Level 1.0 intersects this Level 1.5 line and has been replaced by interpolation between data from adjacent Level 1.0 lines.

**LineRadiometricQuality** indicates the radiometric quality of the line. ‘*Useable*’ means corrupt or missing data contributes slightly to some of this line. ‘*Suspect*’ means corrupt or missing data is a dominant contribution to some pixels in this line, but has been successfully replaced by interpolation. ‘*Do not use*’ means corrupt or missing

data is a dominant contribution to some pixels in this line and has not been replaced by interpolation since adjacent data is also suspect.

**LineGeometricQuality** indicates the geometric quality of the line. The indication values have meanings similar to those for **LineRadiometricQuality**.

**LineData:**

An array of elements holding the pixels constituting the line data for the specified channel. Each element holds one pixel value in the range offered by the 10-bit size (i.e. 0..1023).

## 7.4 1.5 HRV Line Record Structure

The packet body assigned to the 15HRVLine service subtype is defined as follows:

15HRVLINE ::= RECORD			
{15HRVLINEVersion	UNSIGNED BYTE (0),		
LineSideInfo	RECORD		
{SatelliteId	GP_SC_ID,		
TrueRepeatCycleStart	TIME CDS EXPANDED,		
LineNumberInHRVGrid	INTEGER,		
ChannelId	GP_SC_CHAN_ID,		
L10LineMeanAcquisitionTime	TIME CDS SHORT,		
LineValidity	ENUMERATED BYTE		
	{Not derived	(0),	
	Nominal	(1),	
	Based on missing data	(2),	
	Based on corrupted data	(3),	
	Based on replaced or interpolated data	(4)},	
LineRadiometricQuality	ENUMERATED BYTE		
	{Not derived	(0),	
	Nominal	(1),	
	Usable	(2),	
	Suspect	(3),	
	Do not use	(4)},	
LineGeometricQuality	ENUMERATED BYTE		
	{Not derived	(0),	
	Nominal	(1),	
	Usable	(2),	
	Suspect	(3),	
	Do not use	(4)}},	
LineData	ARRAY SIZE (1..5568) OF UNSIGNED (10)}		

**15HRVLINEVersion** is set to zero initially and is used to identify possible future upgrades of this record.

The other field names and definitions for 15HRVLINE are the same as those for the 15VIS/IRLINE record structure, with the following exceptions:

**LineNumberInHRVGrid** is the field name used instead of **LineNumberInVIS\_IRGrid**.

**ChannelId** will take the value 12 for HRV.

**LineData** has 5568 elements instead of 3712, in order to accommodate the HRV data.

## 7.5 15TRAILER Record Structure

The packet body assigned to the 15Trailer service subtype is defined as follows:

15TRAILER ::= RECORD		
{ 15TRAILERVersion	UNSIGNED BYTE (0),	
ImageProductionStats_Record	ImageProductionStats,	-- See below
NavigationExtractionResults_Record	NavigationExtractionResults,	-- See below
RadiometricQuality_Record	RadiometricQuality,	-- See below
GeometricQuality_Record	GeometricQuality,	-- See below
TimelinessAndCompleteness_Record	TimelinessAndCompleteness }	-- See below

15TRAILERVersion is used to identify possible future upgrades of this record.

### 7.5.1 Image Production Stats Record

This is defined as follows:

ImageProductionStats ::= RECORD		
{ SatelliteId	GP_SC_ID,	
ActualScanningSummary	RECORD	
{ NominalImageScanning	BOOLEAN BYTE,	
ReducedScan	BOOLEAN BYTE,	
ForwardScanStart	TIME CDS SHORT,	
ForwardScanEnd	TIME CDS SHORT },	
RadiometerBehaviour	RECORD	
{ NominalBehaviour	BOOLEAN BYTE,	
RadScanIrregularity	BOOLEAN BYTE,	
RadStoppage	BOOLEAN BYTE,	
RepeatCycleNotCompleted	BOOLEAN BYTE,	
GainChangeTookPlace	BOOLEAN BYTE,	
DecontaminationTookPlace	BOOLEAN BYTE,	
NoBBCalibrationAchieved	BOOLEAN BYTE,	
IncorrectTemperature	BOOLEAN BYTE,	
InvalidBBData	BOOLEAN BYTE,	
InvalidAuxOrHKTMDData	BOOLEAN BYTE,	
RefocusingMechanismActuated	BOOLEAN BYTE,	
MirrorBackToReferencePos	BOOLEAN BYTE },	
ReceptionSummaryStats	RECORD	
{ PlannedNumberOfL10Lines	ARRAY SIZE (1..12) OF UNSIGNED,	
NumberOfMissingL10Lines	ARRAY SIZE (1..12) OF UNSIGNED,	
NumberOfCorruptedL10Lines	ARRAY SIZE (1..12) OF UNSIGNED,	
NumberOfReplacedL10Lines	ARRAY SIZE (1..12) OF UNSIGNED },	
L15ImageValidity	ARRAY SIZE (1..12) OF RECORD	
{ NominalImage	BOOLEAN BYTE,	
NonNominalBecauseIncomplete	BOOLEAN BYTE,	
NonNominalRadiometricQuality	BOOLEAN BYTE,	
NonNominalGeometricQuality	BOOLEAN BYTE,	
NonNominalTimeliness	BOOLEAN BYTE,	
IncompleteL15	BOOLEAN BYTE },	
ActualL15CoverageVIS_IR	RECORD	
{ SouthernLineActual	INTEGER,	
NorthernLineActual	INTEGER,	
EasternColumnActual	INTEGER,	
WesternColumnActual	INTEGER },	
Actual L15CoverageHRV	RECORD	
{ LowerSouthLineActual	INTEGER,	
LowerNorthLineActual	INTEGER,	
LowerEastColumnActual	INTEGER,	
LowerWestColumnActual	INTEGER,	

<b>UpperSouthLineActual</b>	INTEGER,
<b>UpperNorthLineActual</b>	INTEGER,
<b>UpperEastColumnActual</b>	INTEGER,
<b>UpperWestColumnActual</b>	INTEGER}}

### **ActualScanningSummary:**

This is a record giving summary details of image-taking for this repeat cycle.

**NominalImageScanning** is a flag that indicates if image-taking was performed in the nominal manner during the whole repeat cycle. A value of true indicates nominal.

**ReducedScan** is a flag that indicates if the repeat cycle was a reduced scan. 'TRUE' indicates a reduced scan.

**ForwardScanStart** is the time of the first line of forward scan.

**ForwardScanEnd** is the time of the last line of forward scan.

### **RadiometerBehaviour:**

This is a record giving details of the behaviour of the radiometer instrument.

**NominalBehaviour** is a flag indicating if the behaviour of the RADIOMETER instrument was nominal during the whole of this repeat cycle. A value of true indicates nominal behaviour.

**RadScanIrregularity** is a flag that indicates if there was a scan irregularity during this repeat cycle. A value of true indicates that an irregularity occurred.

**RadStoppage** is a flag that indicates if there was a radiometer stoppage during this repeat cycle. A value of true indicates that there was a stoppage.

**RepeatCycleNotCompleted** is a flag that indicates that the repeat cycle was not completed. A value of true indicates that it was not complete

**GainChangeTookPlace** is a flag that indicates if a gain change took place during this repeat cycle. A value of true indicates that it took place.

**DecontaminationTookPlace** is a flag that indicates if a decontamination took place during this repeat cycle. A value of true indicates that it took place.

**NoBBCalibrationAchieved** is a flag that indicates that no BB calibration took place even though it was planned. A value of true indicates that BB calibration did not take place

**IncorrectTemperature** is a flag that indicates if the radiometer exhibited an incorrect temperature during this repeat cycle. A value of true indicates an incorrect temperature.

**InvalidBBData** is a flag that indicates that Blackbody sample data was corrupt and/or inconsistent. A value of true indicates corrupt/inconsistent.

**InvalidAuxorHKTMData** is a flag that indicates that AUX and / or HK telemetry data are corrupt and/or inconsistent. A value of true indicates corrupt/inconsistent.

**RefocusingMechanismActuated** is a flag that indicates that the refocusing mechanism was activated during this repeat cycle. A value of true indicates that it was activated.

**MirrorBackToReferencePos** is a flag that indicates if the scan mirror was moved back to the reference position during this repeat cycle. A value of true indicates it was moved.

**ReceptionSummaryStats:**

**PlannedNumberOfL10Lines** is an array with one element per channel giving the planned number of Level 1.0 lines for this repeat cycle.

**NumberOfMissingL10Lines** is an array with one element per channel giving the number of missing Level 1.0 lines for this repeat cycle.

**NumberOfCorruptedL10Lines** is an array with one element per channel giving the number of corrupted Level 1.0 lines for this repeat cycle.

**NumberOfReplacedL10Lines** is an array with one element per channel giving the number of replaced Level 1.0 lines for this repeat cycle.

**L15ImageValidity:**

This is an array with one element per channel. Each element is a record giving details of the image validity for the channel.

**NominalImage** is a flag that indicates if the Level 1.5 image produced for this repeat cycle is of nominal quality. 'TRUE' indicates nominal.

**NonNominalBecauseIncomplete** is a flag that indicates if the image quality is non nominal due to it being incomplete. 'True' indicates non-nominal.

**NonNominalRadiometricQuality** is a flag that indicates if the image quality is non nominal due to bad radiometric quality. 'True' indicates non-nominal.

**NonNominalGeometricQuality** is a flag that indicates if the image quality is non nominal due to bad geometric quality. 'True' indicates non-nominal.

**NonNominalTimeliness** is a flag that indicates if the image quality is non nominal due to late arrival of data. 'TRUE' indicates non-nominal.

**IncompleteL15** is a flag that indicates that not all of the Level 1.5 data was produced.

**Actual L15CoverageVIS IR:**

This is a record giving details of the actual coverage for the VIS and IR channels.

**SouthernLineActual** gives the line number of the southern most line in this Level 1.5 image. Possible values are within the limit of the planned coverage (info present in the Level 1.5 header).

**NorthernLineActual** gives the line number of the northern most line in this Level 1.5 image. Possible values are within the limit of the planned coverage (info present in the Level 1.5 header).

**EasternColumnActual** gives the column number of the easternmost column in this Level 1.5 image. Possible values are within the limit of the planned coverage (info present in the Level 1.5 header).

**WesternColumnActual** gives the column number of the western most column in this Level 1.5 image. Possible values are within the limit of the planned coverage (info present in the Level 1.5 header).

**Actual L15CoverageHRV:**

This is a record giving details of the actual coverage for the Level 1.5 HRV channel. The component fields are the same as those for the record **Actual L15CoverageVIS\_IR**, with the difference that the line and column bounds are given for each of the two areas constituting the scan, i.e. the **Lower** and the **Upper** areas.

## 7.5.2 Navigation Extraction Results Record

This is defined as follows:

NavigationExtractionResults ::= RECORD		
<b>ExtractedHorizons</b>	ARRAY SIZE (1..4) OF HORIZONOBSERVATION,	-- See below
<b>ExtractedStars</b>	ARRAY SIZE (1..20) OF STAROBSERVATION,	-- See below
<b>ExtractedLandmarks</b>	ARRAY SIZE (1..50) OF LANDMARKOBSERVATION}	-- See below

**HORIZONOBSERVATION** is defined as follows:

HORIZONOBSERVATION ::= RECORD		
<b>HorizonId</b>	ENUMERATED BYTE	
	{South (0),	
	North (1),	
	East (2),	
	West (3)},	
<b>Alpha</b>	REAL DOUBLE,	-- in Radians
<b>AlphaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>Beta</b>	REAL DOUBLE,	-- in Radians
<b>BetaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>ObservationTime</b>	TIME CDS,	-- time of observation
<b>SpinRate</b>	REAL DOUBLE	-- at time of observation, in RPM
<b>AlphaDeviation</b>	REAL DOUBLE,	-- in Radians
<b>BetaDeviation</b>	REAL DOUBLE}	-- in Radians

**Alpha** and **Beta** are the alpha and beta coefficients of the observed horizon position in the Spacecraft Frame as it exists at the observation time given in **ObservationTime**. The North and South horizons, as points, lie in the plane containing the spacecraft, the centre of the Earth reference ellipsoid and the Earth spin axis and are at the points where a line in this plane passing through the spacecraft are tangential to the Earth ellipsoid. The East and West horizons are similarly defined but lie in a plane containing the spacecraft and the ellipsoid centre and perpendicular to the spin axis.

**AlphaDeviation** and **BetaDeviation** represent the horizon position error, i.e. the difference between the predicted and actual observed position, expressed in terms of right ascension and declination in the spacecraft frame.

**STAROBSERVATION** is defined as follows:

STAROBSERVATION ::= RECORD		
<b>StarId</b>	UNSIGNED SHORT,	
<b>Alpha</b>	REAL DOUBLE,	-- in Radians
<b>AlphaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>Beta</b>	REAL DOUBLE,	-- in Radians
<b>BetaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>ObservationTime</b>	TIME CDS,	-- time of observation
<b>SpinRate</b>	REAL DOUBLE	-- at time of observation, in RPM
<b>AlphaDeviation</b>	REAL DOUBLE,	-- in Radians
<b>BetaDeviation</b>	REAL DOUBLE}	-- in Radians

**Alpha** and **Beta** are the alpha and beta coefficients of the observed star position in the Spacecraft Frame as it exists at the observation time given in **ObservationTime**.

**AlphaDeviation** and **BetaDeviation** represent the star position error, i.e. the difference between the predicted and actual observed position, expressed in terms of right ascension and declination in the spacecraft frame.

**LANDMARKOBSERVATION** is defined as follows:

LANDMARKOBSERVATION ::= RECORD		
{ <b>LandmarkId</b>	UNSIGNED SHORT,	
<b>LandmarkLongitude</b>	REAL DOUBLE,	-- in Radians
<b>LandmarkLatitude</b>	REAL DOUBLE,	-- in Radians
<b>Alpha</b>	REAL DOUBLE,	-- in Radians
<b>AlphaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>Beta</b>	REAL DOUBLE,	-- in Radians
<b>BetaConfidence</b>	REAL DOUBLE,	-- confidence interval
<b>ObservationTime</b>	TIME CDS,	-- time of observation
<b>SpinRate</b>	REAL DOUBLE	-- at time of observation, in RPM
<b>AlphaDeviation</b>	REAL DOUBLE,	-- in Radians
<b>BetaDeviation</b>	REAL DOUBLE }	-- in Radians

**Alpha** and **Beta** are the alpha and beta coefficients of the observed landmark position in the Spacecraft Frame as it exists at the observation time given in **ObservationTime**. The landmark point whose position is given is the landmark centre as defined in the reference landmark definition.

**AlphaDeviation** and **BetaDeviation** represent the landmark matching error, i.e. the difference between the predicted and actual observed position, expressed in terms of right ascension and declination in the spacecraft frame.

### 7.5.3 Radiometric Quality Record

This is defined as follows:

RadiometricQuality ::= RECORD	
{ <b>L10RadQuality</b>	ARRAY SIZE (1..42) OF RECORD
{ <b>FullImageMinimumCount</b>	UNSIGNED SHORT,
<b>FullImageMaximumCount</b>	UNSIGNED SHORT,
<b>EarthDiskMinimumCount</b>	UNSIGNED SHORT,
<b>EarthDiskMaximumCount</b>	UNSIGNED SHORT,
<b>MoonMinimumCount</b>	UNSIGNED SHORT,
<b>MoonMaximumCount</b>	UNSIGNED SHORT,
<b>FullImageMeanCount</b>	REAL,
<b>FullImageStandardDeviation</b>	REAL,
<b>EarthDiskMeanCount</b>	REAL,
<b>EarthDiskStandardDeviation</b>	REAL,
<b>MoonMeanCount</b>	REAL,
<b>MoonStandardDeviation</b>	REAL,
<b>SpaceMeanCount</b>	REAL,
<b>SpaceStandardDeviation</b>	REAL,
<b>SESpaceCornerMeanCount</b>	REAL,
<b>SESpaceCornerStandardDeviation</b>	REAL,
<b>SWSpaceCornerMeanCount</b>	REAL,
<b>SWSpaceCornerStandardDeviation</b>	REAL,
<b>NESpaceCornerMeanCount</b>	REAL,
<b>NESpaceCornerStandardDeviation</b>	REAL,
<b>NWSpaceCornerMeanCount</b>	REAL,
<b>NWSpaceCornerStandardDeviation</b>	REAL,
<b>4SpaceCornersMeanCount</b>	REAL,
<b>4SpaceCornersStandardDeviation</b>	REAL,
<b>FullImageHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>EarthDiskHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>ImageCentreSquareHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>SESpaceCornerHistogram</b>	ARRAY SIZE (0..127) of UNSIGNED,
<b>SWSpaceCornerHistogram</b>	ARRAY SIZE (0..127) of UNSIGNED,
<b>NESpaceCornerHistogram</b>	ARRAY SIZE (0..127) of UNSIGNED,

<b>NWSpaceCornerHistogram</b>	ARRAY SIZE (0..127) of UNSIGNED,
<b>FullImageEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>EarthDiskEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>ImageCentreSquareEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>SESpaceCornerEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>SWSpaceCornerEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>NESpaceCornerEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>NWSpaceCornerEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>4SpaceCornersEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>ImageCentreSquarePSD_EW</b>	ARRAY SIZE (0..127) of REAL,
<b>FullImagePSD_EW</b>	ARRAY SIZE (0..127) of REAL,
<b>ImageCentreSquarePSD_NS</b>	ARRAY SIZE (0..127) of REAL,
<b>FullImagePSD_NS</b>	ARRAY SIZE (0..127) of REAL},
<b>L15RadQuality</b>	ARRAY SIZE (1..12) OF RECORD
{ <b>FullImageMinimumCount</b>	UNSIGNED SHORT,
<b>FullImageMaximumCount</b>	UNSIGNED SHORT,
<b>EarthDiskMinimumCount</b>	UNSIGNED SHORT,
<b>EarthDiskMaximumCount</b>	UNSIGNED SHORT,
<b>FullImageMeanCount</b>	REAL,
<b>FullImageStandardDeviation</b>	REAL,
<b>EarthDiskMeanCount</b>	REAL,
<b>EarthDiskStandardDeviation</b>	REAL,
<b>SpaceMeanCount</b>	REAL,
<b>SpaceStandardDeviation</b>	REAL,
<b>FullImageHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>EarthDiskHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>ImageCentreSquareHistogram</b>	ARRAY SIZE (0..255) of UNSIGNED,
<b>FullImageEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>EarthDiskEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>ImageCentreSquareEntropy</b>	ARRAY SIZE (0..2) of REAL,
<b>ImageCentreSquarePSD_EW</b>	ARRAY SIZE (0..127) of REAL,
<b>FullImagePSD_EW</b>	ARRAY SIZE (0..127) of REAL,
<b>ImageCentreSquarePSD_NS</b>	ARRAY SIZE (0..127) of REAL,
<b>FullImagePSD_NS</b>	ARRAY SIZE (0..127) of REAL,
<b>SESpaceCornerL15_RMS</b>	REAL,
<b>SESpaceCornerL15_Mean</b>	REAL,
<b>SWSpaceCornerL15_RMS</b>	REAL,
<b>SWSpaceCornerL15_Mean</b>	REAL,
<b>NESpaceCornerL15_RMS</b>	REAL,
<b>NESpaceCornerL15_Mean</b>	REAL,
<b>NWSpaceCornerL15_RMS</b>	REAL,
<b>NWSpaceCornerL15_Mean</b>	REAL}}

### L10RadQuality:

This is an array containing one record for each detector giving details of radiometric quality for the detector.

**FullImageMinimumCount** gives the minimum pixel value for the whole image for this channel/detector.

**FullImageMaximumCount** gives the maximum pixel value for the whole image for this channel/detector.

**EarthDiskMinimumCount** gives the minimum pixel value within the earth disk for this channel/detector.

**EarthDiskMaximumCount** gives the maximum pixel value within the earth disk for this channel/detector.

**MoonMinimumCount** gives the minimum pixel count for the moon image area (0 indicates no statistics extracted).

**MoonMaximumCount** gives the maximum pixel count for the moon image area (0 indicates no statistics extracted).

**FullImageMeanCount** gives the mean image count for the full image.

**FullImageStandardDeviation** gives the standard deviation for the full image.

**EarthDiskMeanCount** gives the mean image count for the Earth disk.

**EarthDiskStandardDeviation** gives the standard deviation for the Earth disk.

**MoonMeanCount** gives the mean count for the moon image area.

**MoonStandardDeviation** gives the standard deviation for the moon image area.

**SpaceMeanCount** gives the mean count for the complete space image area.

**SpaceStandardDeviation** gives the standard deviation for the complete space image area.

**SESpaceCornerMeanCount** gives the mean count for the SE space corner.

**SESpaceCornerStandardDeviation** gives the standard deviation for the SE space corner.

**SWSpaceCornerMeanCount** gives the mean count for the SW space corner.

**SWSpaceCornerStandardDeviation** gives the standard deviation for the SW space corner.

**NESpaceCornerMeanCount** gives the mean count for the NE space corner.

**NESpaceCornerStandardDeviation** gives the standard deviation for the NE space corner.

**NWSpaceCornerMeanCount** gives the mean count for the NW space corner.

**NWSpaceCornerStandardDeviation** gives the standard deviation for the NW space corner.

**4SpaceCornersMeanCount** gives the mean count for all four space corners.

**4SpaceCornersStandardDeviation** gives the standard deviation for all four space corners.

**FullImageHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the full image having the value corresponding to the index for that element.

**EarthDiskHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the earth disk having the value corresponding to the index for that element.

**ImageCentreSquareHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the image centre square having the value corresponding to the index for that element.

**SESpaceCornerHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the SE space corner having the value corresponding to the index for that element.

**SWSpaceCornerHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the SW space corner having the value corresponding to the index for that element.

**NESpaceCornerHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the NE space corner having the value corresponding to the index for that element.

**NWSpaceCornerHistogram** is an array with one element for every four adjacent count value. Each element contains a count of the pixels in the NW space corner having the value corresponding to the index for that element.

**FullImageEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the full image. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**EarthDiskEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the earth disk. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**ImageCentreSquareEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the image centre square. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**SESpaceCornerEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the SE space corner. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**SWSpaceCornerEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the SW space corner. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**NESpaceCornerEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the NE space corner. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**NWSpaceCornerEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for the NW space corner. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**4SpaceCornersEntropy** is an array with elements corresponding to entropy of the 0<sup>th</sup>, 1<sup>st</sup> and 2<sup>nd</sup> order containing the entropy for all four space corners. The entropy is computed per channel (not per detector) and is then repeated for each detector composing one channel.

**ImageCentreSquarePSD\_EW** gives a sub-sampled version of the accumulated Power Spectral Density (PSD) over all applicable E-W rows. The PSD is calculated from the sum of the moduli of the Fourier Transform of all applicable rows. The zeroth element represents the zero spatial frequency component, the next element the component with spatial wavelength 128 pixels, etc.

**FullImagePSD\_EW** gives the same as for 'ImageCentreSquarePSD\_EW', but over all EW rows.

**ImageCentreSquarePSD\_NS** gives the same as for 'ImageCentreSquarePSD\_EW', but for all applicable N-S columns.

**FullImagePSD\_NS** gives the same as for 'ImageCentreSquarePSD\_NS', but over all N-S columns.

### **L15RadQuality:**

This is an array containing one record per channel giving details of the radiometric quality for that channel. The array contains a subset of the fields contained in the array of records '10RadQuality' with the exception of the following:

The fields **xxSpaceCornerL15\_RMS** and **xxSpaceCornerL15\_Mean** (where xx is SE, SW, NE or NW) provide the RMS and mean values respectively for the space corners in the Level 1.5 image (equivalent to the area that would have been produced had a space mask not been applied). The values can be compared with the same information for Level 1.0 to assess the impact on the noise due to IMPF processing from Level 1.0 to 1.5.

### 7.5.4 Geometric Quality Record

This is defined as follows:

<b>GeometricQuality ::= RECORD</b>			
<b>{ AbsoluteAccuracy</b>	<b>ARRAY SIZE (1..12) OF RECORD</b>		
<b>{ QualityInfoValidity</b>	<b>ENUMERATED BYTE</b>		
	{Not derived	(0),	
	Derived and valid	(1),	
	Derived and invalid	(2),	
	Estimated	(3)},	
<b>EastWestAccuracyRMS</b>	<b>REAL,</b>		
<b>NorthSouthAccuracyRMS</b>	<b>REAL,</b>		
<b>MagnitudeRMS</b>	<b>REAL,</b>		
<b>EastWestUncertaintyRMS</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyRMS</b>	<b>REAL,</b>		
<b>MagnitudeUncertaintyRMS</b>	<b>REAL,</b>		
<b>EastWestMaxDeviation</b>	<b>REAL,</b>		
<b>NorthSouthMaxDeviation</b>	<b>REAL,</b>		
<b>MagnitudeMaxDeviation</b>	<b>REAL,</b>		
<b>EastWestUncertaintyMax</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyMax</b>	<b>REAL,</b>		
<b>MagnitudeUncertaintyMax</b>	<b>REAL},</b>		
<b>RelativeAccuracy</b>	<b>ARRAY SIZE (1..12) OF RECORD</b>		
<b>{ QualityInfoValidity</b>	<b>ENUMERATED BYTE</b>		
	{Not derived	(0),	
	Derived and valid	(1),	
	Derived and invalid	(2),	
	Estimated	(3)},	
<b>EastWestAccuracyRMS</b>	<b>REAL,</b>		
<b>NorthSouthAccuracyRMS</b>	<b>REAL,</b>		
<b>MagnitudeRMS</b>	<b>REAL,</b>		
<b>EastWestUncertaintyRMS</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyRMS</b>	<b>REAL,</b>		
<b>MagnitudeUncertaintyRMS</b>	<b>REAL,</b>		
<b>EastWestMaxDeviation</b>	<b>REAL,</b>		
<b>NorthSouthMaxDeviation</b>	<b>REAL,</b>		
<b>MagnitudeMaxDeviation</b>	<b>REAL,</b>		
<b>EastWestUncertaintyMax</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyMax</b>	<b>REAL,</b>		
<b>MagnitudeUncertaintyMax</b>	<b>REAL},</b>		
<b>500PixelsRelativeAccuracy</b>	<b>ARRAY SIZE (1..12) OF RECORD</b>		
<b>{ QualityInfoValidity</b>	<b>ENUMERATED BYTE</b>		
	{Not derived	(0),	
	Derived and valid	(1),	
	Derived and invalid	(2),	
	Estimated	(3)},	
<b>EastWestAccuracyRMS</b>	<b>REAL,</b>		
<b>NorthSouthAccuracyRMS</b>	<b>REAL,</b>		
<b>MagnitudeRMS</b>	<b>REAL,</b>		
<b>EastWestUncertaintyRMS</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyRMS</b>	<b>REAL,</b>		
<b>MagnitudeUncertaintyRMS</b>	<b>REAL,</b>		
<b>EastWestMaxDeviation</b>	<b>REAL,</b>		
<b>NorthSouthMaxDeviation</b>	<b>REAL,</b>		
<b>MagnitudeMaxDeviation</b>	<b>REAL,</b>		
<b>EastWestUncertaintyMax</b>	<b>REAL,</b>		
<b>NorthSouthUncertaintyMax</b>	<b>REAL,</b>		

<b>MagnitudeUncertaintyMax</b>	REAL},
<b>16PixelsRelativeAccuracy</b>	ARRAY SIZE (1..12) OF RECORD
<b>{ QualityInfoValidity</b>	ENUMERATED BYTE
	{Not derived (0),
	Derived and valid (1),
	Derived and invalid (2),
	Estimated (3)},
<b>EastWestAccuracyRMS</b>	REAL,
<b>NorthSouthAccuracyRMS</b>	REAL,
<b>MagnitudeRMS</b>	REAL,
<b>EastWestUncertaintyRMS</b>	REAL,
<b>NorthSouthUncertaintyRMS</b>	REAL,
<b>MagnitudeUncertaintyRMS</b>	REAL,
<b>EastWestMaxDeviation</b>	REAL,
<b>NorthSouthMaxDeviation</b>	REAL,
<b>MagnitudeMaxDeviation</b>	REAL,
<b>EastWestUncertaintyMax</b>	REAL,
<b>NorthSouthUncertaintyMax</b>	REAL,
<b>MagnitudeUncertaintyMax</b>	REAL},
<b>MisregistrationResiduals</b>	ARRAY SIZE (1..12) OF RECORD
<b>{ QualityInfoValidity</b>	ENUMERATED BYTE
	{Not derived (0),
	Derived and valid (1),
	Derived and invalid (2),
	Estimated (3)},
<b>EastWestResidual</b>	REAL,
<b>NorthSouthResidual</b>	REAL,
<b>EastWestUncertainty</b>	REAL,
<b>NorthSouthUncertainty</b>	REAL,
<b>EastWestRMS</b>	REAL,
<b>NorthSouthRMS</b>	REAL,
<b>EastWestMagnitude</b>	REAL,
<b>NorthSouthMagnitude</b>	REAL,
<b>EastWestMagnitudeUncertainty</b>	REAL,
<b>NorthSouthMagnitudeUncertainty</b>	REAL},
<b>GeometricQualityStatus</b>	ARRAY SIZE (1..12) OF RECORD
<b>{ QualityNominal</b>	BOOLEAN BYTE,
<b>NominalAbsolute</b>	BOOLEAN BYTE,
<b>NominalRelativeToPreviousImage</b>	BOOLEAN BYTE,
<b>NominalForREL500</b>	BOOLEAN BYTE,
<b>NominalForREL16</b>	BOOLEAN BYTE,
<b>NominalForResMisreg</b>	BOOLEAN BYTE}}

The above structure 'GeometricQuality' contains the 4 following top-level arrays:

**AbsoluteAccuracy:** An array with one record per channel giving the absolute accuracy of the image.

**RelativeAccuracy:** An array with one record per channel giving the relative accuracy from image to image.

**500PixelsRelativeAccuracy:** An array with one record per channel giving the relative accuracy within the image over 500 pixels.

**16PixelsRelativeAccuracy:** An array with one record per channel giving the relative accuracy within the image over 16 pixels.

Each of the records in the above arrays contains the following identical fields (note that units are the Level 1.5 grid units, i.e. pixels):

**QualityInfoValidity** indicates the whole channel record's validity. This parameter should be checked before using the values of any other fields in the record.

**EastWestAccuracyRMS** gives the E-W component of the image accuracy in RMS terms.

**NorthSouthAccuracyRMS** gives the N-S component of the image accuracy in RMS terms.

**MagnitudeRMS** gives the magnitude of the accumulated RMS.

**EastWestUncertaintyRMS** gives the E-W uncertainty in the accumulated RMS.

**NorthSouthUncertaintyRMS** gives the N-S uncertainty in the accumulated RMS.

**MagnitudeUncertaintyRMS** gives the magnitude uncertainty in the accumulated RMS.

**EastWestMaxDeviation** gives the maximum E-W deviation in the image accuracy.

**NorthSouthMaxDeviation** gives the maximum N-S deviation in the image accuracy.

**MagnitudeMaxDeviation** gives the magnitude of the maximum deviation in the image accuracy.

**EastWestUncertaintyMax** gives the maximum E-W uncertainty factor.

**NorthSouthUncertaintyMax** gives the maximum N-S uncertainty factor.

**MagnitudeUncertaintyMax** gives the maximum magnitude uncertainty factor.

The remainder of the structure 'GeometricQuality' contains the arrays described below:

### **MisregistrationResiduals:**

This is an array with one record per channel giving misregistration residual information. It contains the following fields:

**QualityInfoValidity** indicates the whole channel record's validity. This parameter should be checked before using the values of any other fields in the record.

**EastWestResidual** gives the residual value of the misregistration in the East-West direction.

**NorthSouthResidual** gives the residual value of the misregistration in the North-South direction.

**EastWestUncertainty** gives the uncertainty E-W of the misregistration.

**NorthSouthUncertainty** gives the uncertainty N-S of the misregistration.

**EastWestRMS** gives the RMS E-W of the misregistration.

**NorthSouthRMS** gives the RMS N-S of the misregistration.

**EastWestMagnitude** gives the magnitude E-W of the misregistration.

**NorthSouthMagnitude** gives the magnitude N-S of the misregistration.

**EastWestMagnitudeUncertainty** gives the uncertainty factor in the magnitude E-W of the misregistration.

**NorthSouthMagnitudeUncertainty** gives the uncertainty factor in the magnitude N-S of the misregistration.

### **GeometricQualityStatus:**

This is an array giving geometric quality status information for each radiometer channel. It contains the following fields:

**QualityNominal** is a flag indicating if the quality is nominal. ‘True’ indicates nominal.

**NominalAbsolute** is a flag indicating if the absolute image accuracy is nominal. ‘True’ indicates nominal.

**NominalRelativeToPreviousImage** is a flag indicating if the relative (image to image) accuracy is nominal. ‘True’ indicates nominal.

**NominalForREL500** is a flag indicating if the relative (500 pixels) image accuracy is nominal. ‘True’ indicates nominal.

**NominalForREL16** is a flag indicating if the relative (16 pixels) image accuracy is nominal. ‘True’ indicates nominal.

**NominalForResMisreg** is a flag indicating if the image registration (between spectral bands) is nominal. ‘True’ indicates nominal.

### 7.5.5 TimelinessAndCompleteness Record

This is defined as follows:

```

TimelinessAndCompleteness ::= RECORD
{
    Timeliness          RECORD
        {
            MaxDelay      REAL,
            MinDelay      REAL,
            MeanDelay     REAL},
    Completeness        RECORD of ARRAY SIZE (1..12) OF RECORD
        {
            PlannedL15ImageLines    UNSIGNED SHORT,
            GeneratedL15ImageLines   UNSIGNED SHORT,
            ValidL15ImageLines      UNSIGNED SHORT,
            DummyL15ImageLines      UNSIGNED SHORT,
            CorruptedL15ImageLines   UNSIGNED SHORT}}
    
```

#### **Timeliness:**

This is a record presenting the following information concerning delay in output of the Level 1.5 image:

**MaxDelay** gives the maximum delay, for the whole image, between 1.5 image output and corresponding 1.0 mean acquisition time in seconds for the whole image.

**MinDelay** gives the minimum delay, for the whole image, between 1.5 image output and corresponding 1.0 mean acquisition time in seconds.

**MeanDelay** gives the mean delay between 1.5 image output and corresponding 1.0 mean acquisition time in seconds.

#### **Completeness:**

This is an array with one element for each channel. For each channel details of the number of missing information between the planned and the actual coverage of Level 1.5 image and number of missing lines within the actual coverage are given.

**PlannedL15ImageLines** gives the planned number of 1.5 image lines for the channel.

**GeneratedL15ImageLines** gives the number of generated 1.5 lines for the channel, i.e. the lines that have actually been produced.

**ValidL15ImageLines** gives the number of 1.5 lines that are indicated as being valid. A line is valid if the **LineValidity** field in the line record indicates nominal.

**DummyL15ImageLines** gives the number of dummy 1.5 image lines that were produced without corresponding Level 1.0 data (e.g. due to the data being missing), in order to fill the Level 1.5 format.

**CorruptedL15ImageLines** gives the number of 1.5 lines generated using corrupted 1.0 data. A 1.5 line will be considered as corrupt if any of the 1.0 lines used to construct it are corrupted.

## APPENDIX A      DECODING OF A FUNCTION IN TERMS OF CHEBYSHEV COEFFICIENTS.

Within the L15 Header stricter, many fields are encoded in terms of Chebyshev coefficients. To reconstruct the function, the following formula can be used.

$$f_s(x) = \sum_{k=1}^n c_k T_{k-1}(t) - \frac{1}{2} c_1$$

where  $c_1$  to  $c_8$  are the supplied coefficients,  $T_{k-1}(t)$  is the Chebyshev polynomial for order  $k-1$

$T_k(t)$  is defined by

$$T_0(t) = 1$$

$$T_1(t) = t$$

$$T_2(t) = 2t^2 - 1$$

$$T_3(t) = 4t^3 - 3t$$

$$T_{n+1}(t) = 2tT_n(t) - T_{n-1}(t) \quad n \geq 1$$

and

$$t = \frac{x - \frac{1}{2}(end\_x + start\_x)}{\frac{1}{2}(end\_x - start\_x)}$$

where  $start\_x$  and  $end\_x$  define the validity interval for the set of Chebyshev coefficients. This can be a date or something else. In fact, the parameter  $t$  only projects the validity interval (time or other) within the real number interval  $[-1,1]$ .

```

; INPUT:
;   A, B: [A,B] defines the interval on wich the chebyshev polynomial is defined
;   C: A vector containing the chebychech polynomial coefficients
;   X: The argument;;

      d      = 0.0d0
      dd     = 0.0d0
      save   = 0.0d0
      t      = 0.0d0
      t2     = 0.0d0
;
      M=N_elements(C) ; find the number of coefficients
;                      ;= the dgree of the polynomial
; calculate the position of the argument x within the interval [A,B]
;
      t=X-0.5*(A+B)/(0.5*(B-A))
      t2=2*t
;
      FOR j=m-1 ,1L,-1L DO BEGIN
          save= d
    
```

```
      d = t2 * d - dd + C[j]
      dd = save
    ENDFOR
  RETURN, t * d - dd + 0.5 * C[0]
```

## APPENDIX B      DECODING OF 2 DIMENSIONAL STRAYLIGHT FIELDS

In case of the straylight distribution, the straylight affecting a single image line  $i$  is expressed in terms of 8 Chebyshev coefficients  $C_i^1 \dots C_i^8$ . As the straylight distribution is two dimensional, these coefficients vary from line to line. To describe the variation of the coefficients, each of the 8 coefficients is encoded by a second, nested level Chebyshev approximation. Hence,

Given the  $8 \times 8$  matrix for a specific channel from the level 1.5 header Radiometric Processing Record:  $c_k^l$ . To obtain the straylight correction for the image line  $i$ , it is first necessary to derive the Chebyshev coefficients  $C_i^l$  for line  $i$ , by the nested Chebyshev interpolation:

$$C_i^1 = \sum_{k=1}^8 c_k^1 T_{k-1}(t) - \frac{1}{2} c_1^1$$

...

$$C_i^8 = \sum_{k=1}^8 c_k^8 T_{k-1}(t) - \frac{1}{2} c_1^8$$

And

$$t = \frac{i - \frac{1}{2}(last\_line + first\_line)}{\frac{1}{2}(last\_line - first\_line)}$$

To calculate the straylight SL on line  $i$  ( i.e. for each pixel  $j$  on line  $i$ ), Chebyshev coefficients  $C_i^1 \dots C_i^8$ , as calculated above, are used:

$$SL(i, j) = \sum_{l=1}^8 C_i^l T_{l-1}(s) - \frac{1}{2} C_i^1$$

using

$$s = \frac{j - \frac{1}{2}(last\_pix + first\_pix)}{\frac{1}{2}(last\_pix - first\_pix)}$$

For the encoding of the data, the following parameters are used:

```

first_pix   :1
last_pix    :3834
first_line  :
115header.IMAGEACQUISITION.RADIOMETERSETTING.SCANFirstLINE * 3 -3
    
```

last\_line :  
 115header.IMAGEACQUISITION.RADIOMETERSETTING.SCANLastLINE \* 3 -3

(For IR39 channel, where currently straylight correction is applied)

The following pseudo code illustrates the decoding:

```

;
; INPUT from L15 header
;
straylightcoeffs= $
    L15header.RADIOMETERPROCESSING.MTFADAPTION.STRAYLIGHTCORRECTION[*,* ,channel]
first_NonHRV_detline= $
    115header.IMAGEACQUISITION.RADIOMETERSETTING.SCANFirstLINE * 3
last_NonHRV_detline= $
    115header.IMAGEACQUISITION.RADIOMETERSETTING.SCANLastLINE * 3

    first_NonHRV_pix = 1L
    last_NonHRV_pix = 3834L

; OUTPUT
; this is the actual straylight correction field for each pixel
straylight_array =dblarr(last_NonHRV_pix-first_NonHRV_pix+1 $
    ,last_NonHRV_detline-first_NonHRV_detline+1)
;
;
; for each line i find the relevant Chebychev coefficients Cl,j
; FOR i=first_SLNonHRV_detline, last_SLNonHRV_detline DO BEGIN
;
    coeffs_for_this_line_Clj=dblarr(8)
    FOR l=0,7 DO BEGIN
;        Chebychev interpolation at position i to get the coefficients of the line

        coeffs_for_this_line_Clj(l)= $
            MSG_CHEBYSHEV(first_NonHRV_detline), $
                last_NonHRV_detline), $
                straylightcoeffs[l,*], $
                i)

    END
;
; having obtained the coefficients, we now can obtain the straylight
; correction for each pixel
;
    FOR j=first_NonHRV_pix, last_NonHRV_pix DO BEGIN
        straylight_array[j-1,i-1]= $
            MSG_CHEBYSHEV(first_NonHRV_pix, $
                last_NonHRV_pix $,
                coeffs_for_this_line, $
                j)

    END; j for columns
END ; i for lines
    
```

**APPENDIX C            LEVEL 1.0 CO-ORDINATE FRAME (10CF)**

The level 1.0 co-ordinate frame is defined in terms of detector samples and is orientated in the order of scan. It is referenced to a notional detector at the telescope focal point and is expressed in terms of 3 km pixels. There are considered to be three detectors on the focal plane with the same East-West position but displaced North-South with a single 3 km pixel spacing. The frame is defined at the beginning of each repeat cycle and assumes spin rate is constant at that applying at the start of the repeat cycle, and that there is no jitter. The North South datum is the first detector of the first scan line of the Repeat Cycle. East West each line is defined so that the centre point of the line corresponds to the instant when a plane containing the MSF Y and Z axis intersects the Earth ellipsoid centre.

The datum pixel is then the first sample of the most southerly detector for the first scan line of the image. East-West pixels are in the order within one scan line. The next line North-South consists of samples from the middle detector of the same scan line, than for the northerly detector. The next 3 lines are for the next scan line North, etc.