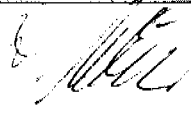

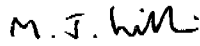
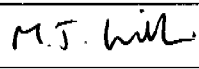


MSG Level 1.5 Image Product - Quality Indicators

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1 INTRODUCTION

1.1 Purpose and Scope

The MSG Level 1.5 Image Product consists of the Level 1.5 Header, the Level 1.5 Image, and the Level 1.5 Trailer. The Level 1.5 Image consists of a set of Level 1.5 Image Lines. Each Level 1.5 Image Line consists of Line Side Information and Line Data. The format of the Level 1.5 Image Product is described in detail in the MSG Level 1.5 Image Data Format Description document [RD 1].

The MSG Level 1.5 Image Product contains numerous image quality indicators. These indicators provide information on the completeness, geometric quality, radiometric quality, and timeliness of the Level 1.5 Image Product, as well as information on the quality and completeness of the Level 1.0 Image from which the Level 1.5 Image Product was derived.

The purpose of this technical note is to provide the user with an overview of the image quality information that is available in the Level 1.5 Image Product. It should be read together with [RD 1], which provides detailed information on the quality indicators.

The Level 1.5 Image Product contains quality indicators on two levels:

1. In the Level 1.5 Trailer. These quality indicators apply to the complete Level 1.5 Image. By definition, these indicators are only available after the Level 1.5 Image Product generation has been completed. Hence, they are provided in the Level 1.5 Trailer, which is part of the HRIT/LRIT epilogue [RD 3].
2. In the Line Side Information of the Level 1.5 Image Lines. Since these quality indicators are provided for each Level 1.5 Image Line, the user can accept or reject Level 1.5 Image data on a line-by-line basis.

Both the Level 1.5 Trailer and the Level 1.5 Image Line quality indicators are provided per channel.

Note that the image quality requirements are provided in [RD 2] and are not always repeated here.

The most useful quality indicators in the Level 1.5 Trailer and the Level 1.5 Image Lines are described in the following sections.

2 REFERENCE DOCUMENTS

- [RD 1] MSG Level 1.5 Image Data Format Description, EUM/MSG/ICD/105, Issue 3, 04/02/2005.
- [RD 2] MSG End-User Requirements Document, EUM/MSG/SPE/013, Issue 2.6, 24/5/2004.
- [RD 3] MSG Ground Segment LRIT/HRIT Mission Specific Implementation, EUM/MSG/SPE/057, Issue 5, 04/02/2005.

3 THE LEVEL 1.5 TRAILER

The Level 1.5 Trailer is the primary source of Level 1.5 image quality information. The Trailer structure and content is described in detail in [RD 1] and is summarised in Figure 1 below.

Trailer	Trailer Records	Trailer Sub-records	
LEVEL 1.5 TRAILER	15TRAILERVersion	<i>Not further decomposed</i>	
	IMAGE PRODUCTION STATS	SatelliteId	
		ActualScanningSummary	
		RadiometerBehaviour	
		ReceptionSummaryStats	
		L15ImageValidity	
		ActualL15CoverageVIS_IR	
		ActualL15CoverageHRV	
	NAVIGATION EXTRACTION RESULTS	ExtractedHorizons	
		ExtractedStars	
		ExtractedLandmarks	
	RADIOMETRIC QUALITY	L10RadQuality	
		L15RadQuality	
	GEOMETRIC QUALITY	AbsoluteAccuracy	
		RelativeAccuracy	
		500PixelsrelativeAccuracy	
		16PixelsRelativeAccuracy	
		MisregistrationResiduals	
		GeometricQualityStatus	
	TIMELINESS AND COMPLETENESS	Timeliness	
		Completeness	

Figure 1 - Structure of the Level 1.5 Trailer

The Level 1.5 image quality information in the Trailer is in the **Image Production Stats** record, the **Radiometric Quality** record, the **Geometric Quality** record and the **Timeliness and Completeness** record (see Figure 1).

The most important Level 1.5 image quality information in the Trailer is in the **L15ImageValidity** sub-record (see Section 3.1.1) of the **Image Production Stats** record (see Figure 1).

3.1 The Image Production Stats Record

The **Image Production Stats** record primarily contains information relating to the SEVIRI image taking. The detailed structure and content of the **Image Production Stats** record is described in [RD 1]. Only the **L15ImageValidity** sub-record is described here since this contains the most important Level 1.5 image quality information in the **Image Production Stats** record (and in the Level 1.5 Trailer overall).

Users needing detailed quality information may also be interested in the **ReceptionSummaryStats**, **Actual_L15CoverageVIS_IR** and **Actual_L15CoverageHRV** sub-records of the **Image Production Stats** record. The interested user is referred to [RD 1].

3.1.1 The Level 1.5 Image Validity Sub-record

The **L15ImageValidity** sub-record consists of 6 flags per channel. The meaning and use of these flags is described below.

3.1.1.1 The Nominal Image Flag

The *NominalImage* flag indicates whether the Level 1.5 image is of nominal quality. TRUE indicates nominal. *NominalImage* is set to TRUE if the following 5 flags are all set to FALSE.

3.1.1.2 The Non Nominal Because Incomplete Flag

The *NonNominalBecauseIncomplete* flag indicates whether the Level 1.5 image quality is non-nominal due to it being incomplete. TRUE indicates non-nominal. *NonNominalBecauseIncomplete* is set to TRUE if the Level 1.0 image from which the Level 1.5 image is derived is incomplete.

A Level 1.0 image is considered to be incomplete if [RD 2]:

1. It has 18 (54 for HRV) or more missing or corrupted detector lines for any spectral channel or
2. It has 12 (36 for HRV) or more consecutive missing or corrupted detector lines for any spectral channel.

Note that when deriving the number of missing or corrupt lines, only those Level 1.0 lines that are required to generate the (masked) Level 1.5 image are considered.

This flag should not be confused with the *IncompleteL15* flag, which is described in Section 3.1.1.6.

3.1.1.3 The Non Nominal Radiometric Quality Flag

The *NonNominalRadiometricQuality* flag indicates whether the Level 1.5 image quality is non-nominal due to it having bad radiometric quality. TRUE indicates non-nominal. *NonNominalRadiometricQuality* is set to TRUE if any of the Level 1.5 radiometric quality statistics is outside the defined limits. Currently only the 2nd order entropy over the Earth disk is checked. Further tests are planned.

NonNominalRadiometricQuality is also set to TRUE if the calibration is inaccurate, e.g. as it will be in the period between a re-initialisation of the IMPF and the first full blackbody calibration.

3.1.1.4 The Non Nominal Geometric Quality Flag

The *NonNominalGeometricQuality* flag indicates whether the Level 1.5 image quality is non-nominal due to it having bad geometric quality. TRUE indicates non-nominal. *NonNominalGeometricQuality* is set to TRUE if any of the Geometric Quality statistics for the channel (see Section 3.3) is larger than the nominal threshold (see [RD 2]).

3.1.1.5 The Non Nominal Timeliness Flag

The *NonNominalTimeliness* flag indicates whether the Level 1.5 image quality is non-nominal due to the late availability of the data. TRUE indicates non-nominal.

3.1.1.6 The Incomplete Level 1.5 Flag

The *IncompleteL15* flag indicates whether the Level 1.5 image is non-nominal due to it not being completely produced. TRUE indicates non-nominal. *IncompleteL15* is set to TRUE if the generated Level 1.5 image is truncated.

This flag should not to be confused with the *NonNominalBecauseIncomplete* flag described in Section 3.1.1.2.

3.1.1.7 Summary

To summarise:

- The *NominalImage* flag enables the user to determine if an image is of nominal quality.
- If an image is flagged as non-nominal then the:
 - ◊ *NonNominalBecauseIncomplete*
 - ◊ *NonNominalRadiometricQuality*
 - ◊ *NonNominalGeometricQuality*
 - ◊ *NonNominalTimeliness* and
 - ◊ *IncompleteL15*

flags enable the user to determine the type of anomaly that led to the non-nominal quality assessment.

For most users, the **L15ImageValidity** flags are the only ones that need to be checked.

3.2 The Radiometric Quality Record

The **Radiometric Quality** record contains radiometric statistics for the Level 1.0 and Level 1.5 images. The detailed structure and content of the **Radiometric Quality** record is described in [RD 1]. Since the **Radiometric Quality** record contains image statistics rather than image quality flags, the information in this record cannot be easily used to assess the Level 1.5 radiometric quality. The contents of this record are therefore not further described here. The interested user is referred to [RD 1].

Note that the *NonNominalRadiometricQuality* flag in the **L15ImageValidity** sub-record of the **Image Production Stats** record (see Section 3.1.1.3) provides the most direct means to assess the Level 1.5 radiometric quality. The **Radiometric Quality** record is only of interest to those users needing detailed radiometric quality information.

3.3 The Geometric Quality Record

The **Geometric Quality** record contains Level 1.5 geometric quality statistics. The detailed structure and content of the **Geometric Quality** record is described in detail in [RD 1] and is summarised in Figure 2 below.

GeometricQuality ::= RECORD	
{AbsoluteAccuracy	ARRAY SIZE (1..12) OF RECORD
RelativeAccuracy	ARRAY SIZE (1..12) OF RECORD
500PixelsRelativeAccuracy	ARRAY SIZE (1..12) OF RECORD
16PixelsRelativeAccuracy	ARRAY SIZE (1..12) OF RECORD
MisregistrationResiduals	ARRAY SIZE (1..12) OF RECORD
GeometricQualityStatus	ARRAY SIZE (1..12) OF RECORD
}	

Figure 2 - Structure of the Geometric Quality Record in the Level 1.5 Trailer

Note that the *NonNominalGeometricQuality* flag in the **L15ImageValidity** sub-record of the **Image Production Stats** record (see Section 3.1.1.4) provides the most direct means to assess the Level 1.5 geometric quality. The **Geometric Quality** record is only of interest to those users needing detailed geometric quality information. The interested user is referred to [RD 1].

3.4 The Timeliness and Completeness Record

The **Timeliness and Completeness** record contains timeliness and completeness statistics for the Level 1.5 images. The **Timeliness and Completeness** record structure and content is described in detail in [RD 1] and is summarised in Figure 3 below.

```
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}
}
```

Figure 3 - Structure of the Timeliness and Completeness Record in the Level 1.5 Trailer

Note that the *NonNominalBecauseIncomplete*, *NonNominalTimeliness* and *IncompleteL15* flags in the **L15ImageValidity** sub-record of the **Image Production Stats** record (see Sections 3.1.1.2, 3.1.1.5 and 3.1.1.6) provide the most direct means to assess the Level 1.5 timeliness and completeness. The **Timeliness and Completeness** record is only of interest to those users needing detailed timeliness and completeness information. The contents of this record are therefore not further described here. The interested user is referred to [RD 1].

4 THE LEVEL 1.5 IMAGE LINE

The Level 1.5 image quality information provided in the Level 1.5 Trailer applies to the complete Level 1.5 Image. However, each Level 1.5 Image Line contains quality information specific to that line. This information is created during the Level 1.5 Image generation process and allows the user to accept or reject Level 1.5 Image data on a line-by-line basis. The Level 1.5 Image Line record structure and content is described in detail in [RD 1] and is summarised, for the non-HRV channels, in Figure 4 below. The structure for the HRV channel is similar.

The quality information in the Level 1.5 Image Line is stored in the **LineSideInfo** sub-record of the Level 1.5 Image Line record (see Figure 4). **LineSideInfo** contains enumerated bytes that indicate the *LineValidity*, *LineRadiometricQuality* and *LineGeometricQuality*.

15VIS/IRLINE::=RECORD	
{15VIS/IRLINEVersion	UNSIGNED BYTE (0),
LineSideInfo	RECORD
{SatelliteId	GP_SC_ID,
TrueRepeatCycleStart	TIME CDS EXPANDED,
LineNumberInVIS_IRGrid	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..3712) OF UNSIGNED (10)}

Figure 4 - Structure of the Level 1.5 Image Line

4.1 Line Validity

Each Level 1.0 image line is made up of a "packet" (or several packets in case of HRV) that is in turn made of several "frames" which can be lost or corrupted during the data transmission from the spacecraft to the IMPF. Missing or corrupted data is "blanked" out, i.e. replaced by zeros. If a single, or part of a single, Level 1.0 image line is blank, then the blank data is replaced by interpolated data. If interpolation is not possible, the data is left blank.

LineValidity is set according to the origin of the Level 1.0 data for each pixel that makes up the Level 1.5 Image Line. The possible values for the *LineValidity* indicator are listed in Figure 4. Note that the setting "Based on corrupted data" is not used because corrupted data is blanked in the same manner as missing data and so there is no difference between missing and corrupted data in practice.

The distortions in the Level 1.0 image mean that any Level 1.0 image line (and hence any damaged¹ line) will contribute to several lines in the Level 1.5 image. Moreover, the spatial filter used for resampling "smears" any damaged pixels across the Level 1.5 image. Hence a single damaged Level 1.0 image line will lead to multiple Level 1.5 image lines with *LineValidity* set to a non-nominal value.

4.2 Line Radiometric Quality

Interpolators can misplace energy amongst adjacent pixels. If the resampling kernel for a Level 1.5 image pixel intersects damaged data this can lead to the corresponding Level 1.5 image line having a non-nominal radiometric quality. The *LineRadiometricQuality* is therefore set so that it reflects the impact of damaged Level 1.0 data on the radiometric quality of the corresponding Level 1.5 image line. The possible values for the *LineRadiometricQuality* indicator are listed in Figure 4.

The relationship between the settings of the *LineValidity* and *LineRadiometricQuality* indicators and the location of the damaged data relative to the centre of the resampling kernel for the Level 1.5 image line is illustrated in see Table 1.

¹ Damaged means based on missing or interpolated data.

Location of damaged data relative to the centre of the resampling kernel for the Level 1.5 image line	Line Validity	Line Radiometric Quality
Missing (and not interpolated) data intersects current Level 1.5 line	Based on missing data	Do not use
Missing (and not interpolated) data passes within ½ kernel length of current Level 1.5 line	Based on missing data	Suspect
Interpolated data intersects current Level 1.5 line	Based on replaced or interpolated data	Suspect
Interpolated data passes within ½ kernel length of current Level 1.5 line	Based on replaced or interpolated data	Usable
Not one of the above	Nominal	Nominal

Table 1 LineValidity and LineRadiometricQuality

4.3 Line Geometric Quality

Although a *LineGeometricQuality* indicator was originally foreseen, it is not used in the current system and *LineGeometricQuality* is always set to "Not Derived".

For completeness, the foreseen values for the *LineGeometricQuality* indicator are listed in Figure 4.

5 SUMMARY

The MSG Level 1.5 Image Product contains numerous image quality indicators. These indicators provide information on the completeness, geometric quality, radiometric quality, and timeliness of delivery of the Level 1.5 Image Product, as well as information on the quality and completeness of the Level 1.0 Image from which the Level 1.5 Image Product was derived.

The Level 1.5 Image Product contains quality indicators on two levels:

1. In the Level 1.5 Trailer. These quality indicators apply to the complete Level 1.5 Image.
2. In the Line Side Information of the Level 1.5 Image Lines. These quality indicators apply to a specific Level 1.5 Image Line and allow the user to accept or reject Level 1.5 Image data on a line-by-line basis.

Users that only wish to know if an image is of nominal quality need only examine the *NominalImage* flag that is provided (per channel) in the **L15ImageValidy** sub-record of the **Image Production Stats** record of the Level 1.5 Trailer.