KOMPSAT At Your Service

KOMPSAT-5 Image Data Manual

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1. SAR INSTRUMENT OVERVIEW

The KOMPSAT-5 SAR payload includes X-band Synthetic Aperture Radar with a fixed antenna capable of electronic steering both in the azimuth and the elevation planes.

The elevation steering capabilities, allows defining an access region spanning approximately from 18.3° up to 49.0° in terms of the corresponding off-nadir angle (20° - 55° incidence angle @ 550 Km). Such range includes one nominal access spanning approximately from 18.3° up to 40.6° in terms of the corresponding off-nadir angle (20° - 45° incidence angle @ 550 Km) in which nominal performance are granted.

The SAR is designed to implement different types of Image Operation Mode that are briefly detailed in the following paragraphs.
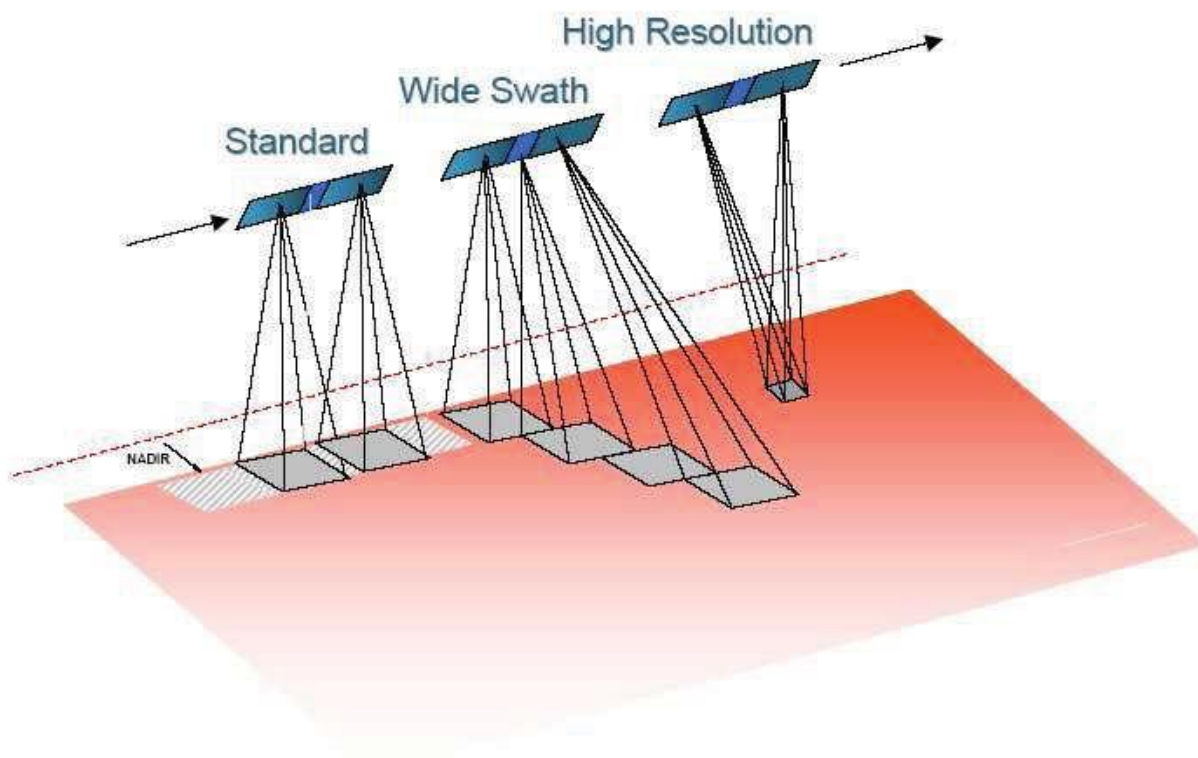
Figure 1-1 Measurement Mode

1.1 High Resolution Mode

In this imaging mode the antenna is steered (in the azimuth plane) during the overall acquisition time in order to illuminate the required scene for a time period longer than the one of the standard strip side view. This increases the length of the synthetic antenna and therefore the azimuth resolution. Such improvement of the radar performance is paid by a loss of azimuth coverage.

For the achievement of a range resolution comparable with the azimuth one, a chirp bandwidth less than or equal to 240 MHz is requested hence, implying the need of de-chirping of the received echo in order to reduce the downlink data rate.

In such configuration the acquisition is limited in the azimuth direction due to the technical constraints deriving from the azimuth antenna pointing.

In High Resolution mode, the spot extension is achieved by a steering scheme, which requires the centre of the beam steering to be located beyond the centre of the imaged spot.

The electronic steering scheme, allows increasing the observed Doppler bandwidth for each target, though the instantaneous footprint is however interested by a sliding effect in the azimuth direction.

Various instrument parameter configurations have been defined depending on the access region as function of the off-nadir angle. The current design can be summarised as:

- The maximum number of beams for covering both the nominal and extended access region is 31

In the following a brief summary of the main imaging characteristics of the High Resolution Mode is given.

- The azimuth frame extension is   5 Km
- The range swath extension is   5 Km
- The ground sample distance at 1 Look ranges from 1 to 3 m
- The PRF values ranges from a minimum of 3100 Hz to a maximum of 4500 Hz
- The allowed chirp duration depending on specific access area ranges from 40 to 80 microseconds
- The chirp bandwidth is accommodated along range on the basis of the required ground resolution and ranges from 50 MHz to 240 MHz
- Due to the de-ramping processing, the sampling frequency ranges from 30 to 120 MHz

1.2 Standard Mode

This is the most common imaging mode. It is obtained by pointing the antenna along a fixed direction with respect to the flight platform path. The antenna footprint covers a strip on the illuminated surfaces as the platform moves and the system operates.

In such configuration the acquisition is performed on a continuous strip on the ground, hence it is virtually unlimited in the azimuth direction, but the current maximum SAR instrument duty cycle is 120 s.

In this mode the radar Tx/Rx configurations are time invariant, allowing receiving from each ground scatterer the full Doppler bandwidth allowed by the azimuth aperture of the antenna beamwidth.

Various instrument parameter configurations have been defined depending on the access region as function of the off-nadir angle. The current design can be summarised as:

- The maximum number of beams for covering both the nominal and extended access region is 19

In the following a brief summary of the main imaging characteristics of the Standard Mode is **given**.

- The swath width value ranges from 23 to 37 Km
- The azimuth extension ranges from 23 to 37 Km (for a standard product)
- The ground sample distance at 1 Look ranges from 2.5 to 10 m in range and from 2.5 to 4 m in azimuth
- The PRF values ranges from a minimum of 3100 Hz to a maximum of 4500 Hz
- The allowed chirp duration depending on specific access area ranges from 25 to 50 microseconds
- The chirp bandwidth is accommodated along range on the basis of the required ground resolution and ranges from 30 MHz to 120 MHz

1.3 Wide Swath Mode

This imaging mode allows larger swath in range with respect to the Standard one, but with a less spatial resolution. Larger range swaths are obtained by periodically stepping the antenna beam to neighbouring sub-swaths.
In this mode only a part of the synthetic antenna length is available in azimuth and consequently the azimuth resolution is reduced.
In such configuration the acquisition is performed in adjacent strip mode, hence it is virtually unlimited in the azimuth direction.
In the Wide Swath Mode, some elementary beams have been defined depending on the selected PRF ambiguity number and the acquisition incidence angle. Each configuration represents one of the subswaths that properly combined will cover the required total ground swath.

The main imaging characteristics of the single beams of the Wide Swath mode are given below.
Various instrument parameter configurations have been defined depending on the access region as function of the off-nadir angle.

- Maximum number of sub-swaths sets: 5
- Maximum number of sub-swaths per set: 4
- Maximum number of beams for covering both the nominal and extended access region: 19

Wide Swath mode, grouping acquisition over up to four adjacent subswaths, allows achieving total swath width between 90 and 120 Km in the nominal access region and a ground sample distance at 1 Look between 15 and 30 meters.

In the following a brief summary of the main imaging characteristics of the Wide Swath is given.
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- The chirp duration for the Wide Swath Mode ranges from 25 to 40 microseconds.
- The chirp bandwidth is accommodated along range on the basis of the required ground resolution and ranges from 9 MHz to 30 MHz
- The PRF values ranges from a minimum of 3100 Hz to a maximum of 4500 Hz

2. PROCESSING LEVELS OVERVIEW

SAR Standard product consists of SAR signal data or SAR image (originated by standard processing of the signal data) distributed on magnetic, optical or electronic media.

The standard processing of the KOMPSAT-5 SAR data has been thought to be as much as possible aligned with the definition deriving from literature.
If some alternative approach has been in some case adopted for the product specification, it has been however oriented to add value to the output data, preserving in any case the possibility for the final user to remove the effects of the additional non-standard processing applied to the data. Implementation of such policy will be better detailed in the following sections.

KOMPSAT-5 products may be classified according to the following basic features:

- instrument mode
- instrument configuration to be appropriately selected within each mode according to the desired access area and acquisition technical constraints
- the level of processing that has been applied to the data.

The KOMPSAT-5 SAR processors implement five levels of standard processing (from 0 up to level 1D), which a specific output product corresponds to. More than one product can correspond to each processing level:

- a product obtained by a basic processing will be in the following referred with the suffix <B>;
- additionally, one or more products obtained by special processing can be considered, applying "non-standard" (from the point of view of the literature definition) operators for the product generation; such special processing will be indicated with a their own suffix.

If the suffix is omitted, all products of the specific processing level have to be understood.

The following table summarizes the feature of the KOMPSAT-5 SAR Standard Products, which can be considered applicable independently on the instrument mode:

Proc. Lev.	Code	Sample Information	Projection
0	RAW_B	In-Phase and Quadrature of the echoed data with annexed Noise and Periodic Calibration measurements	N/A Time ordering organization within pulse and between pulses
1A	SCS_B	In-Phase and Quadrature focused data, weighted and radiometrically equalized vs. slant range losses	Slant Range / Azimuth (Zero-Doppler)

	SCS_U	In-Phase and Quadrature focuded data, unweighted and radiometrically equalized vs. slant range losses	Slant Range / Azimuth (Zero-Doppler)	
1B	DSM_U	Amplitude of the focused data, multilooked (but for HR mode)	Slant Range / Azimuth (Zero-Doppler)	
	DSM_E	Amplitude of the focused data, multilooked (but for HR mode) and radiometrically equalized	Slant Range / Azimuth (Zero-Doppler)	
	DGM_B	Amplitude of the focused data, multilooked (but for High Resolution Mode)	Ground Range (WGS84 Ellipsoid) / Azimuth (Zero-Doppler)	
1C	GEC_B	Amplitude of the focused data, multilooked (but for High Resolution Mode)	UTM (-80° ≤ center latitude ≤ 84°) UPS (otherwise)	
1D	GTC_B	Backscattering coefficient of the observed scene, multilooked (but for High Resolution Mode), with annexed the Incidence Angles Mask	UTM (-80° ≤ center latitude ≤ 84°) UPS (otherwise)	

Table 2-1 List of SAR Standard Products

The following table summarizes the data types to be used for storage of the data layers of the KOMPSAT-5 SAR Standard Products, independently on the SAR operation mode.

Product	Dataset	Sample Format	Bits per Sample	Samples per Pixel	Type Represent.	Invalid Value
RAW_B	Echo Data	Unsigned Integer	8	2		[0, 0]
	Noise Data	Unsigned Integer	8	2		[0, 0]
	Cal Data	Unsigned Integer	8	2		[0, 0]
	Replica	Floating Point	32	2	Little Endian	QNaN
SCS_B SCS_U	Focused data	Signed Integer	16	2	Little Endian	[0, 0]
DSM_U DSM_E	Signal Amplitude	Floating Point	32	1	Little Endian	0
DGM_B	Signal Amplitude	Unsigned Integer	16	1	Little Endian	0

GEC_B	Signal Amplitude	Unsigned Integer	16	1	Little Endian	0
GTC_B	Backscattering coefficient	Unsigned Integer	16	1	Little Endian	0
	Incidence angle	Signed Integer	16	1	Little Endian	+32767

Table 2-2 Data types for SAR Standard Products

Peculiarities of processing levels, independently on the instrument mode are given in the following sections.

2.1 Processing Level 0

2.1.1 RAW_B Product

The RAW product contains for each sensor acquisition mode the unpacked echo data in complex in-phase and quadrature signal (I and Q) format.
It is originated starting from the following input data:

- SAR Level 0 data file
- Satellite auxiliary data
- Orbital, attitude and pointing data (only for generation of attributes)

The only processing performed to the downlinked X-band raw signal data is:

- the frame synchronization at byte level, which consists in the analysis within the CCSDS data array stream in order to find out the SYNC pattern (synchronization 16 bit word) and supplementary secondary header constant bit fields. This allows the further CCSDS packet structure extraction
- removal of the data overstructure due to the CCSDS on-board to ground transmission protocol
- data decompression in the case the BAQ algorithm has been used on board to pack the data in order to reduce the downlink rate
- re-assembly of the Packet Data Field into contiguous radar range lines in increasing time order (duplicated range lines are discarded), by zero filling of the missing echo lines or missing echo blocks
- evaluation of statistics on the RAW data
- data formatting into the output format.

The RAW product includes data acquired in each single Instrument Mode, depending on the operation of the SAR instrument during the data reception or recording period.
A RAW product will not ever combine data from more than one Instrument Mode, which are always packaged as two separate products.
A RAW product must be SAR processed before it can be displayed as imagery.

The Level 0 product include a set of annotations, which detail its features in terms of:

- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localization info
- Raw data quality statistical parameters

It's worth stating that parameters for the internal calibration of the RAW data (that is the channels' bias, imbalance and non-orthogonality) are evaluated but not applied, in order to leave the data unchanged as much as possible.

Finally the product includes the QLK dataset which represent a raw data quick look (e.g. a down-sampled detected raw data array).

2.2 Processing Level 1A

2.2.1 SCS_B Product

The SCS product contains for each sensor acquisition mode the focused data in complex format, in slant range and zero doppler projection.

The basic processing features characterizing the SCS_B product are:
- compensation of the transmitter gain and receiver attenuation
- internal calibration on the RAW data in terms of:
  - unbiasing
  - compensation of gain imbalance
  - compensation of non-orthogonality of I and Q channels
- the data focusing according to algorithm depending on the specific instrument
- weighted processing is performed with application of cosine-like windowing, so obtaining the maximum performances of the IRF features in terms of PSLR, ISLR, SSLR to the detriment of spatial resolution;
- radiometric equalization of the complex image in terms of:
  - compensation of the range spreading loss
  - rescaling with respect to a reference slant range in order to not alter the dynamic of the output product

Data are processed at full range and azimuth resolution; hence any multilook processing isn't applied.

Concerning with the radiometric equalization of the single-look products, though it is considered on optional step and is explicitly to be avoided by some literature at the processing Level 1A, it has been taken into consideration in order to distribute to the users community a class of products having minimised the mis-calibration (both within scene and across swaths) originated by the SAR geometry acquisition. Moreover, to preserve the reversibility of the equalization process, an approach based on the use of a mathematical reference surface such as the ellipsoid has been selected for the compensation of the incidence angle and for the estimation and application of the range antenna pattern.
Therefore, enhanced processing based on the usage of DEM for the compensation of the incidence angle has been considered out of scope of this processing level.
This choice also derives from the considerations that usage of DEM for radiometric correction at standard processing level can introduce worsening effects on image calibration under the following conditions:
- if the DEM accuracy were of poor quality
- if problems on POD module occurred, due to on-board instruments or to data post-processing
- if the SAR image were affected by a not compensated time shift (both slow and fast time) that imply a wrong product localization on ground

- if a failure in the Doppler estimation occurred, hence implying a wrong product localization on ground

It's worth stating that the value of the calibration constant that allows converting the information of the image sample to backscattering coefficient is appended to the distributed product but not applied to it, considering this step as matter of backscattering product origination. For that reason, the product performances listed in sections 6 (Output Format Description) that strictly depends on the measure on the image of the backscattering coefficients (radiometric accuracy, radiometric linearity, radiometric stability, local radiometric stability), have to be considered valid supposing that the quality control procedure take care of the application on the examined image of the annotated calibration constant.

The SCS product will include a set of attributes, which detail its features in terms of:
- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localisation info
- Processing parameters
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)

Additional considerations depending on the instrument mode need to be done

High Resolution
It's worth stating that:
- considering SAR instrument nominal parameters, portion of data will be discarded, always corresponds to degraded resolution ground area
- cutting of image columns on the range pre-processed data, will be equi-distributed at the near and the far edge of the image (under the assumption that the reference time for the de-ramping signal is centered on the range sampling window of the downlinked data)

The processor will generate useful ground range coverage in the range 3.5 ÷ 5.5 Km.
This product feature is applicable to all L1 products originated from High Resolution data.

Wide Swath mode
In the case of data acquired in Wide Swath mode the SCS product is formed by the mosaicking in the azimuth direction of the focused bursts belonging to the same subswath after the compensation in each burst of the azimuth antenna pattern in order to avoid scalloping effects.

As the available Doppler bandwidth in Wide Swath data is much smaller than PRF (hence, originating a natural spacing much higher than the azimuth resolution), in order to reduce the processing time and the product size, the focusing process is performed on an output grid that in the azimuth direction, is undersampled (w.r.t the nominal line time interval) according to a factor that is defined in compliance with the Nyquist sampling limit, hence preserving the product resolution performances.

Though different beams use different PRFs, all focused subswaths, due to the azimuth undersampling approach detailed above, will adopt the same line time interval and maintaining the line spacing approximately constant. On the contrary, each subswath uses its own natural time column interval deriving from the specific sampling rate of the beam.

This processing and distribution approach:

- it represents a compromise between the conservative approach to be guaranteed on the processing level 1A (at the base of the preservation of the natural range sampling rate) and the needs of reduction of data size and processing time (at the base of the choice of azimuth undersampling)

- it tricks the problem of beams boundary equalisation that could represent a criticality on the complex data if the phase must be leaved unchanged

- it avoids the data volume increasing, due to data oversampling to the highest sampling frequency in the range direction

- it derives from the SAR payload operative mode, in particular it provides a single azimuth look for each subswath

2.2.2 SCS_U Product

An optional processing of Level 1A can be requested, differing from that one of the SCS_B product because of an unweighted processing is performed, that is any windowing isn't applied on the processed bandwidth.

This processing level is thought to originate, by an approach as much conservative as possible, the focused representation of the raw signal echoed by the observed scene, in order to not change the data for higher processing levels.

For that reason, an unweighted processing is performed on raw data, so obtaining the maximum performances in terms of spatial resolution to the detriment of the IRF features (in terms of PSLR, ISLR, SSLR).

For the same reason, any radiometric calibration (with the exception of the range spreading loss) isn't applied during the processing, postponing this step to optional or higher processing levels.

2.3 Processing Level 1B

2.3.1 DSM_U Product

The Detected Slant Multilook Un-equalized (DSM_U) product contains for each sensor acquisition mode the focused data detected, in slant range and zero doppler projection.

The basic processing features characterizing the DSM_U product are:

- the same ones previously detailed for the generation of the SCS_B product, but suppressing the weighting of the processed bandwidth
- multilooking processing with weighted processing on each look, oriented to reduce the speckle on the image; if necessary, oversampling interpolation is performed to prevent problems deriving from band enlargement due to detection operation. [It should be noted that the SAR Payload performance specified in the "Technical Appendix to Terms & Conditions of KOMPSAT-5 SAR Payload System" are provided at 1 Look, hence, in case the multilooking processing functionality is applied, the relevant degradation of resolution will be accepted].

The product will include a set of annotations, which detail its features in terms of:

- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localisation info
- Processing parameters (including that ones specific to multilooking)
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)

Additional considerations depending on the instrument mode need to be done

High Resolution mode

In the case of data acquired in High Resolution mode the multilooking step is not foreseen as resolution is the distinguishing feature of this mode
In order to realize the full radiometric equalization, HR processor includes also the compensation of the Azimuth radiometric signature on the sensed area.

Wide Swath mode

In the case of data acquired in Wide Swath mode, the DSM_U product is obtained by the mosaicking both in range and azimuth direction of the processed bursts.

2.3.2 DSM_E Product

The Detected Slant Multilook Equalized (DSM_E) product contains for each sensor acquisition mode the focused data, detected and radiometrically equalized, in slant range and zero doppler projection.

The basic processing features characterizing the DSM_E product are:

- the same ones previously detailed for the generation of the DSM_U product
- radiometric equalization of the complex image in terms of:
  - compensation of the range antenna pattern, with off-nadir angles estimated on the ellipsoid in the Zero Doppler geometry
  - compensation of the incidence angle estimated on the ellipsoid in the Zero Doppler geometry
  - rescaling with respect to a reference incidence angle in order to not alter the dynamic of the output product

The product will include a set of annotations, which detail its features in terms of:

- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localisation info
- Processing parameters (including that ones specific to multilooking)
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)

Additional considerations depending on the instrument mode need to be done

High Resolution mode

In the case of data acquired in High Resolution mode the multilooking step is not foreseen as resolution is the distinguishing feature of this mode.
In order to realize the full radiometric equalization, HR processor includes also the compensation of the Azimuth radiometric signature on the sensed area.

Wide Swath mode

In the case of data acquired in Wide Swath mode, the DSM_E product is obtained by the mosaicking both in range and azimuth direction of the processed bursts. For this reason, in order to minimize the beam boundary effects, for this class of products the calibration constant is applied to all subswaths composing the SAR image.

2.3.3 DGM_B Product

The DGM_B product contains for each sensor acquisition mode focused data, detected, radiometrically equalized, in ground range and zero doppler projection.

The basic processing features characterizing the DGM_B product are:
- the same ones previously detailed for the generation of the DSM_E product
- the slant to ground projection on the WGS84 ellipsoid

The product includes a set of annotations, which detail its features in terms of:
- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localisation info
- Processing parameters (including that ones specific to multilooking and ground projection)
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)

Additional considerations depending on the instrument mode need to be done

High Resolution mode

In the case of data acquired in High Resolution mode the multilooking step is not foreseen as resolution is the distinguishing feature of this mode.
In order to realize the full radiometric equalization, HR processor includes also the compensation of the Azimuth radiometric signature on the sensed area.

Wide Swath mode

In the case of data acquired in Wide Swath mode, the DGM product is obtained by the mosaicking both in range and azimuth direction of the processed bursts. For this reason, in order to minimize the beam boundary effects, for this class of products the calibration constant is applied to all subswaths composing the SAR image.

2.4 Processing Level 1C

2.4.1 GEC_B Product

The GEC product contains for each sensor acquisition mode the focused data, detected, geolocated on the reference ellipsoid and represented in cartographic projection (UTM or UPS depending on the Scene Center). Any geometric or radiometric correction derived by usage of terrain model isn't applied to this product.

The basic processing features characterizing the GEC_B product are:
- the same ones previously detailed for the generation of the SCS_B product (including radiometric equalization with the usage of the ellipsoid for the estimation of antenna pattern and incidence angle)
- multilooking and detection as specified for DGM product
- for Wide Swath mode only, subswath mosaicking and calibration constant equalization as specified for DGM product
- the map projection on the ellipsoid

The data shall be aligned with the north direction. The area of the product, outside the SAR sensed image data, shall be filled with invalid value because of the rotation to align with North.

The product will include a set of annotations, which detail its features in terms of:
- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localization info
- Processing parameters (including that ones specific to multilooking)
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)
- Geolocation Parameters

The same processing features peculiar to various instrument modes, detailed for Level 1B product, are applicable to Level 1C, too.

2.5 Processing Level 1D

2.5.1 GTC_B Product

The GTC product contains for each sensor acquisition mode the focused data, fully calibrated with the usage of terrain model, detected, geolocated on a DEM and represented cartographic projection (UTM or UPS depending on the Scene Center). The planimetric accuracy of the product will depend on DEM accuracy.

The processing features characterizing the GTC_B product are similar to that ones listed for the processing Level 1C with the following differences:
- usage of DEM for the ground projection

- usage of DEM for the estimation/compensation of the range antenna pattern and incidence angle
- application of the calibration constant to derive the backscattering coefficient

Image is represented in dB scale.

The product include a set of annotations which detail its features in terms of:
- Time Correlation Data
- Sensor Parameters
- Orbital and attitude data
- Calibration data
- Localization info
- Processing parameters (including that ones specific to multilooking)
- Raw data quality statistical parameters
- Product Confidence Data
- Doppler Parameters (Doppler Centroid, Doppler Rate)
- Geolocation Parameters

The same processing features peculiar to various instrument modes, detailed for Level 1B product, are applicable to Level 1D, too.

2.5.2 GIM Layer

The GTC product includes an additional layer representing the mask (coregistered with the GTC product, therefore in the same cartographic projection) of the incidence angles at which each pixel included into the GTC SAR data had been acquired. Such angle is measured between the target to sensor direction and local normal to the terrain (not projected on the acquisition plane).
It's worth stating that, in the case of data acquired in High Resolution mode, the incidence angles included in the GIM layer are defined supposing a zero-doppler geometry for the scene observation; hence, implication on the incidence angle evaluation deriving from the antenna azimuth steering scheme are not considered.
This layer also gives information about conditions of layover and shadowing occurred at the sensing time due to particular acquisition geometry and terrain horography.

It's worth stating that L1D processor shall have a DEM file without missing values as input.
To account for pixels whose value is interpolated (an antecedent step not performed by PL1D, those pixels are identified with "-1" value in the HEM dataset), L1D processor will flag the affected region in the GIM dataset by using the range [11000 29000] (i.e. 20000+incidence angle).

The following table, summarizes the coding key of the GIM layer annexed to Level 1D products:

Sample Information	Pixel Value
Incidence Angle	The radar wave incidence angle in degrees (as detailed above) multiplied by one hundred (Incidence Angle Rescaling Factor attribute value equal to 100), if the corresponding GTC pixel wasn't observed under layover or shadowing conditions (the allowed dynamic for such pixels is [–9000, 9000] corresponding to incidence angles ranging in the interval [-90°, 90°])
Layover Code	9999
Shadowing Code	-9999
Interpolated DEM quote	20000 + Incidence Angle

Table 2-3 GIM layer coding key

3. PRODUCTS OVERVIEW

Processing levels detailed in chapter 2 applied to data acquired in all modes allowed by the KOMPSAT-5 SAR instrument, so obtaining the products listed in the following subsections.
The following table summarises the reference applicable performance requirements:

RQS name	Standard Mode	Wide Swath	High Resolution
Nominal Access Region	20 deg $\leq \theta \leq$ 45 deg	20 deg $\leq \theta \leq$ 45 deg	20 deg $\leq \theta \leq$ 45 deg
Extended Access Region	45 deg $< \theta \leq$ 55 deg	45 deg $< \theta \leq$ 55 deg	45 deg $< \theta \leq$ 55 deg
Swath Width	$\geq$ 30 km @ 45 incidence angle	$\geq$ 100 km @ 45 incidence angle	$\geq$ 5 km @ 45 incidence angle
Ground Sample Distance	$\leq$ 3 m @ 45 incidence angle	$\leq$ 20 m @ 45 incidence angle	$\leq$ 1 m @ 45 incidence angle
NEσ	$\leq$ -17dBm^2/m^2 @ Nominal Access Region	$\leq$ -17dBm^2/m^2 @ Nominal Access Region	$\leq$ -17dBm^2/m^2 @ Nominal Access Region

NOTE: *the values of Ground Sample Distance are to be intended at 1 Look*

Table 3-1 Overall Performance Requirements

	Standard Mode	Wide Swath	High Resolution
PSLR	-19 dB @ Nominal Access Region	-19 dB @ Nominal Access Region	-19 dB @ Nominal Access Region
ISLR	-13 dB @ Nominal Access Region	-13 dB @ Nominal Access Region	-13 dB @ Nominal Access Region
AAR	-17 dB @ Nominal Access Region	-17 dB @ Nominal Access Region	-17 dB @ Nominal Access Region
RAR	-17 dB @ Nominal Access Region	-17 dB @ Nominal Access Region	-17 dB @ Nominal Access Region
RA	1 dB @ Nominal Access Region	1 dB @ Nominal Access Region	1 dB @ Nominal Access Region

Table 3-2 IRF characteristics

3.1 High Resolution Mode Products

The following standard products originated depending on the processing level from data acquired in High Resolution Mode.

Product name	Processing Level
HR-RAW_B	0
HR-SCS_B HR-SCS_U	1A
HR-DSM_U HR-DSM_E HR-DGM_B	1B
HR-GEC_B	1C
HR-GTC_B	1D

Table 3-3 High Resolution Products list

Table 3-4 summarizes the basic features for the KOMPSAT-5 products originated from data acquired in High Resolution Mode.

	HR -RAW	HR -SCS	HR -DGM	HR -GEC HR -GTC
Line Spacing (azimuth) (m)	-	$0.5 \div 0.9$	$0.4 \div 0.8$	$0.4 \div 0.8$
Column Spacing (range) (m)	-	$0.4 \div 1.5$	$0.4 \div 0.8$	$0.4 \div 0.8$
Number of lines	$7000 \div 16000$	$5000 \div 12500$	$4000 \div 14000$	$4000 \div 20000$
Number of columns	$5200 \div 10000$	$5200 \div 9000$	$4000 \div 14000$	$4000 \div 20000$
Product Size (MB)	$100 \div 300$	$140 \div 450$	$30 \div 400$	$30 \div 1500$

Table 3-4 High Resolution Products Features

Table 3-5 lists the quality specifications considering the instrument operation modes nominal parameters in the nominal access region for the KOMPSAT-5 High Resolution Mode focused products. Such quality performances are guaranteed under the assumption the scene acquisition is performed under instrument and platform nominal condition.
When applicable such performances have to be considered valid both in range and azimuth directions.

	HR-SCS_B	HR-SCS_U	HR-DGM_B	HR-GEC_B	HR-GTC_B
Ground Range resolution (m)	-	-	≤ 1	-	-
Azimuth resolution (m)	≤ 1	≤ 1	≤ 1	-	-
PSLR (dB)	≤ -19	≤ -13	≤ -19	-	-
ISLR (dB)	≤ -13	≤ -11	≤ -13	-	-
Azimuth Ambiguity Ratio (dB)	-17	-	-17	-	-
Range Ambiguity Ratio (dB)	-17	-	-17	-	-
Radiom. Accuracy (dB)	-	-	-	-	1
Geometric Conformity	-	-	-	10^{-3}	10^{-3}

Table 3-5 High Resolution Mode Products Requirement

The following table, lists the processing conditions under which, the product requirements listed in the previous table should be verified. Nevertheless, such parameters shall be considered as living ones up to the completion of the commissioning phase of each satellite.

	HR-SCS_B	HR-SCS_U	HR-DGM_B	HR-GEC_B	HR-GTC_B
Processing nom. range looks	1	1	1	1	1
Processing nom. azimuth looks	1	1	1	1	1
Range Processing weighting factor	0.35 ÷ 0.5	0	0.3 ÷ 0.5	0.3 ÷ 0.5	0.3 ÷ 0.5
Azimuth Processing weighting factor	0 ÷0.2	0	0 ÷ 0.2	0 ÷ 0.2	0 ÷ 0.2
Range processed bandwidth (% of PBW)	90 ÷100%	100%	90 ÷ 100%	90 ÷ 100%	90 ÷ 100%
Azimuth processed bandwidth (KHz)	7 ÷ 8	7 ÷ 8	7 ÷ 8	7 ÷ 8	7 ÷ 8

Table 3-6 High Resolution Mode processing condition

3.2 Standard Mode Products

The following standard products originated depending on the processing level from data acquired in Standard Mode.

Product name	Processing Level
ST-RAW_B	0
ST-SCS_B ST-SCS_U	1A
ST-DSM_U ST-DSM_E ST-DGM_B	1B
ST-GEC_B	1C
ST-GTC_B	1D

Table 3-7 Standard Products list

Table 3-8 summarizes the basic features for the KOMPSAT-5 products originated from data acquired in Standard Mode.

	ST-RAW	ST-SCS	ST-DGM	ST-GEC ST-GTC
Line Spacing (azimuth) (m)	-	1.5 ÷ 3.1	1 ÷ 2.5	1 ÷ 2.5
Column Spacing (range) (m)	-	1.4 ÷ 3.8	1 ÷ 2.5	1 ÷ 2.5
Number of lines	15500 ÷ 25500	12000 ÷ 24000	9000 ÷ 37000	9000 ÷ 45000
Number of columns	7000 ÷ 18000	5800 ÷ 17000	9000 ÷ 37000	9000 ÷ 45000
Product Size (GB)	0.22 ÷ 0.91	0.4 ÷ 1.6	0.15 ÷ 2.6	0.15 ÷ 7.8

Table 3-8 Standard Products Features

Table 3-9 lists the quality specifications (considering the instrument operation modes parameters in the nominal access region) for the KOMPSAT-5 Standard Mode focused products. Such quality performances are guaranteed under the assumption the scene acquisition is performed under instrument and platform nominal condition.
When applicable such performances have to be considered valid both in range and azimuth directions.
For set of performance applicable to products originated from SPF product see sections 2.4.1 and 2.5.1

PROPRIETARY MATERIAL

	ST-SCS_B	ST-SCS_U	ST-DGM_B	ST-GEC_B	ST-GTC_B
Ground Range resolution (m)	-	-	≤ 3	-	-
Azimuth resolution (m)	≤ 3	≤ 3	≤ 3	-	-
PSLR (dB)	≤ -19	≤ -13	≤ -19	-	-
ISLR (dB)	≤ -13	≤ -11	≤ -13	-	-
Azimuth Ambiguity Ratio (dB)	-17	-	-17	-	-
Range Ambiguity Ratio (dB)	-17	-	-17	-	-
Radiom. Accuracy (dB)	-	-	-	-	1
Geometric Conformity	-	-	-	10^{-3}	10^{-3}

Table 3-9 Standard Mode Products Quality

The following table, lists the processing conditions under which, the product requirements listed in the previous table should be verified. Nevertheless, such parameters shall be considered as living ones up to the completion of the commissioning phase of each satellite.

	ST-SCS_B	ST -SCS_U	ST-DGM_B	ST -GEC_B	ST -GTC_B
Processing nom. range looks	1	1	1	1	1
Processing nom. azimuth looks	1	1	1	1	1
Range Processing weighting factor	0.35 ÷ 0.5	0	0.3 ÷ 0.5	0.3 ÷ 0.5	0.3 ÷ 0.5
Azimuth Processing weighting factor	0 ÷ 0.2	0	0 ÷ 0.2	0 ÷ 0.2	0 ÷ 0.2
Range processed bandwidth (% of PBW)	90 ÷100%	100%	90 ÷ 100%	90 ÷ 100%	90 ÷ 100%
Azimuth processed bandwidth (% of PRF)	70 ÷ 85%	70 ÷ 85%	70 ÷ 85%	70 ÷ 85%	70 ÷ 85%

Table 3-10 Standard Mode processing condition

3.3 Wide Swath Mode Products

The following standard products originated depending on the processing level from data acquired in Wide Swath Mode.

Product name	Processing Level
WS-RAW_B	0
WS-SCS_B WS-SCS_U	1A
WS-DSM_U WS-DSM_E WS-DGM_B	1B
WS-GEC_B	1C
WS-GTC_B	1D

Table 3-11 Wide Swath Products list

Table 3-12 summarizes the basic features for the KOMPSAT-5 products originated from data acquired in Wide Swath Mode.

	WS-RAW	WS-SCS	WS-DGM	WS-GEC WS-GTC
Line Spacing (azimuth) (m)	-	10 ÷ 15	7.5 ÷ 10	7.5 ÷ 10
Column Spacing (range) (m)	-	3.56 ÷ 16	7.5 ÷ 10	7.5 ÷ 10
Number of lines	7000 ÷ 20000	8000 ÷ 16000	9000 ÷ 16000	9000 ÷ 20000
Number of columns	7600 ÷ 16000	6400 ÷ 15700	9000 ÷ 16000	9000 ÷ 20000
Product Size (GB)	0.7 ÷ 2.4	1.27 ÷ 2.7	0.15 ÷ 0.6	0.15 ÷ 1.6

Table 3-12 Wide Swath Products Features

Table 3-13 lists the quality specifications (considering the instrument operation modes parameters in the nominal access region) for the KOMPSAT-5 Wide Swath Mode focused products. Such quality performances are guaranteed under the assumption the scene acquisition is performed under instrument and platform nominal condition.
When applicable such performances have to be considered valid both in range and azimuth directions.
For set of performance applicable to products originated from SPF product see sections 2.4.1 and 2.5.1

	WS-SCS_B	WS-SCS_U	WS-DGM_B	WS-GEC_B	WS-GTC_B
Ground Range resolution (m)	-	-	≤ 20	-	-
Azimuth resolution (m)	≤ 20	≤ 20	≤ 20	-	-
PSLR (dB)	≤ -19	≤ -13	≤ -19	-	-
ISLR (dB)	≤ -13	≤ -11	≤ -13	-	-
Azimuth Ambiguity Ratio (dB)	-17	-	-17	-	-
Range Ambiguity Ratio (dB)	-17	-	-17	-	-
Radiom. Accuracy (dB)	-	-	-	-	1
Geometric Conformity	-	-	-	10^{-3}	10^{-3}

Table 3-13 Wide Swath Mode Products Quality

The following table, lists the processing conditions under which, the product requirements listed in the previous table should be verified. Nevertheless, such parameters shall be considered as living ones up to the completion of the commissioning phase of each satellite.

	WS-SCS_B	WS-SCS_U	WS-DGM_B	WS -GEC_B	WS -GTC_B
Processing nom. range looks	1	1	1	1	1
Processing nom. azimuth looks	1	1	1	1	1
Range Processing weighting factor	0.35 ÷ 0.5	0	0.3 ÷ 0.5	0.3 ÷ 0.5	0.3 ÷ 0.5
Azimuth Processing weighting factor	0 ÷ 0.2	0	0 ÷ 0.2	0 ÷ 0.2	0 ÷ 0.2
Range processed bandwidth (% of PBW)	90 ÷ 100%	100%	90 ÷100%	90 ÷ 100%	90 ÷ 100%
Azimuth processed bandwidth (% of PRF)	10 ÷ 25%	10 ÷ 25%	10 ÷ 25%	10 ÷ 25%	10 ÷ 25%

Table 3-14 Wide Swath Mode processing condition

4. OUTPUT FORMAT DESCRIPTION

The data packaging organization adopted as distribution format for the standard products is HDF5. The support format detailed below will be used to store image layers and the relevant ancillary information, forming the output product to be distributed to the final user.

4.1 Format Overview

The HDF5 (Hierarchical Data Format) format and software, was developed and supported by NCSA (National Centre for Supercomputing Applications University of Illinois) since 1988 and is freely available.
It is used worldwide in many fields, including environmental science, the study of neutron scattering, non-destructive testing, and aerospace research. Scientific projects that use HDF include NASA's Earth Observing System (EOS), and the Department of Energy's Accelerated Strategic Computing Initiative (ASCI).
For more information or software the following link is available http://hdf.ncsa.uiuc.edu.

HDF5 files are organized in a hierarchical structure, with two primary structures:

- groups
- datasets

A grouping structure contains instances of zero or more groups or datasets, together with supporting metadata.
Any HDF5 group or dataset may have an associated attribute list. An HDF5 attribute is a user-defined HDF5 structure that provides extra information about an HDF5 object. Attributes are described in more detail below.

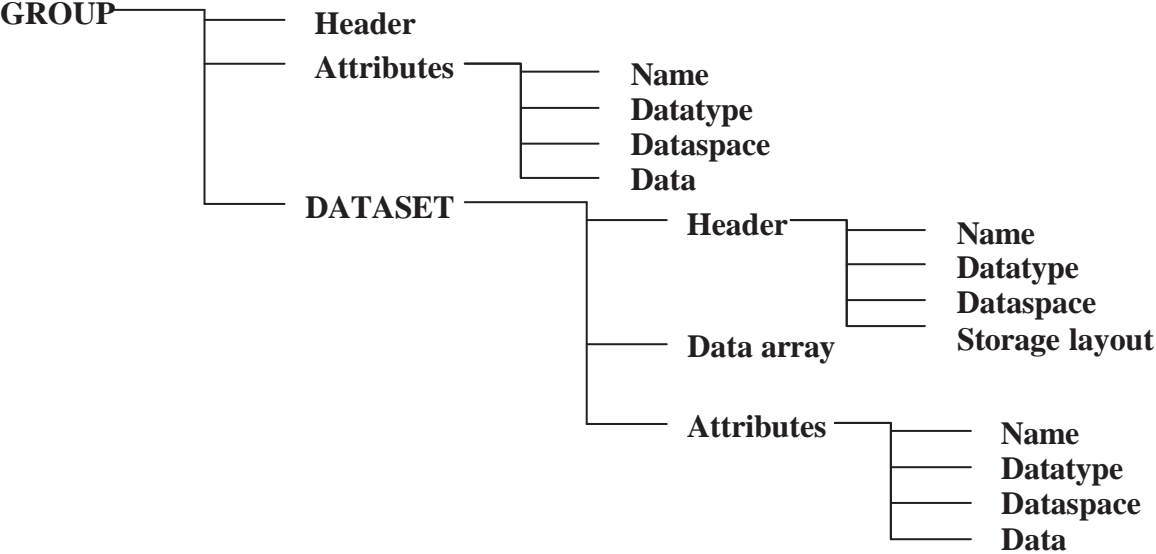The hierarchical organization of the HDF5 format is graphically represented in Figure 4-1.

```
GROUP──┐
       ├──── Header
       │     Attributes──┐
       │                 ├──── Name
       │                 ├──── Datatype
       │                 ├──── Dataspace
       │                 └──── Data
       └──── DATASET──┐
                      ├──── Header──┐
                      │             ├──── Name
                      │             ├──── Datatype
                      │             ├──── Dataspace
                      │             └──── Storage layout
                      ├──── Data array
                      └──── Attributes──┐
                                        ├──── Name
                                        ├──── Datatype
                                        ├──── Dataspace
                                        └──── Data
```

Figure 4-1 HDF5 organization

4.1.1 Groups

An HDF5 group is a structure containing zero or more HDF5 objects. A group has two parts:

- A group header, which contains a group name and a list of group attributes.
- A group symbol table, which is a list of the HDF5 objects that belong to the group.

Working with groups and group members is similar in many ways to working with directories and files in UNIX. As with UNIX directories and files, objects in an HDF5 file are often described by giving their full (or absolute) path names.

/ signifies the root group.
/foo signifies a member of the root group called foo.
/foo/zoo signifies a member of the group foo, which in turn is a member of the root group.

4.1.2 Datasets

A dataset is a multidimensional array of data elements, together with supporting metadata.
A dataset is stored in a file in two parts

- A header
- A data array.

4.1.2.1 Dataset header

The header contains information that is needed to interpret the array portion of the dataset, as well as metadata (or pointers to metadata) that describes or annotates the dataset. Header information includes the name of the object, its dimensionality, its number-type, information about how the data itself is stored on disk, and other information used by the library to speed up access to the dataset or maintain the file's integrity.

There are four essential classes of information in any header:

- Name
- Datatype
- Dataspace
- Storage layout

4.1.2.1.1 *Name*

A dataset name is a sequence of alphanumeric ASCII characters.

4.1.2.1.2 *Datatype*

HDF5 allows one to define many different kinds of datatypes. There are two categories of datatypes:

- atomic datatypes (which differentiates in system-specific, NATIVE or named)
- compound datatypes (which can only be named).

Atomic datatypes are those that are not decomposed at the datatype interface level, such as integers and floats.
NATIVE datatypes are system-specific instances of atomic datatypes.
Compound datatypes are made up of atomic datatypes.
Named datatypes are either atomic or compound datatypes that have been specifically designated to be shared across datasets.

Atomic datatypes include integers and floating-point numbers. Each atomic type belongs to a particular class and has several properties: size, order, precision, and offset. In this introduction, we consider only a few of these properties.

Atomic classes include integer, float, date and time, string, bit field, and opaque. (Note: Only integer, float and string classes are available in the current implementation.)
Properties of integer types include size, order (endian-ness), and signed-ness (signed/unsigned).
Properties of float types include the size and location of the exponent and mantissa, and the location of the sign bit.

The datatypes that are supported in the current implementation are:

- Integer datatypes: 8-bit, 16-bit, 32-bit, and 64-bit integers in both little and big-endian format.
- Floating-point numbers: IEEE 32-bit and 64-bit floating-point numbers in both little and big-endian format.
- References.
- Strings.
- NATIVE datatypes. Although it is possible to describe nearly any kind of atomic data type, most applications will use predefined datatypes that are supported by their compiler. In HDF5 these are called native datatypes. NATIVE datatypes are C-like datatypes that are generally supported by the hardware of the machine on which the library was compiled. In order to be portable, applications should almost always use the NATIVE designation to describe data values in memory.

The NATIVE architecture has base names that do not follow the same rules as the others. Instead, native type names are similar to the C type names.
A compound datatype is one in which a collection of simple datatypes are represented as a single unit, similar to a struct in C. The parts of a compound datatype are called members. The members of a compound datatype may be of any datatype, including another compound datatype. It is possible to read members from a compound type without reading the whole type.
Named datatypes. Normally each dataset has its own datatype, but sometimes we may want to share a datatype among several datasets. This can be done using a named datatype. A named data type is stored in the file independently of any dataset, and referenced by all datasets that have that datatype. Named datatypes may have an associated attributes list. See Datatypes in the HDF User's Guide for further information.

4.1.2.1.3 *Dataspace*

A dataset dataspace describes the dimensionality of the dataset. The dimensions of a dataset can be fixed (unchanging), or they may be unlimited, which means that they are extendible (i.e. they can grow larger).

Properties of a dataspace consist of the rank (number of dimensions) of the data array, the actual sizes of the dimensions of the array, and the maximum sizes of the dimensions of the array. For a fixed-dimension dataset, the actual size is the same as the maximum size of a dimension.

A dataspace can also describe portions of a dataset, making it possible to do partial I/O operations on selections.

Given an n-dimensional dataset, there are currently four ways to do partial selection:

- Select a logically contiguous n-dimensional hyperslab.
- Select a non-contiguous hyperslab consisting of elements or blocks of elements (hyperslabs) that are equally spaced.
- Select a union of hyperslabs.
- Select a list of independent points.

Since I/O operations have two end-points, the raw data transfer functions require two dataspace arguments: one describes the application memory dataspace or subset thereof, and the other describes the file dataspace or subset thereof.

4.1.2.1.4 *Storage layout*

The HDF5 format makes it possible to store data in a variety of ways. The default storage layout format is contiguous, meaning that data is stored in the same linear way that it is organized in memory. Two other storage layout formats are currently defined for HDF5: compact, and chunked. In the future, other storage layouts may be added.

Compact storage is used when the amount of data is small and can be stored directly in the object header.

Chunked storage involves dividing the dataset into equal-sized "chunks" that are stored separately. Chunking has three important benefits.

It makes it possible to achieve good performance when accessing subsets of the datasets, even when the subset to be chosen is orthogonal to the normal storage order of the dataset.
It makes it possible to compress large datasets and still achieve good performance when accessing subsets of the dataset.
It makes it possible efficiently to extend the dimensions of a dataset in any direction.

4.1.3 HDF5 Attributes

Attributes are small named datasets that can be attached to one of the following structures:

- primary datasets
- groups
- named datatypes

Attributes can be used to describe the nature and/or the intended usage of a dataset or group.
An attribute has two parts

- name
- value

The value part contains one or more data entries of the same data type.

When accessing attributes, they can be identified by name or by an index value. The use of an index value makes it possible to iterate through all of the attributes associated with a given object.

4.2 Products Organization

Specific data organization will be detailed to meet the storage needs of data acquired with all the instrument modes allowed by the KOMPSAT-5.

4.2.1 Constituent

There are four essential files

- Image data in hdf5 format(~.h5) or GeoTiff(~.tif)
- Ancillary in XML (~_Aux.xml)
- Browse image (~br.jpg)
- Thumbnail image (~_th.jpg)

4.2.2 Naming Convention

The following naming convention will be used for the identification of the KOMPSAT-5 SAR Standard Products files

Directory
<K5>_<YYYYMMDDhhmmss>_<tttttt>_<nnnnn>_<o>_<MM><SS>_<PP>_<LLL>
Image(HDF5)
<K5>_<YYYYMMDDhhmmss>_<tttttt>_<nnnnn>_<o>_<MM><SS>_<PP>_<YYY_Z>_<LLL>.h5
Image(L1A GeoTiff)
<K5>_<YYYYMMDDhhmmss>_<tttttt>_<nnnnn>_<o>_<MM><SS>_<PP>_<c>_<bb>_<YYY_Z>_<LLL>.tif

The semantic of the variable sub-strings is reported in the following table:

Sub-string code	Meaning	Allowed values
<K5>	Identifier of the satellite that acquired the scene	K5 (KOMPSAT-5)
<YYYYMMDDhhmmss>	Sensing Start Time rounded to the closest integer second	YYYY= year MM = month DD = day of the month hh = hour mm = minute ss = second
<tttttt>	Processing offset	In millisecond
<nnnnn>	Number of Orbit	[00000..99999]

<o>	Identifier of the Orbit Direction	A = Ascending D = Descending
<MM>	Instrument Mode used during the acquisition	ST (Standard) WD (Wide Swath) HR (High Resolution)
<SS>	Identifier of the swath (or subswath combination in the case of Wide Swath mode) used for the data acquisition	[01-...-19] for Standard Mode [01-...-05] for Wide Swath Mode [01-...-31] for High Resolution Mode
<PP>	Polarizations used during the acquisition	HH = Horizontal Tx/Horizontal Rx VV = Vertical Tx/ Vertical Rx HV = Horizontal Tx/ Vertical Rx VH = Vertical Tx/ Horizontal Rx
<c>	Channel indicator I/Q for L1A GeoTiff	I or Q
<bb>	Sub-beam ID for L1A GeoTiff	[01..04]
<YYY_Z>	Product Type	Standard Products: RAW_B SCS_B SCS_U DSM_U DSM_E DGM_B GEC_B GTC_B
<LLL>	Processing level	L1A L1B L1C L1D

<div align="center">

Table 4-1 File naming convention

</div>

4.2.3 Hierarchies organization

The HDF5 allows the hierarchical organization of the information to be stored.
In order to standardize the data organization and the access to the image layers stored by the HDF5 support format, each level of the HDF5 hierarchy has been univocally assigned to the storage of a specific level of information of the SAR products according to the following scheme.

/ - Root group
Instrument Modes (Processing Level): All (0/1A/1B/1C/1D)
For each Instrument Mode and processing level it includes:

- the attributes to be considered applicable to the whole acquisition/product, hence that are subswaths-independent
- one or more group named S<mm> detailed below

PROPRIETARY MATERIAL

- zero or one dataset named MBI (Multi Beam Image) detailed below
- zero or one dataset named QLK (Quick Look) detailed below
- zero or one dataset named GIM (Geocoded Incidence Mask) detailed below

S<mm> groups
Instrument Modes (Processing Level): All (0/1A/1B/1C/1D)
It includes:

- the attributes dependent on the specific subswath used within the full multi-beam swath in the case of Wide Swath mode and within the access area otherwise (for example the PRF)
- one or more dataset named B<nnn> detailed below
- zero or one dataset named SBI (Single Beam Image), in the case of Wide Swath modes, detailed below
- zero or one dataset named QLK (Quick Look) detailed below
- zero or one dataset CAL including all the ShortCal pulses acquired during the acquisition's sequence of the scene echoes.
- zero or one dataset REPLICA including all the reconstructed replica chirp.
- zero or one one dataset NOISE including all the Noise measures performed during the acquisition's sequence of the scene echoes.

In the case of Standard and High Resolution products <mm> = 01
In the case of Wide Swath products <mm> $\in$ {01, 02, 03, 04} used in increasing order from the nearest subswath to the farthest one. Moreover, S01 group will always include the earliest acquired burst.

B<nnn> can be a group or dataset according to the following scheme:
B<nnn> dataset
Instrument Modes (Processing Level): All (0)
It includes:

- the attributes dependent on the time sequential data block (the burst) to be considered applicable for the acquired raw data (for example the Sensing Start Time)
- the data array with the raster layer.
- In the case of Standard and High Resolution products <nnn> = 001
- In the case of Wide Swath products <nnn> $\in$ [001, 999] used in increasing order from the earliest acquired burst to the latest one. The same number of bursts will be always included in each S<mm> group of the distributed product.

B<nnn> group
Instrument Modes (Processing Level): All (1A/1B/1C/1D)
It includes the attributes dependent on the time sequential data block (the burst) to be considered applicable for the acquired raw data (for example the Sensing Start Time)

SBI dataset
Instrument Modes (Processing Level): Standard, High Resolution (1A/1B/1C/1D) Wide Swath (1A)
It includes:

- the attributes dependent on the subswath used within the access area to be considered applicable for the distributed product (for example the Line Time Interval)
- one raster data array representing the product to be distributed

MBI dataset
Instrument Modes: Wide Swath (1B/1C/1D)
It includes

- the attributes dependent on the mosaicked full scene to be considered applicable for the distributed product (for example the Line Time Interval)
- one raster data array representing the range/azimuth mosaicked product to be distributed

QLK Dataset
It includes the quick look of the distributed product.
See 6.2.3 for further details.

GIM Dataset
It includes the raster layer representing the mask (coregistered with the GTC product) of the incidence angles at which each pixel included into the level 1D product had been acquired.

START group
Instrument Modes (Processing Level): All (0)
It includes the dataset of Calibration (CAL) and Noise (NOISE) measurements performed during the acquisition initialization sequence extracted from the downlinked RAW data

STOP group
Instrument Modes (Processing Level): All (0)
It includes the dataset of Calibration (CAL) and Noise (NOISE) measurements performed during the acquisition termination sequence extracted from the downlinked RAW data

NOISE dataset
Instrument Modes (Processing Level): All (0)
It includes the Noise data from the downlinked RAW data.

- The dataset START/NOISE (respectively STOP/NOISE), includes the Noise measurements performed during the acquisition Initialization (respectively Termination) sequence;
- The dataset /S<nn>/NOISE, includes all the Noise measures performed during the acquisition's sequence of the scene echoes

CAL dataset
Instrument Modes (Processing Level): All (0)
It includes the Calibration data from the downlinked RAW data. Three cases can be identified:

- the dataset /START/CAL, includes all the Calibration measurements (Tx1a, Tx1b and Rx performed on each row of the antenna plus an additional ShortCal pulse) performed during the acquisition's Initialization sequence;

- the dataset /STOP/CAL, includes all the Calibration measurements (Tx1a, Tx1b and Rx performed on each row of the antenna plus an additional ShortCal pulse) performed during the acquisition's Termination sequence;

- the dataset /S<nn>/CAL, includes all the ShortCal pulses acquired during the acquisition's sequence of the scene echoes.

REPLICA dataset

Instrument Modes (Processing Level): All (0)

It includes the replica chirp reconstructed from the calibration data included into the downlinked RAW data. It includes a number of lines equal to the number of measured ShortCal pulses

The hierarchical organization for each Instrument Mode and Processing Level is graphically represented in the following diagrams

A not colour filled structure
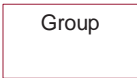
Group

represents a HDF5 structure group.

A colour filled structure
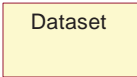
Dataset

represents a generic HDF5 dataset including data array and the relevant attributes.

Suffixes <mm>/<nnn> between angular brackets indicates that the cardinality of the group/dataset is greater than one.
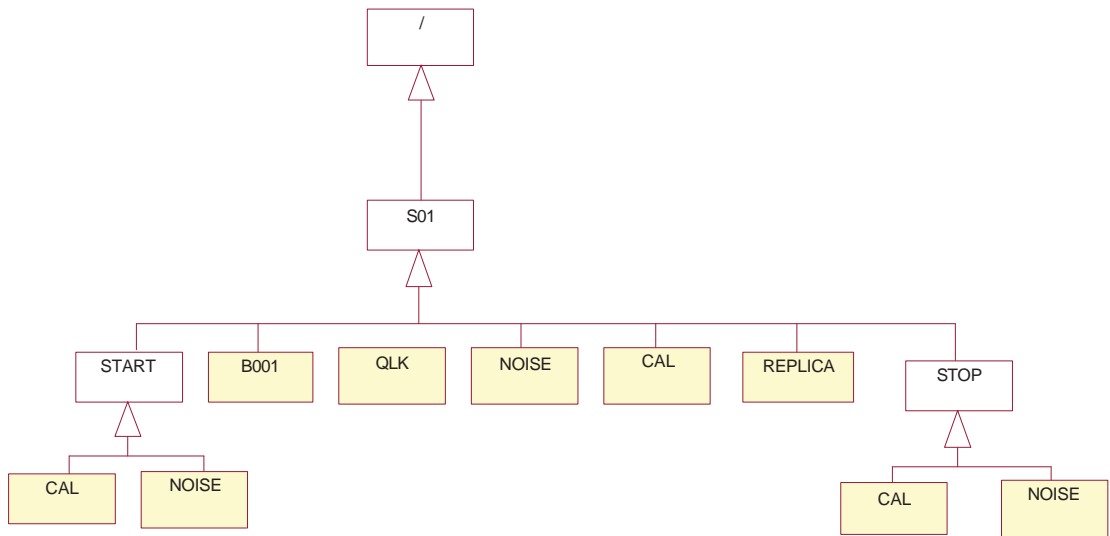

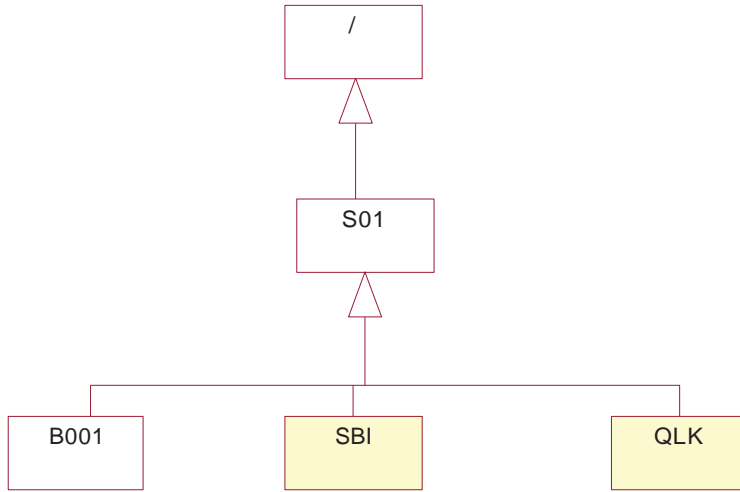**Figure 4-2 Standard/High Resolution Mode – Level 0**

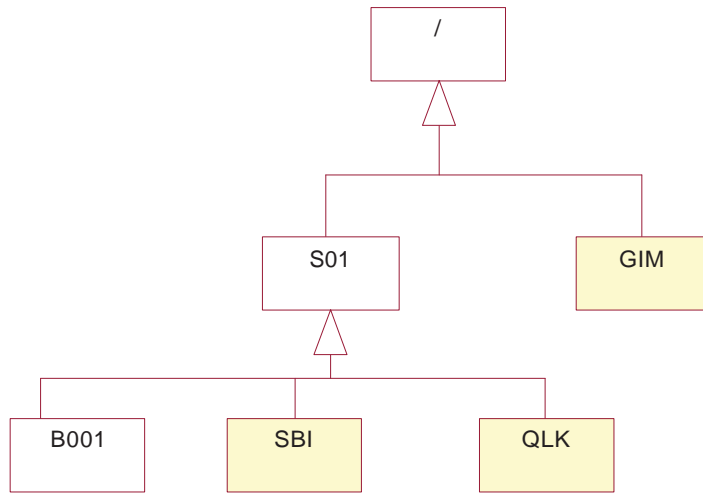**Figure 4-3 Standard/High Resolution Mode – Level 1A/1B/1C**

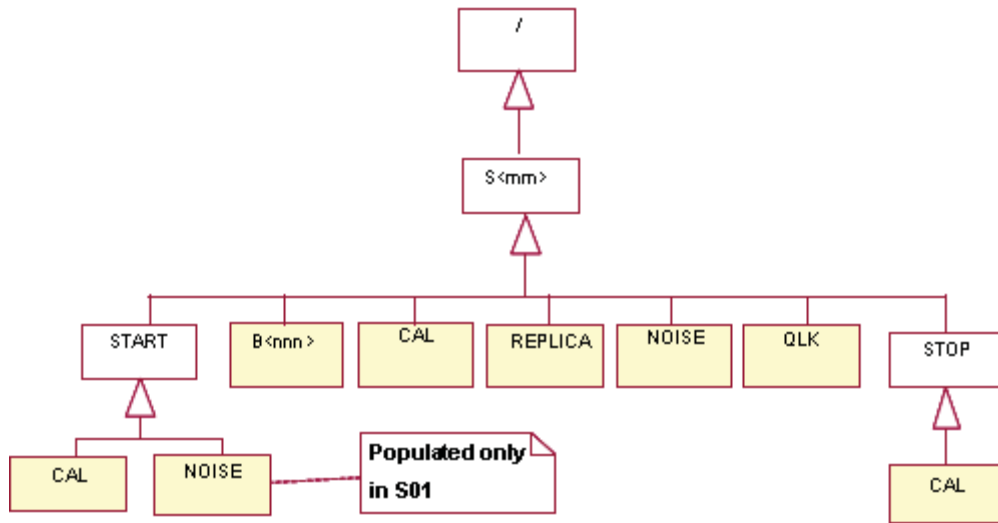**Figure 4-4 Standard/High Resolution Mode – Level 1D**

Figure 4-5 Wide Swath Mode – Level 0

Please note that the Level 0 Wide Swath product presents the NOISE dataset of the START group in each subswath group (S<mm>) even if only for the first subswath (S<01>) this dataset will be populated according to the SAR Instrument design.
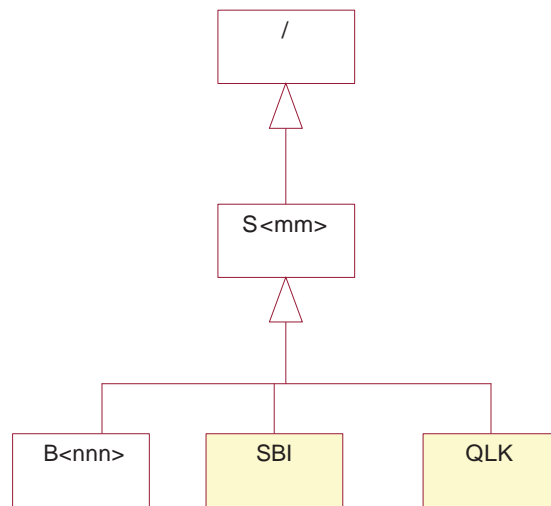

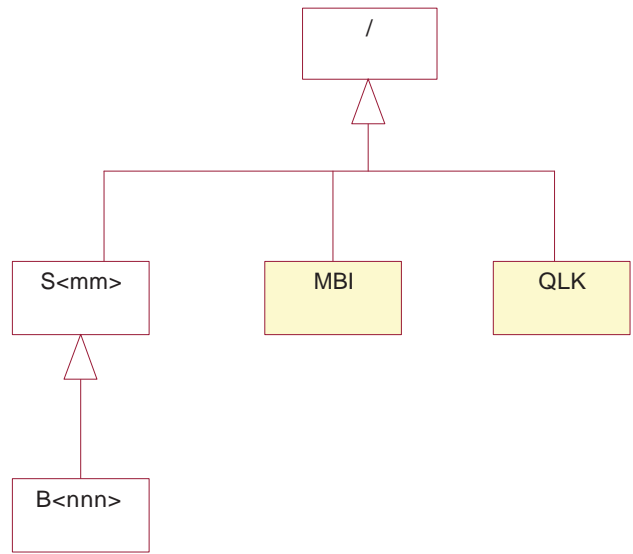**Figure 4-6 Wide Swath Mode – Level 1A**
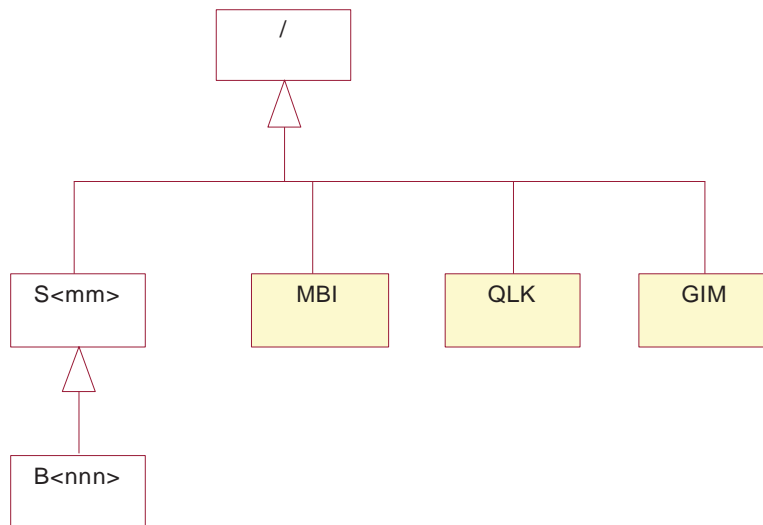
Figure 4-7 Wide Swath Mode – Level 1B/1C

Figure 4-8 Wide Swath Mode – Level 1D

4.2.4 Quick Look

A synoptic of the entire datum allowing having a look to the image content is annexed to all SAR standard product.

For product at processing level 1, the quick look is originated by undersampling of the full resolution raster layer, obtained by a filter (realized by a kernel of configurable size) moving in the raw and columns directions at steps derived by the ratios of the output and input spacing. Following tables details features of the quick look layer.

Products	Sample Information	Projection
Lev. 0	Unfocused image, detected, extracted as down-sampled of the RAW data echoes.	N/A
Lev. 1A	The same sample information of the distributed product the quick look is annexed to, detected, undersampled both in range and azimuth direction with the following factors depending on the sensor mode: High Resolution: 25 Standard: 30 Wide Swath: 15	Slant Range/Azimuth
Lev. 1B	The same sample information of the distributed product the quick look is annexed to, undersampled both in range and azimuth direction to the pixel/line spacings depending on the sensor mode: High Resolution: 25 Standard: 30 Wide Swath: 15	Slant Range/Azimuth (DSM_U and DSM_E) Ground Range/Azimuth (DGM_B)
Lev. 1C/1D	The same sample information of the distributed product the quick look is annexed to, undersampled both in range and azimuth direction with the following factors depending on the sensor mode: High Resolution: 25 Standard: 30 Wide Swath: 15	UTM ($-80° \leq$ center latitude $\leq 84°$) UPS (otherwise)

Table 4-2 Features of the Quick Look layers

Dataset	Sample Format	Bits per Sample	Samples per Pixel	Type Represent.	Invalid Value
Quick Look annexed to the Full resolution product	Unsigned Integer	8	1	Little Endian	0

Table 4-3 Data type for Quick look layer

4.2.5 Ancillary information organization

The attributes to be appended (in terms of HDF5 Attributes) to the KOMPSAT-5 SAR standard products, depending on the processing Level (from Level 0 up to Level 1D) are listed in the "KOMPSAT-5 SAR Products Attributes" For each attribute the corresponding HDF5 storage structure is reported.

4.2.6 Data storage policy

The arrangement used for storage of raster data layers of the SAR Standard Products into HDF5 datasets is listed in the following table:

Samples per pixel	HDF5 data type
Two (Complex data)	Tri-dimensional array having: - the first dimension (the slowest varying) corresponding to the number of lines of the data array - the second dimension corresponding to the number of columns of the data array - the third dimension (the most fast varying) corresponding to the pixel depth, hence used for representation of Real and Imaginary part of each pixel Such representation, will be used for complex types independently on the sample format (byte, short, integer, long, long long, float, double) and sign (signed, unsigned). Data organization in file is shoed in the following schema Line 1 Line 2 I_1 Q_1 ... ... I_n Q_n I_1 Q_1 ... ... I_n Q_n ... ...
One (Real data)	Bi-dimensional array having: - the first dimension (the slowest varying) corresponding to the number of lines of the data array - the second dimension corresponding to the number of columns of the data array Such representation will be used for images on single-sample pixel, independently on the sample format (byte, short, integer, long, long long, float, double) and sign (signed, unsigned) Line 1 Line 2 P_1 P_2 ... ... P_n P_1 P_2 ... ... P_n ... ...

The following chunking policy for data storage is recommended.

Dimension	Chunk Size
Image Length (Lines)	128
Image Width (Columns)	128
Image Depth (Samples)	2

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