



# **SPOT DEM Precision Product description**

**Version1.0 - April 1st, 2006**

**This edition supersedes previous versions**

## Acronyms

<b>DIMAP</b>	Digital Image MAP (encapsulation format supporting data display with an Internet browser)
<b>DTED</b>	Digital Terrain Elevation Data
<b>DXF</b>	Drawing Exchange Format (AutoCAD)
<b>HRS</b>	High Resolution Stereoscopic (SPOT 5 sensor)
<b>JPEG, JPG</b>	Joint Photographic Expert Group
<b>Mb</b>	Megabytes
<b>DTM</b>	Digital Terrain Model
<b>DEM</b>	Digital Elevation Model
<b>SRTM</b>	Shuttle Radar Topographic Mission
<b>SVG</b>	Scalable Vector Graphics
<b>TIFF - GeoTIFF</b>	Tag Image File Format – GeoTIFF is the geocoded version of TIFF
<b>XML</b>	eXtensible Markup Language – Format of certain files in DIMAP

# Contents

<b>1</b>	<b><i>Introduction</i></b> .....	<b>3</b>
<b>2</b>	<b><i>Product features</i></b> .....	<b>4</b>
<b>2.1</b>	<b>SPOT DEM Precision contents</b> .....	<b>4</b>
2.1.1	Data framing.....	4
2.1.2	Coverage.....	4
2.1.3	Quality layers .....	4
2.1.4	Product format.....	4
2.1.5	Source data naming .....	4
<b>2.2</b>	<b>SPOT DEM Precision feasibility</b> .....	<b>5</b>
<b>3</b>	<b><i>SPOT DEM Precision layer specification</i></b> .....	<b>6</b>
<b>3.1</b>	<b>DEM layer</b> .....	<b>6</b>
3.1.1	Data format and encoding.....	6
3.1.2	Framing .....	6
3.1.2.1	GeoTIFF option .....	6
3.1.2.2	DTED option.....	6
3.1.3	Datum.....	7
3.1.4	DEM post-spacing .....	7
3.1.5	DEM geometric accuracy .....	7
3.1.6	Landform characteristics .....	8
3.1.7	Uniformity and continuity within a SPOT DEM Precision product.....	8
<b>3.2</b>	<b>Quality layer</b> .....	<b>9</b>
3.2.1	Source data footprint and type.....	9
3.2.2	SPOT DEM Precision quality masks.....	9
3.2.3	Quality control masks of the Reference3D source data used for generation .....	11
<b>3.3</b>	<b>Metadata</b> .....	<b>11</b>
<b>4</b>	<b><i>SPOT DEM Precision product structure</i></b> .....	<b>12</b>
<b>4.1</b>	<b>File tree</b> .....	<b>12</b>
<b>4.2</b>	<b>File formats</b> .....	<b>13</b>
<b>4.3</b>	<b>Style sheets</b> .....	<b>14</b>
<b>5</b>	<b><i>SPOT DEM Precision sizes</i></b> .....	<b>15</b>
<b>6</b>	<b><i>Annex 1</i></b> .....	<b>17</b>

# 1 Introduction

---

This document describes the specifications and format for the SPOT DEM Precision product, fully derived from the Reference3D database. The Reference3D database, which chiefly comprises SPOT 5 HRS data covering pre-defined regions of interest, is planned to cover at least 30 million square kilometres by June 2008. Reference3D is co-produced by Spot Image and IGN, France's national survey and mapping agency.

As of April 1<sup>st</sup>, 2006, more than 15 millions km<sup>2</sup> of Reference3D tiles are available for SPOT DEM Precision products generation.

SPOT DEM Precision comprises several registerable layers of data:

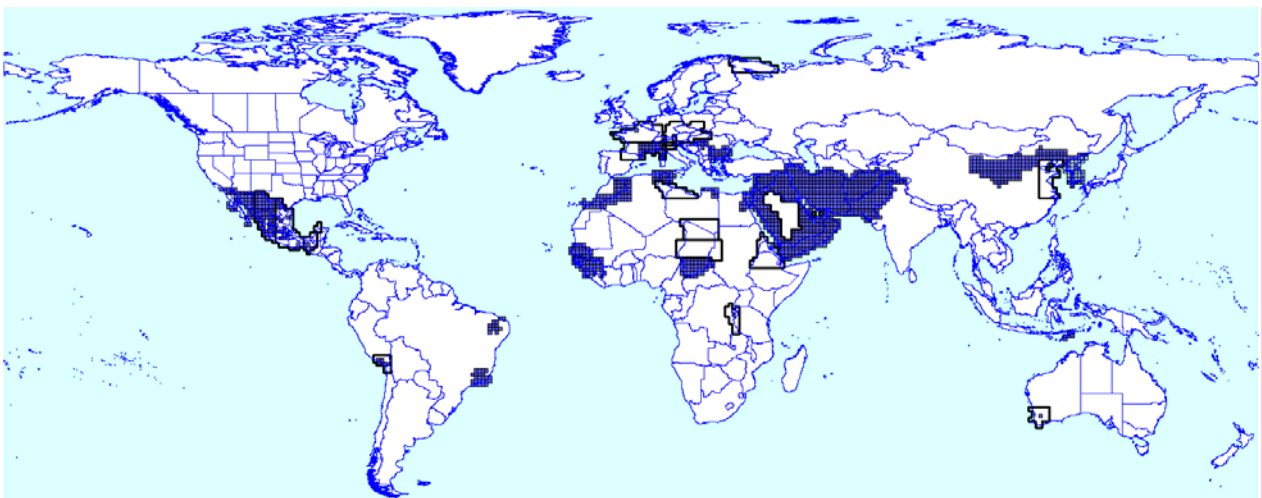
- A 16 bits-signed DEM in GeoTIFF format (DTED2 as an option)
- full layers of quality and traceability data

These layers are encapsulated within a DIMAP profile for display using an Internet browser.

SPOT DEM Precision is the sole DEM on the market providing detailed information on both the identification and localisation of residual errors (artefacts) inherent to automatic correlation computation.

This capacity proves SPOT DEM Precision to be the ideal tool for UAV, missiles and aircrafts on-board databases, as well as mission planning for the MODs and armament industry.

## 1 328 Reference3D available tiles as of April 1<sup>st</sup>



## 2 Product features

---

### 2.1 SPOT DEM Precision contents

SPOT DEM Precision comprises the following layers of information:

- A DTED2-class DEM, exclusively derived from existing Reference3D tiles
- Layers of quality and traceability information

#### 2.1.1 Data framing

SPOT DEM Precision is provided by square kilometers, according to the framing provided by the customer.

#### 2.1.2 Coverage

The HRS instrument cannot guarantee complete coverage of some zones due to weather conditions, stereopair correlation limits due to the landscape, and the inherent limits of the sensor when imaging very mountainous terrain (B/H ratio of 0.8). Gaps in DEMs therefore will be filled locally by interpolation or with other source data.

Unless specified, the standard ratio of HRS data within one Reference3D tile is 90% or more. As of April 1<sup>st</sup>, 2006, figures computed for the 1 328 available tiles are:

Percentage of HRS data	Percentage of concerned tiles
Less than 90%	3%
From 90% to 95%	6%
From 95% to 99.9%	40%
100%	51%

#### 2.1.3 Quality layers

The quality layers provide:

- general information about the product and the DEM layer
- the references of source DEM data (identification of necessary Reference3D tiles)
- binary and 8-bit uncompressed GeoTIFF masks containing geocoded data for DEM quality control

#### 2.1.4 Product format

SPOT DEM Precision products are in DIMAP format. Each product is a set of XML files referencing the DEM, as well as the metadata.

The advantage of DIMAP is that it allows users to the product with off-the-shelf software. For example, they can read the DEM in GeoTIFF or DTED level 2format with any software supporting these formats.

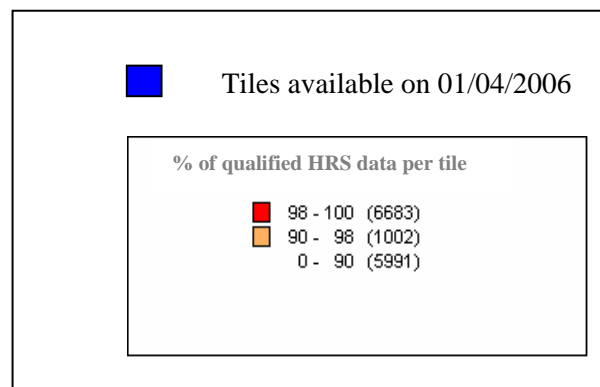
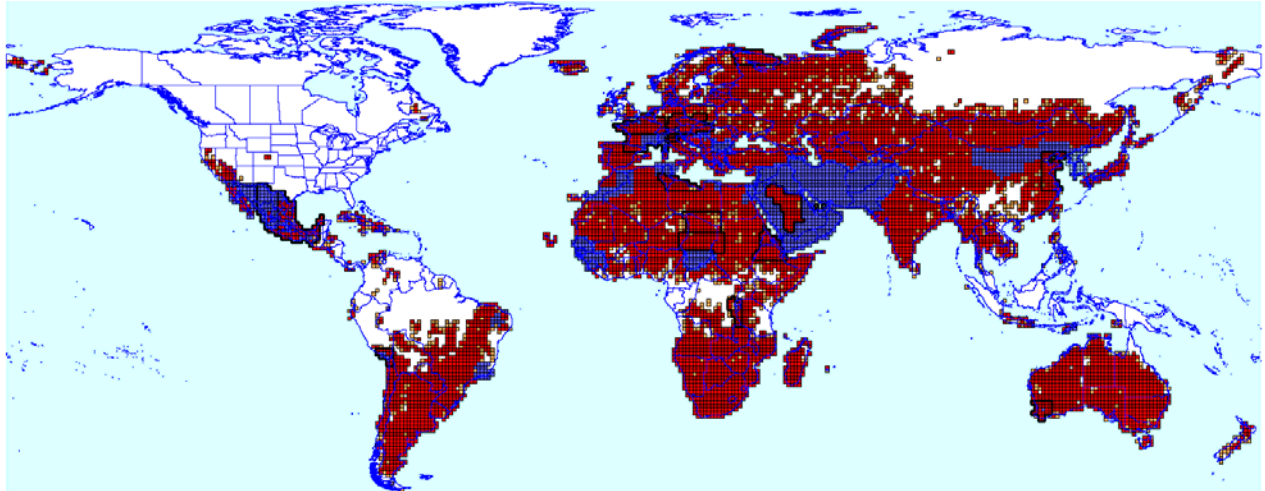
#### 2.1.5 Source data naming

The identifier of each Reference3D one-degree-square tile is built from the geographic coordinates of its South-West corner using a **<N/S>XX<E/W>YYY** model, where XX is the corner latitude and YYY the corner longitude in degrees.

## 2.2 SPOT DEM Precision feasibility

SPOT DEM Precision is fully derived from existing Reference3D product. As of April 1<sup>st</sup>, 2006, more than 15 millions km<sup>2</sup> are available off-the-shelf, enabling rapid generation of SPOT DEM Precision (see map in §1).

More than 100 millions km<sup>2</sup> of qualified HRS data are though available worldwide for SPOT DEM Precision production upon request. The map found below highlights in red and orange the areas where SPOT DEM Precision generation can be initiated.



### 3 SPOT DEM Precision layer specification

#### 3.1 DEM layer

##### 3.1.1 Data format and encoding

The DEM layer of the SPOT DEM Precision product contains elevation values in metres, encoded as 16-bit signed integers with the most significant bit first (Intel coding).

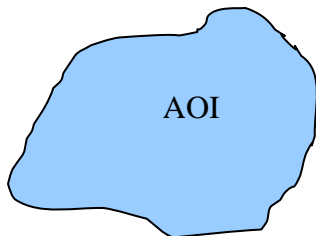
When generated in DTED format, this layer exclusively derived from Reference3D source data is fully compliant with the DTED level 2 standards. The  $-32767$  value in the DTED format that indicates a null value is also used whenever outside of the Area of Interest (AOI) provided by the customer.

##### 3.1.2 Framing

Depending on the selected generation format (GeoTIFF or DTED) a SPOT DEM Precision product may comprise on or more products covering the AOI (see below).

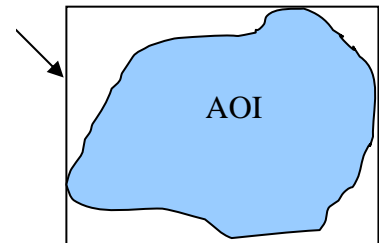
##### 3.1.2.1 GeoTIFF option

Customer's area of Interest



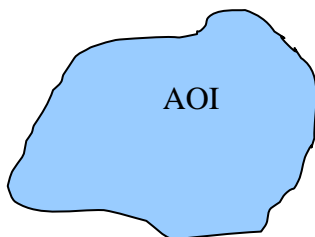
Provided product

Bounding box

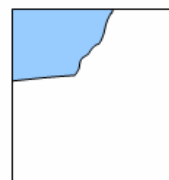
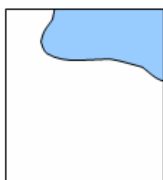
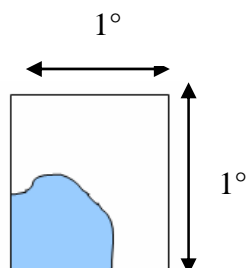
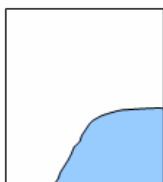


##### 3.1.2.2 DTED option

Customer's area of Interest



Provided products



### 3.1.3 Datum

The vertical datum is EGM 96.

On request, SPOT DEM Precision values can be provided in:

- Geographic coordinates with respect to WGS84
- Cartographic coordinates in UTM WGS84 system, within the (one of the) applicable UTM zone

Other cartographic systems can be used if all necessary conversion parameters between these systems and UTM WGS84 are provided by the customer. In such a case, no specifications are guaranteed by Spot Image.

### 3.1.4 DEM post-spacing

Depending on the chosen referential system, the post-spacing of SPOT DEM Precision products can be provided in:

- Cartographic referential: resampled with a constant post spacing of 20 metres
- or
- In accordance with the DTED level 2 standard (Geographic referential), as shown in the table below:

Tile latitude	Latitude post spacing	Longitude post spacing	Nodes
0° to 50° North or South	1 arc second	1 arc second	3601 * 3601
50° to 70° North or South	1 arc second	2 arc seconds	3601 * 1801
70° to 75° North or South	1 arc second	3 arc seconds	3601 * 1201
75° to 80° North or South	1 arc second	4 arc seconds	3601 * 901
80° to 90° North or South	1 arc second	6 arc seconds	3601 * 601

### 3.1.5 DEM geometric accuracy

The DEM accuracy specifications below apply to DEMs generated from HRS imagery and not to DEMs derived from external sources.

- **Absolute elevation accuracy**
  - linear error with respect to EGM96 (confidence level 90%)
  - flat or rolling terrain (slope ≤ 20 %) ..... **10 m**
  - hilly terrain (20 % < slope ≤ 40 %) ..... **18 m**
  - mountainous terrain (slope > 40 %) ..... **30 m**
- **Absolute planimetric accuracy**
  - circular error with respect to WGS84 (confidence level 90%) ..... **15 m**
- **Relative elevation accuracy within tile**
  - linear error (confidence level 90%)
  - flat or rolling terrain (slope ≤ 20 %) ..... **5 m**
  - hilly terrain (20 % < slope ≤ 40 %) ..... **15 m**
  - mountainous terrain (slope > 40 %) ..... **28 m**
- **Relative planimetric accuracy within tile**
  - circular error (confidence level 90%) ..... **8 m**



### 3.1.6 Landform characteristics

Landform characteristics supplement geometric accuracy specifications, in particular for local features in a DEM. Special attention is paid to the following features, which must be visible in the DEM:

- ✓ **Critical landforms other than islands** (confidence level 96%)
  - features larger than 200 m by 100 m
  - and an elevation difference with the surrounding terrain greater than 30 m
- ✓ **Islands** (confidence level 99%)
  - islands larger than 200 m by 100 m
  - and an elevation difference with the surrounding water greater than 15 mOR
  - islands larger than 300 m by 300 m
- ✓ **Watersheds and drains** (confidence level 96%)
  - Drains wider than 150 m
- ✓ **Cliffs** (confidence level 99%)
  - longer than 200 m
  - higher than 30 m with a local slope greater than 80%
- ✓ **Artefacts**
  - artefacts larger than 300 m by 200 m
  - and an elevation error greater than 40 mmust cover less than 1% of the 1° x 1° square
- ✓ **Water bodies**

Water bodies are:

- oceans and open seas with an elevation of 0 m
- lakes of constant elevation where they are more than 600 m across

Landscapes surrounding water bodies are not artificially raised.

### 3.1.7 Uniformity and continuity within a SPOT DEM Precision product

No elevation discontinuities exhibiting a bias greater than 2 m are accepted within a SPOT DEM Precision product.

## 3.2 Quality layer

### 3.2.1 Source data footprint and type

SPOT DEM Precision contains the references and ground footprints of source data, in polygon form in DXF and SVG formats.

### 3.2.2 SPOT DEM Precision quality masks

#### ✓ Performance mask MPL

This mask describes the areas of the Reference3D source tiles where the SEM specifications are met. The performance mask is a GeoTIFF raster file expressed in geographic coordinates, fully superimposable to the DEM of the SPOT DEM Precision product. A JPEG quicklook (500x500) is associated to this mask, enabling it to be displayed by the style sheet.

The performance mask is represented by 6 colours (8-bit encoding per value). The following chart provides the correspondence between the 6 levels of quality and their respective colour code:

Class	Performance	Colours			
		R	V	B	Colour
255	No data (outside Area of Interest)	0	0	0	■
1	No applicable specification	128	128	128	■
2	Reach medium specification with low PLCN requirement	255	255	255	□
3	Reach medium specification	255	255	64	■
4	Reach high specification except on some thalwegs	255	198	1	■
5	Reach high specification	255	0	0	■

#### ✓ Homogeneous geometric quality areas MGD

A homogeneous geometric quality class is affected to each area of the SPOT DEM Precision product. For each class, the Quality Assessment metadata provides values for the AHA, RHA, AVA, RVA geometric quality indicators, respectively Absolute Horizontal Accuracy, Relative Horizontal Accuracy, Absolute Vertical Accuracy and Relative Vertical Accuracy.

Within the GeoTIFF file, the value of each pixel corresponds to the class number to which it belongs.

The following chart provides the correspondence between the quality classes and their respective colour code:

Index	Quality classes				Colours			
	AHA	RHA	AVA	RVA	R	V	B	Colour
0	0	0	0	0	0	0	0	■
1	13	8	10	5	0	0	225	■
2	13	8	10	15	30	30	225	■
3	13	8	10	28	60	60	95	■
4	13	8	18	5	180	100	65	■
5	13	8	18	15	210	130	35	■
6	13	8	18	28	240	160	5	■
7	13	8	30	5	195	195	60	■
8	13	8	30	15	225	225	30	■
9	13	8	30	28	255	255	0	■
10	15	10	12	7	0	255	0	■
11	15	10	12	18	30	245	20	■
12	15	10	12	35	90	235	40	■
13	15	10	22	7	120	225	60	■
14	15	10	22	18	150	215	80	■
15	15	10	22	35	180	205	100	■
16	15	10	35	7	210	195	120	■
17	15	10	35	18	240	185	140	■
18	15	10	35	35	255	175	160	■
19	30	18	25	15	255	0	0	■
20	30	18	25	30	245	30	20	■
21	30	18	25	40	235	90	40	■
22	30	18	40	15	225	120	60	■
23	30	18	40	30	215	150	80	■
24	30	18	40	40	205	180	100	■
25	30	18	50	15	195	210	120	■
26	30	18	50	30	185	240	140	■
27	30	18	50	40	175	255	160	■

✓ **Water mask (MWa)**

Contains flat maritime or inland water bodies visible in the Reference3D orthoimages source data. It is produced by manual delineation with an orthoimage underlay. The water mask is not significant in zones that are zero-rated in the MCI mask (snow or cloud).

- 0: sea or water body more than 600 m across
- 1: no water

✓ **Exogenous mask (MEx)**

Indicates areas computed using external data. It is delineated manually.

- 0: exogenous data
- 1: no exogenous data

### 3.2.3 Quality control masks of the Reference3D source data used for generation

Masks are 1-bit GeoTIFF files containing geographic coordinates, with the same post spacing as the DEM. They are provided on the entire footprint of the square-degree framing source data. Full description of these masks is to be found in Annex 1.

## 3.3 Metadata

### ✓ Reference3D source data

A link towards the Reference3D source data used for the SPOT DEM Precision product is included. These source data remain within their native projection system (WGS84).

### ✓ HRS data strip

The following metadata are provided for each HRS data strip used to produce a source tile:

SPOTSSEGMENTS5S1S0210150732178	
DESCRIPTION	SEGMENT HRS1 S
DATE	2002-10-15
TIME	07:32:32
INSTRUMENT	HRS1
MODE	B_W
INCIDENCE_ANGLE	-22.957857 (DEG)
VIEWING_ANGLE	0.000000 (DEG)
SUN_AZIMUTH	154.089591 (DEG)
SUN_ELEVATION	39.245105 (DEG)

### ✓ Block triangulation

Tie points:

- number of points
- mean of planimetric residuals (in 10-m pixels)
- standard deviation of planimetric residuals (in 10-m pixels)

Z points:

- number of points used
- mean of Z residuals (in metres)
- standard deviation of Z residuals (in metres)

### ✓ DEM

- number of rows/columns
- coordinates of 4 corners
- post spacing

### ✓ DEM derived from HRS data strips merged to produce tile

- mean of elevation differences in overlap areas
- standard deviation of elevation differences in overlap areas

### ✓ Exogenous data

- Source
- Rotation/translation

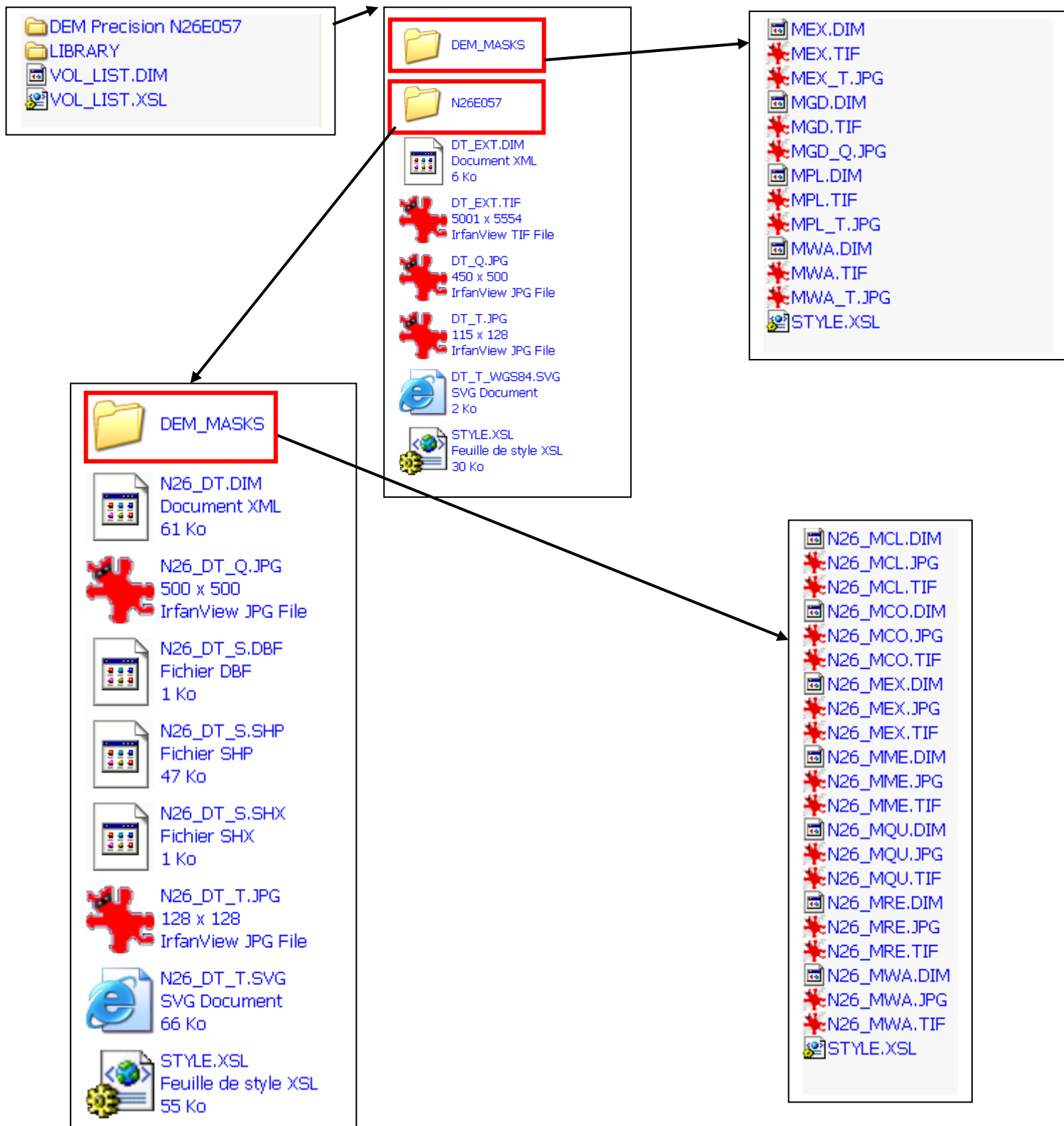
### ✓ General information

- Geodetic reference system
- Producer reference

## 4 SPOT DEM Precision product structure

### 4.1 File tree

Files containing data for SPOT DEM Precision covering data source N26E057 are organized according to the tree below:



File names are eight characters and file extensions three characters maximum, in accordance with the ISO 9660 standard.

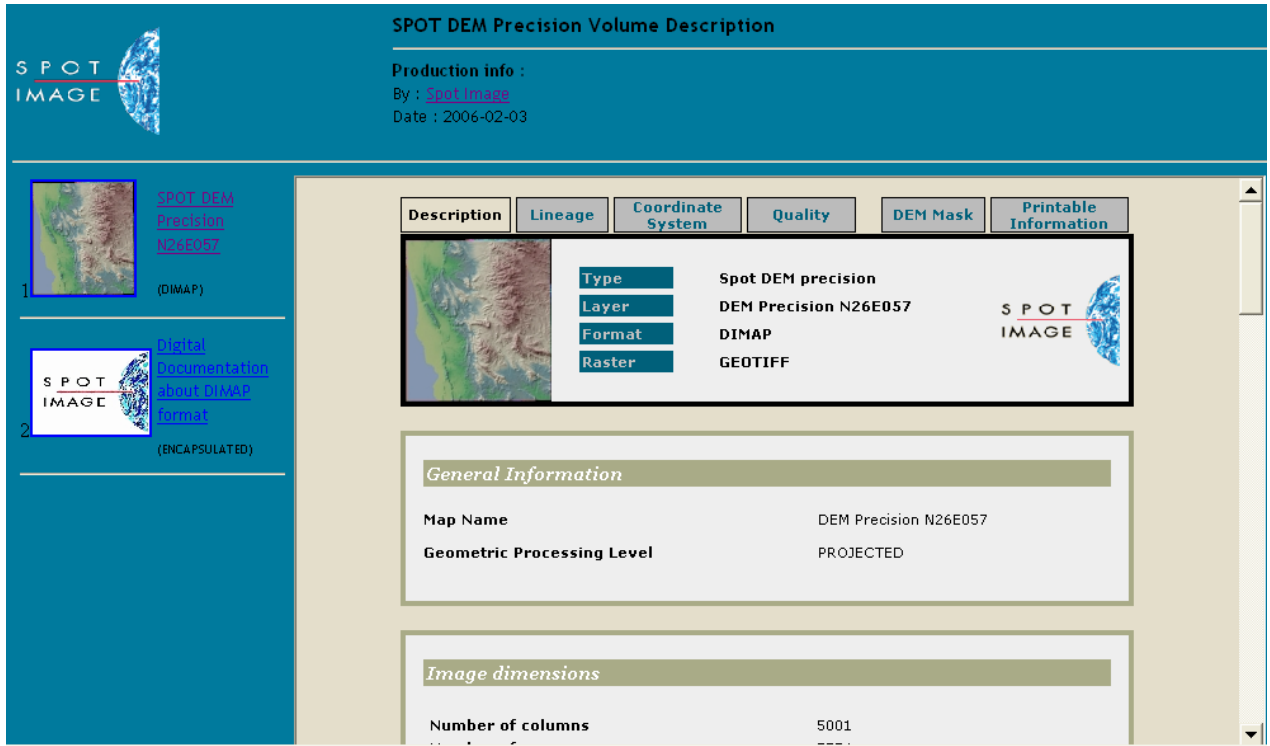
## 4.2 File formats

<b>File</b>	<b>Format</b>
Productb information	XML
Source metadata	XML
DEM metadata	XML
DEM	16-bit uncompressed GeoTIFF or DTED 2
DEM quality specific masks	8-bit uncompressed GeoTIFF
Source data quality masks	1-bit uncompressed GeoTIFF
Source DEM footprints	DXF (polygons)
DEM quicklook	JPEG
DEM thumbnail	JPEG
Quicklooks of source DEM footprints	SVG

### 4.3 Style sheets


Every SPOT DEM Precision product in DIMAP format comes with several XSL style sheets that allow its main features to be displayed with an Internet browser.


An example style sheet is shown below:



**SPOT DEM Precision Volume Description**

Production info :  
By : [Spot Image](#)  
Date : 2006-02-03

1  [SPOT DEM Precision N26E057](#)  
(DIMAP)

2  [Digital Documentation about DIMAP format](#)  
(ENCAPSULATED)

**Description** | Lineage | Coordinate System | Quality | DEM Mask | Printable Information

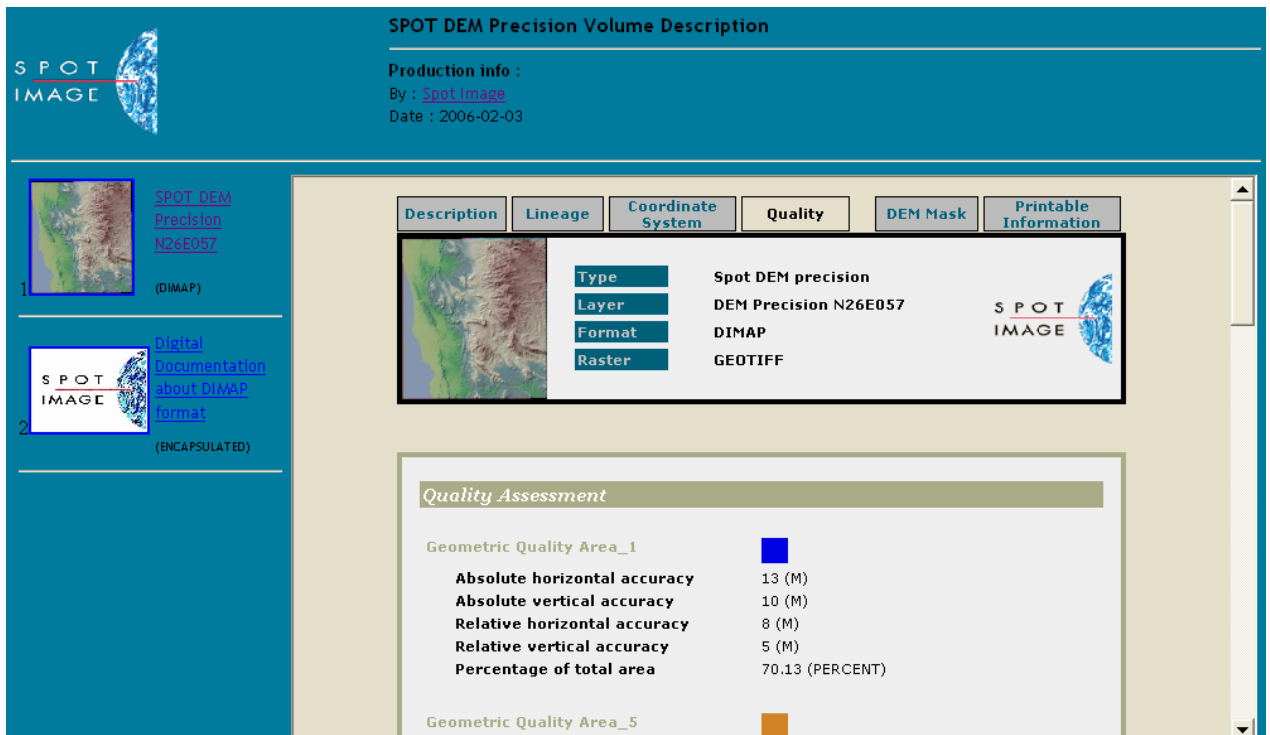
Type	Spot DEM precision
Layer	DEM Precision N26E057
Format	DIMAP
Raster	GEOTIFF

**General Information**

Map Name: DEM Precision N26E057  
Geometric Processing Level: PROJECTED


**Image dimensions**


Number of columns: 5001



**SPOT DEM Precision Volume Description**

Production info :  
By : [Spot Image](#)  
Date : 2006-02-03

1  [SPOT DEM Precision N26E057](#)  
(DIMAP)

2  [Digital Documentation about DIMAP format](#)  
(ENCAPSULATED)

Description | **Quality** | Lineage | Coordinate System | DEM Mask | Printable Information

Type	Spot DEM precision
Layer	DEM Precision N26E057
Format	DIMAP
Raster	GEOTIFF

**Quality Assessment**

Geometric Quality Area\_1 ■

Absolute horizontal accuracy	13 (M)
Absolute vertical accuracy	10 (M)
Relative horizontal accuracy	8 (M)
Relative vertical accuracy	5 (M)
Percentage of total area	70.13 (PERCENT)

Geometric Quality Area\_5 ■

Characteristics of the style sheets are given as an indication and are subject to change without notice.

## 5 SPOT DEM Precision sizes

The appropriate maximum file sizes for a SPOT DEM Precision product located at the Equator can be estimated as shown below. The largest files will be those constituting tiles at latitudes below 50°. File sizes for all other products will decrease significantly as latitude increases.

<b>GeoTIFF option (without reprojection)</b> <b>20 m constant post-spacing</b>	Encoding (Nbits)	1° x 1°	30' x 30'	15' x 15'
		12 000 km <sup>2</sup>	3 000 km <sup>2</sup>	750 km <sup>2</sup>
DEM	16	26 Mo	7 Mo	2 Mo
Specific SPOT DEM Precision masks (MGD, MPL, MWA, MEX)	8	52 Mo	13 Mo	3 Mo
Source data masks (MCL, MCO, MEX, MME, MQU, MRE, MVA, MWA)	1	11 Mo	3 Mo	1 Mo

<b>DTED option</b> <b>1 sec arc post-spacing</b>	Encoding (Nbits)	1° x 1°	30' x 30'	15' x 15'
		12 000 km <sup>2</sup>	3 000 km <sup>2</sup>	750 km <sup>2</sup>
DEM	16	26 Mo	7 Mo	2 Mo
Specific SPOT DEM Precision masks (MGD, MPL)	8	26 Mo	7 Mo	2 Mo
Source data masks (MCL, MCO, MEX, MME, MQU, MRE, MVA, MWA)	1	11 Mo	3 Mo	1 Mo





## 6 Annex 1

---

Quality control masks of the Reference3D source data used for generation (see Reference3D Product Description for detailed information).

Masks are 1-bit GeoTIFF files containing geographic coordinates, with the same post spacing as the DEM. They are provided on the entire footprint of the square-degree framing source data.

✓ **Water mask (MWa)**

Contains flat maritime or inland water bodies visible in Reference3D orthoimages. It is produced by manual delineation with an orthoimage underlay. The water mask is not significant in zones that are zero-rated in the MCI mask (snow or cloud).

0: sea or water body more than 600 m across  
1: no water

✓ **DEM merge mask (MMe)**

Contains areas derived from a single DEM and is generated automatically.

0: no DEM or one single DEM used  
1: at least two merged DEMS

✓ **Correlation mask (MCo)**

Generated by a 50% thresholding of CCs.

0: confidence coefficient less than 50%  
1: confidence coefficient greater than or equal to 50%

✓ **Cloud/snow mask (MCI)**

Describes the cloud- and snow-covered areas which remain in the Reference3D orthoimage. It is delineated manually using the orthoimage. On snow-covered areas, this mask only describes areas with out-of-specifications DEM.

0: cloud or snow  
1: no cloud or snow

✓ **Exogenous mask (MEx)**

Indicates areas computed using external data. It is delineated manually.

0: exogenous data  
1: no exogenous data

✓ **Regulation mask (MRe)**

Contains DEM artefacts corrected without external data. Water bodies in the MWa mask are not included.

0: artefacts detected and corrected  
1: no artefacts

✓ **Visual control mask (MQu)**

Generated by a visual examination of the final DEM. This mask identifies areas in the DEM deemed by the operator not to meet specifications.

0: data do not meet Reference3D specifications  
1: data meet Reference3D specifications