STANDARDS CHANGE REQUEST
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Purpose: Introduce and define the new SPECTRAL_QUBE object. This SCR is intended to accurately define both the data structure and label for the PDS SPECTRAL_QUBE Object.

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Background
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Instruments classified as imaging spectrometers are increasingly being used in planetary missions. Data from these instruments are naturally represented in a three-dimensional structure consisting of an image plane, with spectra associated with each pixel in the image. The ISIS group at the USGS has designed a data structure, the ISIS Cube, to represent this kind of data. But more importantly, the group has developed a tool suite, referred to collectively as ISIS software, which is capable of viewing and processing the ISIS Cube.

Beginning with Mars Odyssey, a number of planetary missions have requested a new object designed specifically for imaging spectrometer data which would enable compatibility with ISIS software. Two issues have driven development of the new SPECTRAL_QUBE object within PDS: (1) known problems with the existing PDS QUBE specification, and (2) the degree to which SPECTRAL_QUBE could be made more general and still maintain compatibility with the ISIS Cube structure. There were also considerations based on the fact that instrument teams were already generating or designing SPECTRAL_QUBE products, based on the emerging standard. This SPECTRAL_QUBE is an improvement over the existing QUBE object, both in rigor and in compatibility with current PDS and ISIS standards and represents a "best fit," given the design constraints.

Current Urgency
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The following missions are rapidly approaching the archive production phase, have chosen to use the SPECTRAL_QUBE object, and as yet have no PDS standard against which to validate these products:

* Mars Exploration Rover (MER)
* Cassini
* Rosetta

The Mars Odyssey mission has already begun distributing SPECTRAL_QUBE products, causing problems with validation. It is critical that this not occur for the missions listed above. The MER mission intends to distribute SPECTRAL_QUBE EDR and RDR products in August 2004, underlining the urgent need to publish and implement this standard.

Recommendations
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Given the urgency described above, the PDS Project Engineer recommends the following actions:

1. To Management Council: Approve the SPECTRAL_QUBE object standard as soon as possible.

2. To the Central Node System Engineering Team: Upon Management Council approval, implement the changes to the PDS Standards Reference, Data Dictionary, and tool suite, as described in this SCR, below. These actions should be accomplished within thirty days of Management Council approval.

Changes to the Standards Reference
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The following changes to the PDS Standards Reference are required to support this SCR:

1. Insert the SPECTRAL_QUBE description, which is provided in the accompanying file, into the PDS Standards Reference, as the new Appendix A.25. Current Appendices A.25 through A.30 will be renumbered accordingly.

2. Insert the descriptions of the BAND_BIN, BAND_SUFFIX, LINE_SUFFIX, and SAMPLE_SUFFIX groups, which are provided in the accompanying file, into Appendix H. These specify the required or optional groups within the SPECTRAL_QUBE object.

3. In Section 12.4.5 and Section 13.2.1, there is a list of restrictions on the use of GROUPs. Delete Item 2 of this list, which will remove the restriction against using GROUPs within OBJECTs.

Changes to the Data Dictionary
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The following are the set of changes to the Planetary Science Data Dictionary (PSDD) required to support the new SPECTRAL_QUBE object:

1. A new SPECTRAL_QUBE Object will be defined, in accordance with the new Appendix A.25 (See Changes to the Standards Reference, Above).

2. The following new Groups will be defined for use within the SPECTRAL_QUBE, in accordance with the Data Dictionary tables in the new Appendix A.25:

   * BAND_BIN (required)
   * BAND_SUFFIX
   * LINE_SUFFIX
   * SAMPLE_SUFFIX

3. The following new Keywords will be defined for use within the SPECTRAL_QUBE, in accordance with the Data Dictionary tables in the new Appendix A.25:

   * ISIS_STRUCTURE_VERSION
   * MD5_CHECKSUM
   * BAND_BIN_BAND_NUMBER
   * BAND_BIN_FILTER_NUMBER
   * BAND_BIN_BASE
   * BAND_BIN_MULTIPLIER

4. Where needed, the following existing Keywords will be made consistent with SPECTRAL_QUBE usage, in accordance with the Data Dictionary tables in the new Appendix A.25.

   Changes to the keywords are noted briefly, below. One common change is when a description states that the keyword applies to a specific object or objects, and it should also apply to the SPECTRAL_QUBE. The phrase "Apply to SPECTRAL_QUBE" indicates this change.

   * AXES - Apply to SPECTRAL_QUBE
   * AXIS_NAME - Apply to SPECTRAL_QUBE and note that for the

SPECTRAL_QUBE, the first axis is the fastest varying

* CORE_ITEMS - Apply to SPECTRAL_QUBE
* CORE_ITEM_TYPE - Apply to SPECTRAL_QUBE, remove references to VAX and SUN hardware, and use standard values from the Data Dictionary tables in Appendix A.25.
* CORE_ITEM_BYTES - Apply to SPECTRAL_QUBE and allow values of 1, 2, or 4
* SUFFIX_ITEMS - Apply to SPECTRAL_QUBE
* SUFFIX_BYTES - Apply to SPECTRAL_QUBE and allow values of 1, 2, or 4
* SUFFIX_NAME - Apply to SPECTRAL_QUBE
* SUFFIX_ITEM_BYTES - Apply to SPECTRAL_QUBE and allow values of 1, 2, or 4
* SUFFIX_ITEM_TYPE - Apply to SPECTRAL_QUBE
* BANDS - Apply to SPECTRAL_QUBE
* BAND_BIN_CENTER - Apply to SPECTRAL_QUBE and allow for frequency as well as wavelength
* BAND_BIN_UNIT - Apply to SPECTRAL_QUBE and allow for frequency as well as wavelength
* BAND_BIN_WIDTH - Apply to SPECTRAL_QUBE and allow for frequency as well as wavelength
* CORE_NAME - Apply to SPECTRAL_QUBE
* CORE_BASE - Apply to SPECTRAL_QUBE
* CORE_MULTIPLIER - Apply to SPECTRAL_QUBE
* CORE_UNIT - Apply to SPECTRAL_QUBE
* CORE_VALID_MINIMUM - Apply to SPECTRAL_QUBE
* CORE_NULL - Apply to SPECTRAL_QUBE
* CORE_LOW_REPR_SATURATION - Apply to SPECTRAL_QUBE
* CORE_LOW_INSTR_SATURATION - Apply to SPECTRAL_QUBE
* CORE_HIGH_REPR_SATURATION - Apply to SPECTRAL_QUBE
* CORE_HIGH_INSTR_SATURATION - Apply to SPECTRAL_QUBE
* SUFFIX_BASE - Apply to SPECTRAL_QUBE
* SUFFIX_MULTIPLIER - Apply to SPECTRAL_QUBE
* SUFFIX_VALID_MINIMUM - Apply to SPECTRAL_QUBE
* SUFFIX_NULL - Apply to SPECTRAL_QUBE
* SUFFIX_LOW_REPR_SAT - Apply to SPECTRAL_QUBE
* SUFFIX_LOW_INSTR_SAT - Apply to SPECTRAL_QUBE
* SUFFIX_HIGH_REPR_SAT - Apply to SPECTRAL_QUBE
* SUFFIX_HIGH_INSTR_SAT - Apply to SPECTRAL_QUBE
* SUFFIX_UNIT - Apply to SPECTRAL_QUBE
* BAND_BIN_STANDARD_DEVIATION - Apply to SPECTRAL_QUBE and allow frequency as well as wavelength
* BAND_BIN_DETECTOR - Apply to SPECTRAL_QUBE
* BAND_BIN_GRATING_POSITION - Apply to SPECTRAL_QUBE
* BAND_BIN_ORIGINAL_BAND - Apply to SPECTRAL_QUBE

Changes to the PDS Tool Suite

LVTOOL: Changes to the PSDD should ensure that LVTOOL properly validates SPECTRAL_QUBE objects. There should be no LVTOOL code changes needed.

NASAView: Version 2.6.6 of NASAView is capable of displaying the legacy QUBE object. Modifications are in progress to ensure that it properly displays the Mars Odyssey SPECTRAL_QUBE object. Once the SPECTRAL_QUBE standard is approved, modification and testing will be done to ensure that all PDS-compliant SPECTRAL_QUBEs can be properly displayed.

Impact Statement

PDS Standards Reference

The PDS Standards Reference will be modified as described above. The new Appendix A.25 will be added, the changes to Appendix H will be incorporated, and the changes, describe above, for allowing the use of groups inside objects, will be made. All material needed to make these modifications will be supplied with this SCR.

Planetary Science Data Dictionary (PSDD)

The PSDD will be modified to incorporate the SPECTRAL_QUBE object, the BAND_BIN, BAND_SUFFIX, LINE_SUFFIX, and SAMPLE_SUFFIX groups, and all associated keywords. The definitions of all existing QUBE keywords will be examined and notes will be added wherever SPECTRAL_QUBE usage differs from that of the existing QUBE. All groups and keywords associated with the SPECTRAL_QUBE are given in the Data Dictionary tables of the new Appendix A.25. One person-week should be sufficient for this task.

Tool Suite

As noted above, changes to NASAView will be made to ensure that NASAView can display the SPECTRAL_QUBE object. Three person-weeks should be sufficient for these coding changes and unit testing.

Other Impacts

SPECTRAL_QUBE-to-ISIS translaters may need to be written for ISIS software to properly read the SPECTRAL_QUBE described here. If the ISIS label is provided with the PDS label, then such translaters are not neccessary.

Open Issues
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None.

[END OF SCR]

A.25 SPECTRAL_QUBE

INTRODUCTION

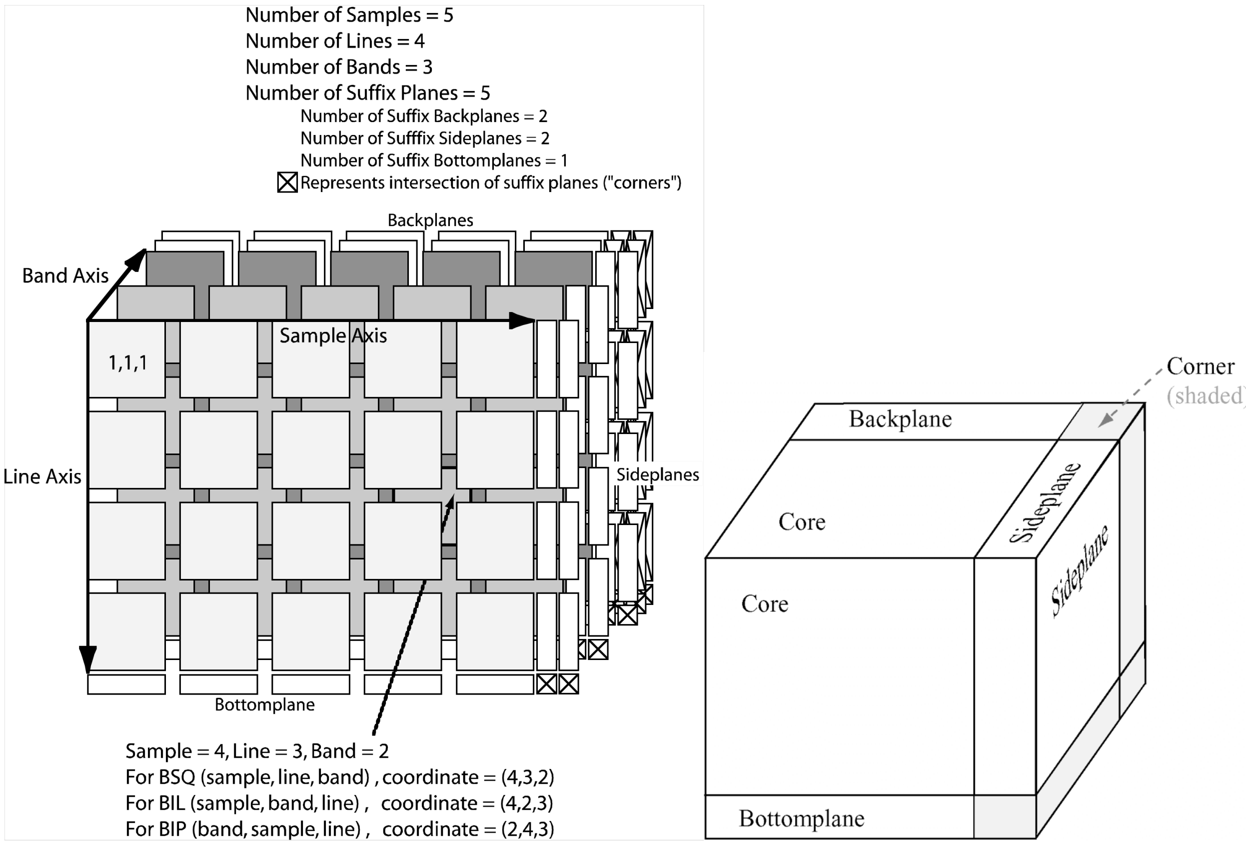
Instruments classified as imaging spectrometers are increasingly being used in planetary missions. Data from these instruments are simultaneously a set of images, at different wavelengths, of the same target area, and a set of spectra at each point of the target area. In PDS archives, these data may be stored as SPECTRAL_QUBEs, three-dimensional objects with two spatial dimensions and one spectral dimension. In these three-dimensional structures, called “qubes,” the axes have the interpretations “sample,” “line”, and “band,” respectively.

Each of the three axes in a PDS SPECTRAL_QUBE object may optionally include suffix data that extend the length of the axis. Conceptually, this can be viewed as forming one or more Suffix planes that are attached to the Core qube, as shown in the diagram below. Suffix planes that extend the band dimension are called BACKPLANES. Suffix planes that extend the sample dimension are called SIDEPLANES. Suffix planes that extend the line dimension are called BOTTOMPLANES.

Note that these terms refer to the “logical” axes – that is, how the axes are conceptually modeled – and are not necessarily related to the physical storage of the SPECTRAL_QUBE object. The Suffix planes are used for storing auxiliary data that are associated with the core data. For example, a backplane might be used for storing the latitude values for each spatial-spatial pixel. Another backplane might be used for storing the wavelength of the deepest absorption feature that was found in the spectrum at each spatial-spatial pixel. One or more SIDEPLANES might be used for storing engineering data that are associated with each spatial line.

LOGICAL STRUCTURE OF A SPECTRAL_QUBE

As mentioned above, the logical structure of the SPECTRAL_QUBE is its conceptual model. This is best presented visually, as is shown in the following diagrams:



Exploded Views of a SPECTRAL_QUBE Object

Pixel Coordinates

SAMPLE=1 is the left edge of the spatial-spatial core image. LINE=1 is the top edge of the spatial-spatial core image. BAND=1 corresponds to the spatial-spatial image at the "front" of the diagram. Core coordinates do not carry over to the suffix regions.

PHYSICAL STRUCTURE OF A SPECTRAL_QUBE

Storage Orders

The file in which a PDS SPECTRAL_QUBE data object is stored is physically accessed as though it were a one-dimensional data structure. Storing the PDS SPECTRAL_QUBE pictured above thus requires that the "logical" three-dimensional structure be mapped into the one-dimensional physical file structure. This involves moving through the three-dimensional structure in certain patterns to determine the linear sequence of core and suffix pixel values that occur in the file. In PDS SPECTRAL_QUBE files, this pattern is defined by specifying which axis index varies fastest in the linear sequence of pixel values in the file, which axis varies second fastest, and which axis varies slowest.

In PDS SPECTRAL_QUBE files, the names of the three axes are always SAMPLE, LINE, and BAND. The AXIS_NAME keyword has an array of values that list the names of the axes in the qube. The order of the names specifies the qube storage order in the file. The first axis is the fastest varying, and the third axis is the slowest varying. The PDS SPECTAL_QUBE supports the following three storage orders:

- (SAMPLE, LINE, BAND) – Band Sequential (BSQ)
- (SAMPLE, BAND, LINE) – Band Interleaved by Line (BIL)
- (BAND, SAMPLE, LINE) – Band Interleaved by Pixel (BIP)

The lengths of the Core axes are given by the CORE_ITEMS keyword, and the lengths of the Suffix axes are given by the SUFFIX_ITEMS keyword. Both these keywords have array values, whose order corresponds to the order of the axes given by the AXIS_NAME keyword.

In the physical file storage, Suffix pixel data (if present) are interspersed with the associated Core pixel data. For example, in a BSQ storage order file, the physical qube storage in the file begins with the pixels in the first (top) line of the spatial-spatial image plane at the first wavelength band. This is followed by the sideplane pixel values that extend this line of core pixels. Next are the core pixels for the second line, followed by the sideplane pixels for the second line. After the last line of this first core image plane (and its associated sideplane pixels) come the bottomplane pixels associated with the first band. This is then repeated for the second through last bands. Finally, all the backplane data are stored after all the core data and associated sideplane and bottomplane pixels.

If a PDS SPECTRAL_QUBE file includes suffixes on more than one axis, then the region that is the intersection between two (or all three) of the suffix regions is called a CORNER region. The PDS requires that space for CORNER region data be allocated in the data files. However this space is never actually used.

Pixel Storage Sizes

In a PDS SPECTRAL_QUBE file, core pixels can occupy one, two, or four bytes. All core pixels within a single file must be of the same physical storage size. Suffix pixels can also occupy one, two, or four bytes of storage in the file. All the suffix pixels within a single file must be of the same physical storage size. Suffix pixels need not be the same size as core pixels. *Handling of different pixel data types is described in detail below.*

Core Pixel Data Types

In PDS SPECTRAL_QUBE files, core pixel values can be represented by one of several formats. The formats available are dependent on the number of bytes used to store the values in the file. The format is given by the CORE_ITEM_TYPE keyword and the number of bytes stored is given by the CORE_ITEM_BYTES keyword. The following table shows the allowable formats and the number of bytes of storage they use:

CORE_ITEM_BYTES	CORE_ITEM_TYPE	Type Conversion Parameters
1, 2, or 4	UNSIGNED_INTEGER	Yes
1, 2, or 4	MSB_UNSIGNED_INTEGER	Yes
1, 2, or 4	LSB_UNSIGNED_INTEGER	Yes
1, 2, or 4	INTEGER	Yes
1, 2, or 4	MSB_INTEGER	Yes
1, 2, or 4	LSB_INTEGER	Yes
4	IEEE_REAL	No
4	VAX_REAL	No
4	PC_REAL	No

As the table above indicates, stored integer values can be converted to real values, representing the actual pixel. The type conversion parameters are given by the CORE_BASE and CORE_MULTIPLIER keywords, and the real value being represented is determined as follows:

"real_value" = CORE_BASE + (CORE_MULTIPLIER * REAL(stored_value))

For 4-byte real formats, the stored values are floating point values that directly represent the pixel values.

Suffix Pixel Data Types

The same data types and number of storage bytes that are shown in the above table are also available to Suffix pixels. However, Suffix pixels need not be the same size or have the same data type as the Core pixels. Therefore, there is a SUFFIX_ITEM_BYTES keyword to indicate the number of bytes stored for Suffix pixels and a SUFFIX_ITEM_TYPE keyword to describe the data type of the Suffix pixels. Each suffix plane within a single file can have a different data format. Thus, the values of these keywords are arrays. Each element of the array refers to a separate suffix plane.

Aligning Suffix Pixels within Allocated Bytes

The SPECTRAL_QUBE allows the number of bytes used to store data in each Suffix pixel (SUFFIX_ITEM_BYTES) to be less than the total number of bytes allocated to each Suffix pixel (SUFFIX_BYTES). It is therefore necessary to describe how the stored bytes are aligned within the allocated bytes. The BIT_MASK keyword is used for this purpose.

DATA DICTIONARY ELEMENTS for the SPECTRAL_QUBE

The following section details the required and optional data dictionary elements that comprise the SPECTRAL_QUBE.

NOTE: Some of the following required and optional elements of the SPECTRAL_QUBE object are ISIS-specific. Since the ISIS system was designed before the current version of the Planetary Science Data Dictionary, some of the element names below conflict with current PDS nomenclature standards.

Required Objects

None.

Optional Objects

Group Name	Definition
IMAGE_MAP_PROJECTION	Map projection information for the image planes

Required Groups

Group Name	Definition
BAND_BIN	Group describing properties of each "bin" along the spectral axis

Optional Groups

The following groups are optional, in that they describe optional Suffix axes. However, if the named axis does appear, its descriptive keywords must be part of the appropriate group:

Group Name	Definition
BAND_SUFFIX	Group describing properties of the BAND Suffix plane ("BACKPLANE")

Group Name	Definition
LINE_SUFFIX	Group describing properties of the LINE Suffix plane (“BOTTOMPLANE”)
SAMPLE_SUFFIX	Group describing properties of the SAMPLE Suffix plane (“SIDEPLANE”)

Required Keywords – Outside of Groups

Keyword Name	Definition	Values
AXES	Number of axes or dimensions of SPECTRAL_QUBE	3 (SPECTRAL_QUBEs are 3-dimensional by definition).
AXIS_NAME	Names of axes in order of physical storage.	Literal values SAMPLE, LINE, and BAND in storage order. One of these three storage orders is required: (SAMPLE, LINE, BAND) (BAND, SAMPLE, LINE) (SAMPLE, BAND, LINE).
CORE_ITEMS	Number of pixels on each axis of the Core, in the same order as in AXIS_NAME	Sequence of three integers, e.g. (256,512, 3).
CORE_ITEM_BYTES	Number of bytes in each core pixel.	1, 2, or 4.
CORE_ITEM_TYPE	Data type of core pixels.	UNSIGNED_INTEGER, MSB_UNSIGNED_INTEGER, LSB_UNSIGNED_INTEGER, INTEGER, MSB_INTEGER, LSB_INTEGER, IEEE_REAL, VAX_REAL, PC_REAL.
SUFFIX_ITEMS	Number of side (SAMPLE) suffix planes, bottom (LINE) suffix planes, and back (BAND) suffix planes, in same order as in AXIS_NAME.	Sequence of three integers. If there are no suffix planes, the value is (0, 0, 0).
If suffix planes are present:		
SUFFIX_BYTES	Number of bytes allocated for each suffix pixel.	1, 2, or 4. See also SUFFIX_ITEM_BYTES.

Required Keywords – In the *_SUFFIX Groups

If there are SUFFIX planes, then the following keywords are required. In order to avoid having to create up to three instances of each one (e.g., BAND_SUFFIX_NAME, LINE_SUFFIX_NAME, and SAMPLE_SUFFIX_NAME), the keywords must be nested in the appropriate group (see section on Optional Groups):

BAND_SUFFIX group – if describing a BAND SUFFIX
LINE_SUFFIX group – if describing a LINE SUFFIX
SAMPLE_SUFFIX group – if describing a SAMPLE SUFFIX

Keyword Name	Definition	Values
SUFFIX_NAME	Name of suffix plane	Literal, e.g. LATITUDE
SUFFIX_ITEM_BYTES	Number of bytes used to store data in each suffix pixel; may be less than the number of bytes allocated for each pixel.	1, 2, or 4. See also SUFFIX_BYTES.
SUFFIX_ITEM_TYPE	Data type of suffix pixels.	UNSIGNED_INTEGER, MSB_UNSIGNED_INTEGER, LSB_UNSIGNED_INTEGER, INTEGER, MSB_INTEGER, LSB_INTEGER, IEEE_REAL, VAX_REAL, PC_REAL.

Required Keywords – In the BAND_BIN Group

Keyword Name	Definition	Values
BANDS	Number of bands in SPECTRAL_QUBE (same as given for the BAND axis in CORE_ITEMS, repeated here for convenience).	Integer.
BAND_BIN_CENTER	Wavelengths or frequencies at band centers.	Sequence of real values, one per band.
BAND_BIN_UNIT	Unit of measurement of BAND_BIN_CENTER and BAND_BIN_WIDTH values.	For example, MICROMETER.
BAND_BIN_WIDTH	Widths (at half height) of bands.	Sequence of real values, one per band.

Note: In the case where there are so many bands that the BAND_BIN group becomes cumbersome in the label, it may be stored in a separate file indicated in the label by a structure pointer, e.g. ^STRUCTURE = "BAND_BIN.FMT".

Optional Keywords

The following keywords are optional for the PDS SPECTRAL_QUBE. Some of these keywords must be used if the SPECTRAL_QUBE is designed for use with the Integrated Software for Imagers and Spectrometers (ISIS). The column labeled **ISIS** indicates whether the keyword is required by ISIS software. A "YES" means the keyword is required by ISIS, while a "NO" means it is not:

Keyword Name	Definition	Values	ISIS
ISIS_STRUCTURE_VERSION	Version of ISIS software with which the SPECTRAL_QUBE's physical structure is compatible	2.1 (Only current valid version number)	YES
CORE_NAME	Name of data value stored in the SPECTRAL_QUBE	Literal, e.g. SPECTRAL_RADIANCE.	YES
CORE_BASE	Base value for scaling core pixels	Real.	YES
CORE_MULTIPLIER	Multiplier for scaling core pixels	Real.	YES
CORE_UNIT	Unit of measurement of core data values.	For example, 'WATT*M**-2*SR**-1*uM**-1' (for spectral radiance) or 'DIMENSIONLESS' (for raw data).	YES
CORE_VALID_MINIMUM	Minimum valid core value.	Values below CORE_VALID_MINIMUM have special meaning.	YES
CORE_NULL	Special value that indicates invalid data.	Must be less than CORE_VALID_MINIMUM.	YES
CORE_LOW_REPR_ SATURATION	Special value that indicates representation saturation at low end.	Must be less than CORE_VALID_MINIMUM.	YES
CORE_LOW_INSTR_ SATURATION	Special value that indicates instrument saturation at low end.	Must be less than CORE_VALID_MINIMUM.	YES
CORE_HIGH_REPR_ SATURATION	Special value that indicates representation saturation at high end.	Must be less than CORE_VALID_MINIMUM.	YES

Keyword Name	Definition	Values	ISIS
CORE_HIGH_INSTR_ SATURATION	Special value that indicates instrument saturation at high end.	Must be less than CORE_VALID_MINIMUM.	YES
SUFFIX_BYTES	Number of bytes allocated for each suffix pixel (required even if no suffix planes are present).	1, 2 or 4. See also SUFFIX_ITEM_BYTES.	YES
MD5_CHECKSUM	MD5 checksum of all core and suffix bytes.	Character String.	NO
LINE_DISPLAY_DIRECTION	The preferred orientation of lines within an image for viewing on a display device. The default value is down, where lines are viewed top to bottom on the display.	DOWN, UP, LEFT, RIGHT.	NO
SAMPLE_DISPLAY_DIRECTION	The preferred orientation of samples within a line for viewing on a display device. The default is right, meaning samples are viewed from left to right on the display.	DOWN, UP, LEFT, RIGHT.	NO
In BAND_SUFFIX, LINE_SUFFIX, and SAMPLE_SUFFIX groups:			
BIT_MASK	A series of binary digits defining the active bits in a value. Required when fewer bytes are used than are allocated.	A sequence of bits equal to the bit-length of the allocated storage.	NO
SUFFIX_BASE	Base value for scaling suffix pixels.	Real.	NO
SUFFIX_MULTIPLIER	Multiplier for scaling suffix pixels.	Real.	NO
SUFFIX_VALID_MINIMUM	Minimum valid suffix value.	Values below SUFFIX_VALID_MINIMUM have special meaning.	NO
SUFFIX_NULL	Special value that indicates invalid data.	Must be less than SUFFIX_VALID_MINIMUM.	NO
SUFFIX_LOW_REPR_SAT	Special value that indicates representation saturation at low end.	Must be less than SUFFIX_VALID_MINIMUM.	NO

Keyword Name	Definition	Values	ISIS
SUFFIX_LOW_INSTR_SAT	Special value that indicates instrument saturation at low end.	Must be less than SUFFIX_VALID_MINIMUM.	NO
SUFFIX_HIGH_REPR_SAT	Special value that indicates representation saturation at high end.	Must be less than SUFFIX_VALID_MINIMUM.	NO
SUFFIX_HIGH_INSTR_SAT	Special value that indicates instrument saturation at high end.	Must be less than SUFFIX_VALID_MINIMUM.	NO
SUFFIX_UNIT	Unit of measurement of suffix data values.	For example, 'DEGREE', 'DIMENSIONLESS'.	NO
In BAND_BIN group:			
BAND_BIN_STANDARD_ DEVIATION	Standard deviations of spectrometer values at each band.	Sequence of real values, one per band.	NO
BAND_BIN_DETECTOR	Instrument detector number of each band, where relevant.	Sequence of integers, one per band.	NO
BAND_BIN_GRATING_ POSITION	Instrument grating position of each band, where relevant.	Sequence of integers, one per band.	NO
BAND_BIN_ORIGINAL_BAND	Where relevant, band numbers from the original qube of which the current qube is a subset. Band numbers in the original qube are sequential integers.	Sequence of integers, one per band, listed in storage order for the current qube.	NO
BAND_BIN_BAND_NUMBER	List of band numbers corresponding to each band contained in the image. The band number is equivalent to the instrument band number.	Sequence of integers, one per band.	NO

Keyword Name	Definition	Values	ISIS
BAND_BIN_FILTER_NUMBER	List of filter numbers corresponding to each band contained in the image. The filter number describes the physical location of the band in the detector array. Filter 1 is on the leading edge of the array.	Sequence of integers, one per band.	NO
BAND_BIN_BASE	The offset value for the stored data of each band listed in the BAND_BIN_BAND_NUMBER. The BAND_BIN_BASE value is added to the scaled data (see BAND_BIN_MULTIPLIER) to reproduce the true data.	Sequence of real values, one per band.	NO
BAND_BIN_MULTIPLIER	The constant value by which the stored data of each band listed in the BAND_BIN_BAND_NUMBER is multiplied to produce the scaled data; the BAND_BIN_BASE value is added to the scaled data to reproduce the true data.	Sequence of real values, one per band.	NO

Example label for a PDS SPECTRAL_QUBE

```
PDS_VERSION_ID                  = PDS3

/* File Identification and Structure */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 644
FILE_RECORDS                    = 249888

/* Pointer to Data Object */

^SPECTRAL_QUBE                  = "SAMPLE1.QUB"

/* Identification Data Elements */

DATA_SET_ID                     =
PRODUCT_ID                      =
INSTRUMENT_HOST_NAME            =
INSTRUMENT_NAME                 =
TARGET_NAME                     =
START_TIME                      =
STOP_TIME                       =
SPACECRAFT_CLOCK_START_COUNT    =
SPACECRAFT_CLOCK_STOP_COUNT     =
PRODUCT_CREATION_TIME           =

/* SPECTRAL_QUBE Object Description */

OBJECT                          = SPECTRAL_QUBE

    AXES                        = 3
    AXIS_NAME                   = (SAMPLE, LINE, BAND)
    ISIS_STRUCTURE_VERSION      = "N/A"
    MD5_CHECKSUM                = cf65a98aff4232f5ac5171406590a932

    /* Core Description */

    CORE_ITEMS                  = (320, 272, 224)
    CORE_NAME                   = "CALIBRATED SPECTRAL RADIANCE"
    CORE_ITEM_BYTES             = 2
    CORE_ITEM_TYPE              = MSB_INTEGER
    CORE_BASE                   = 0.000000
    CORE_MULTIPLIER             = 1.000000
    CORE_UNIT                   = "WATT*CM**-2*SR**-1*UM**-1"
    CORE_NULL                   = -32768
    CORE_VALID_MINIMUM          = -32752
    CORE_LOW_REPR_SATURATION    = -32767
    CORE_LOW_INSTR_SATURATION   = -32766
    CORE_HIGH_REPR_SATURATION   = -32765
    CORE_HIGH_INSTR_SATURATION  = -32764

    /* Suffix Descriptions */

    SUFFIX_ITEMS                = (1, 1, 2)
    SUFFIX_BYTES                = 4
```

```
GROUP                          = SAMPLE_SUFFIX
    SUFFIX_NAME                = HORIZONTAL_DESTRIPE
    SUFFIX_ITEM_BYTES          = 4
    SUFFIX_ITEM_TYPE           = IEEE_REAL
    SUFFIX_BASE                = 0.000000
    SUFFIX_MULTIPLIER          = 1.000000
    SUFFIX_VALID_MINIMUM       = 16#FFEFFFFF#
    SUFFIX_NULL                = 16#FFFFFFFF#
    SUFFIX_LOW_REPR_SAT        = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT       = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT       = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT      = 16#FFFCFFFF#
END_GROUP                      = SAMPLE_SUFFIX

GROUP                          = LINE_SUFFIX
    SUFFIX_NAME                = VERTICAL_DESTRIPE
    SUFFIX_ITEM_BYTES          = 4
    SUFFIX_ITEM_TYPE           = IEEE_REAL
    SUFFIX_BASE                = 0.000000
    SUFFIX_MULTIPLIER          = 1.000000
    SUFFIX_VALID_MINIMUM       = 16#FFEFFFFF#
    SUFFIX_NULL                = 16#FFFFFFFF#
    SUFFIX_LOW_REPR_SAT        = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT       = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT       = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT      = 16#FFFCFFFF#
END_GROUP                      = LINE_SUFFIX

GROUP                          = BAND_SUFFIX
    SUFFIX_NAME                = (LATITUDE, LONGITUDE)
    SUFFIX_UNIT                = (DEGREE, DEGREE)
    SUFFIX_ITEM_BYTES          = (4, 4)
    SUFFIX_ITEM_TYPE           = (IEEE_REAL, IEEE_REAL)
    SUFFIX_BASE                = (0.000000, 0.000000)
    SUFFIX_MULTIPLIER          = (1.000000, 1.000000)
END_GROUP                      = BAND_SUFFIX

/* Band bin information */
/* For this example with 224 bands: */
/* The BAND_BIN group is stored in a separate file. */

^STRUCTURE                     = "BAND_BIN.FMT"

/* Map projection information */

OBJECT                         = IMAGE_MAP_PROJECTION
    A_AXIS_RADIUS              = 1737.4000000
    B_AXIS_RADIUS              = 1737.4000000
    C_AXIS_RADIUS              = 1737.4000000
    POSITIVE_LONGITUDE_DIRECTION = EAST
    MAP_PROJECTION_TYPE        = "SINUSOIDAL EQUAL AREA"
    MAP_SCALE                  = 0.1000000
    MAP_RESOLUTION             = 303.2334900
    EASTERNMOST_LONGITUDE      = 126.0177002
    WESTERNMOST_LONGITUDE      = 120.0000000
    MINIMUM_LATITUDE           = 20.9867992
    MAXIMUM_LATITUDE           = 28.0000000
```

```
        CENTER_LONGITUDE        = 135.0000000
        REFERENCE_LATITUDE      = 0.0000000
        REFERENCE_LONGITUDE     = 0.0000000
        MAP_PROJECTION_ROTATION = 0.0000000
        LINE_PROJECTION_OFFSET  = -8490.0381188
        SAMPLE_PROJECTION_OFFSET = -4246.2684059
    END_OBJECT                  = IMAGE_MAP_PROJECTION

END_OBJECT                      = SPECTRAL_QUBE

END
```

Contents of Example BAND_BIN.FMT:

```
  GROUP = BAND_BIN
    BANDS = 224
    BAND_BIN_UNIT   = MICROMETER
    BAND_BIN_CENTER = (
  0.374370, 0.384460, 0.394120, 0.403770, 0.413430, 0.423090, 0.432750,
  0.442420, 0.452080, 0.461750, 0.471410, 0.481080, 0.490750, 0.500410,
  0.510080, 0.519760, 0.529430, 0.539100, 0.548780, 0.558450, 0.568130,
  0.577810, 0.587490, 0.597170, 0.606850, 0.616530, 0.626210, 0.635900,
  0.645580, 0.655270, 0.664960, 0.676310, 0.655020, 0.664890, 0.674430,
  0.683970, 0.693520, 0.703070, 0.712620, 0.722170, 0.731730, 0.741290,
  0.750860, 0.760420, 0.770000, 0.779570, 0.789150, 0.798720, 0.808310,
  0.817890, 0.827480, 0.837070, 0.846670, 0.856270, 0.865870, 0.875470,
  0.885080, 0.894690, 0.904300, 0.913920, 0.923540, 0.931740, 0.946990,
  0.956410, 0.966100, 0.975560, 0.985010, 0.994470, 1.003930, 1.013390,
  1.022840, 1.032300, 1.041760, 1.051210, 1.060670, 1.070130, 1.079590,
  1.089040, 1.098500, 1.107950, 1.117410, 1.126870, 1.136320, 1.145780,
  1.155240, 1.164690, 1.174150, 1.183600, 1.193060, 1.202520, 1.211970,
  1.221430, 1.230890, 1.240340, 1.249800, 1.259770, 1.254350, 1.264320,
  1.274300, 1.284270, 1.294240, 1.304210, 1.314180, 1.324150, 1.334130,
  1.344100, 1.354070, 1.364040, 1.374010, 1.383980, 1.393950, 1.403920,
  1.413880, 1.423850, 1.433820, 1.443790, 1.453760, 1.463720, 1.473690,
  1.483660, 1.493620, 1.503590, 1.513560, 1.523520, 1.533490, 1.543450,
  1.553420, 1.563380, 1.573350, 1.583310, 1.593270, 1.603240, 1.613200,
  1.623160, 1.633130, 1.643090, 1.653050, 1.663010, 1.672970, 1.682930,
  1.692900, 1.702860, 1.712820, 1.722780, 1.732740, 1.742700, 1.752650,
  1.762610, 1.772570, 1.782530, 1.792490, 1.802450, 1.812400, 1.822360,
  1.832320, 1.842270, 1.852230, 1.862190, 1.872140, 1.882100, 1.880310,
  1.890370, 1.900420, 1.910470, 1.920520, 1.930570, 1.940620, 1.950660,
  1.960700, 1.970740, 1.980770, 1.990800, 2.000830, 2.010860, 2.020880,
  2.030900, 2.040920, 2.050940, 2.060950, 2.070960, 2.080970, 2.090970,
  2.100980, 2.110980, 2.120970, 2.130970, 2.140960, 2.150950, 2.160940,
  2.170920, 2.180900, 2.190880, 2.200860, 2.210830, 2.220810, 2.230770,
  2.240740, 2.250700, 2.260660, 2.270620, 2.280580, 2.290530, 2.300480,
  2.310430, 2.320370, 2.330320, 2.340260, 2.350190, 2.360130, 2.370060,
  2.379990, 2.389920, 2.399840, 2.409760, 2.419680, 2.429600, 2.439510,
  2.449420, 2.459330, 2.469240, 2.479140, 2.489040, 2.498940, 2.508830)

    BAND_BIN_WIDTH = (
  0.015450, 0.011530, 0.011380, 0.011230, 0.011090, 0.010960, 0.010830,
  0.010710, 0.010590, 0.010490, 0.010380, 0.010290, 0.010200, 0.010120,
  0.010040, 0.009970, 0.009910, 0.009850, 0.009800, 0.009760, 0.009720,
  0.009690, 0.009660, 0.009640, 0.009630, 0.009630, 0.009630, 0.009640,
```

```
0.009650, 0.009670, 0.009700, 0.012670, 0.010880, 0.009560, 0.009520,
0.009500, 0.009480, 0.009470, 0.009470, 0.009470, 0.009490, 0.009510,
0.009540, 0.009580, 0.009620, 0.009680, 0.009740, 0.009810, 0.009890,
0.009970, 0.010070, 0.010170, 0.010280, 0.010390, 0.010520, 0.010650,
0.010790, 0.010940, 0.011100, 0.011260, 0.011440, 0.010160, 0.009210,
0.009790, 0.009440, 0.009440, 0.009430, 0.009420, 0.009410, 0.009410,
0.009400, 0.009400, 0.009390, 0.009390, 0.009380, 0.009380, 0.009380,
0.009380, 0.009380, 0.009380, 0.009380, 0.009380, 0.009380, 0.009380,
0.009390, 0.009390, 0.009390, 0.009400, 0.009410, 0.009410, 0.009420,
0.009430, 0.009430, 0.009440, 0.009450, 0.010090, 0.011130, 0.011140,
0.011150, 0.011150, 0.011160, 0.011160, 0.011170, 0.011170, 0.011180,
0.011180, 0.011180, 0.011190, 0.011190, 0.011190, 0.011190, 0.011190,
0.011200, 0.011200, 0.011200, 0.011200, 0.011200, 0.011190, 0.011190,
0.011190, 0.011190, 0.011190, 0.011180, 0.011180, 0.011180, 0.011170,
0.011170, 0.011160, 0.011160, 0.011150, 0.011140, 0.011140, 0.011130,
0.011120, 0.011110, 0.011110, 0.011100, 0.011090, 0.011080, 0.011070,
0.011060, 0.011050, 0.011040, 0.011030, 0.011010, 0.011000, 0.010990,
0.010980, 0.010960, 0.010950, 0.010930, 0.010920, 0.010910, 0.010890,
0.010870, 0.010860, 0.010840, 0.010820, 0.010810, 0.010790, 0.009980,
0.009970, 0.009950, 0.009940, 0.009930, 0.009910, 0.009900, 0.009890,
0.009880, 0.009860, 0.009850, 0.009840, 0.009820, 0.009810, 0.009800,
0.009790, 0.009770, 0.009760, 0.009750, 0.009730, 0.009720, 0.009710,
0.009700, 0.009680, 0.009670, 0.009660, 0.009650, 0.009630, 0.009620,
0.009610, 0.009600, 0.009580, 0.009570, 0.009560, 0.009550, 0.009530,
0.009520, 0.009510, 0.009500, 0.009490, 0.009470, 0.009460, 0.009450,
0.009440, 0.009420, 0.009410, 0.009400, 0.009390, 0.009380, 0.009360,
0.009350, 0.009340, 0.009330, 0.009320, 0.009300, 0.009290, 0.009280,
0.009270, 0.009260, 0.009250, 0.009230, 0.009220, 0.009210, 0.009200)

END_GROUP = BAND_BIN
```

NOTE ON USING PDS SPECTRAL_QUBEs WITH ISIS SOFTWARE

The Integrated Software for Imagers and Spectrometers (ISIS) system, developed by the U.S. Geological Survey, uses image qubes as its principal data structure. The PDS SPECTRAL_QUBE may be designed in such a way as to be suitable for use with ISIS. The optional keyword ISIS_STRUCTURE_VERSION is used to indicate that the SPECTRAL_QUBE is to be used with ISIS. As of this writing, “2.1” is the only valid ISIS version that can be used for this keyword:

ISIS_STRUCTURE_VERSION = "2.1"

This indicates that the PDS SPECTRAL_QUBE can be used with ISIS software version 2.1.

For data providers interested in producing PDS SPECTRAL_QUBEs with a physical data structure compatible with ISIS, consider the following. In order for a SPECTRAL_QUBE object to conform to the ISIS structure, the following are specifically required in addition to all other PDS SPECTRAL_QUBE requirements:

- Record lengths must be 512, i.e., RECORD_BYTES = 512.

- Core pixels of type UNSIGNED_INTEGER must be a single byte value, i.e., if CORE_ITEM_TYPE = UNSIGNED_INTEGER, then CORE_ITEM_BYTES = 1.

- Core pixels of type MSB_UNSIGNED_INTEGER, LSB_UNSIGNED_INTEGER, INTEGER, MSB_INTEGER, or LSB_INTEGER must be a 2-byte value, i.e., if CORE_ITEM_TYPE is one of these integer types, then CORE_ITEM_BYTES = 2.

- Suffix regions (if present) must allocate storage for 4-byte pixels.

Note: Conformance to these criteria ensures ISIS physical structure compatibility only. A fully compliant ISIS label is generated within ISIS at the time of ISIS ingestion. Existing ISIS ingestion software may need modifications to ingest specific PDS SPECTRAL_QUBEs, even when the SPECTRAL_QUBE is physically structured for ISIS.

Example label for a PDS SPECTRAL_QUBE intended for use with ISIS software

```
PDS_VERSION_ID                  = PDS3

/* File Identification and Structure */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 512
FILE_RECORDS                    = 9650

/* Pointer to Data Object */

^SPECTRAL_QUBE                  = "SAMPLE2.QUB"

/* Identification Data Elements */

DATA_SET_ID                     =
PRODUCT_ID                      =
INSTRUMENT_HOST_NAME            =
INSTRUMENT_NAME                 =
TARGET_NAME                     =
START_TIME                      =
STOP_TIME                       =
SPACECRAFT_CLOCK_START_COUNT    =
SPACECRAFT_CLOCK_STOP_COUNT     =
PRODUCT_CREATION_TIME           =

/* SPECTRAL_QUBE Object Description */

OBJECT                          = SPECTRAL_QUBE

    AXES                        = 3
    AXIS_NAME                   = (SAMPLE, LINE, BAND)
    ISIS_STRUCTURE_VERSION      = "2.1"
    MD5_CHECKSUM                = cf65a98aff4232f5ac5171406590a929
```

```
/* Core Description */

CORE_ITEMS                  = (320, 272, 3)
CORE_NAME                   = "CALIBRATED SPECTRAL RADIANCE"
CORE_ITEM_BYTES             = 2
CORE_ITEM_TYPE              = MSB_INTEGER
CORE_BASE                   = 0.000000
CORE_MULTIPLIER             = 1.000000
CORE_UNIT                   = "WATT*CM**-2*SR**-1*UM**-1"
CORE_NULL                   = -32768
CORE_VALID_MINIMUM          = -32752
CORE_LOW_REPR_SATURATION    = -32767
CORE_LOW_INSTR_SATURATION   = -32766
CORE_HIGH_REPR_SATURATION   = -32765
CORE_HIGH_INSTR_SATURATION  = -32764

/* Suffix Descriptions */

SUFFIX_ITEMS                = (1, 1, 2)
SUFFIX_BYTES                = 4

GROUP                       = SAMPLE_SUFFIX
    SUFFIX_NAME             = HORIZONTAL_DESTRIPE
    SUFFIX_ITEM_BYTES       = 4
    SUFFIX_ITEM_TYPE        = IEEE_REAL
    SUFFIX_BASE             = 0.000000
    SUFFIX_MULTIPLIER       = 1.000000
    SUFFIX_VALID_MINIMUM    = 16#FFEFFFFF#
    SUFFIX_NULL             = 16#FFFFFFFF#
    SUFFIX_LOW_REPR_SAT     = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT    = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT    = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT   = 16#FFFCFFFF#
END_GROUP                   = SAMPLE_SUFFIX

GROUP                       = LINE_SUFFIX
    SUFFIX_NAME             = VERTICAL_DESTRIPE
    SUFFIX_ITEM_BYTES       = 4
    SUFFIX_ITEM_TYPE        = IEEE_REAL
    SUFFIX_BASE             = 0.000000
    SUFFIX_MULTIPLIER       = 1.000000
    SUFFIX_VALID_MINIMUM    = 16#FFEFFFFF#
    SUFFIX_NULL             = 16#FFFFFFFF#
    SUFFIX_LOW_REPR_SAT     = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT    = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT    = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT   = 16#FFFCFFFF#
END_GROUP                   = LINE_SUFFIX

GROUP                       = BAND_SUFFIX
    SUFFIX_NAME             = (LATITUDE, LONGITUDE)
    SUFFIX_UNIT             = (DEGREE, DEGREE)
    SUFFIX_ITEM_BYTES       = (4, 4)
    SUFFIX_ITEM_TYPE        = (IEEE_REAL, IEEE_REAL)
    SUFFIX_BASE             = (0.000000, 0.000000)
    SUFFIX_MULTIPLIER       = (1.000000, 1.000000)
END_GROUP                   = BAND_SUFFIX
```

```
    /* Band bin information */

    GROUP                           = BAND_BIN
        BANDS                       = 3
        BAND_BIN_UNIT               = MICROMETER
        BAND_BIN_FILTER_NUMBER      = (1, 2, 3)
        BAND_BIN_BAND_NUMBER        = (2, 3, 4)
        BAND_BIN_CENTER             = (6.78, 9.35, 14.88)
        BAND_BIN_WIDTH              = (1.01, 1.20, 0.87)
        BAND_BIN_BASE               = (0.0, 0.0, 0.0)
        BAND_BIN_MULTIPLIER         = (1.0, 1.0, 1.0)
    END_GROUP                       = BAND_BIN

    /* Map projection information */

    OBJECT                          = IMAGE_MAP_PROJECTION
        A_AXIS_RADIUS               = 1737.4000000
        B_AXIS_RADIUS               = 1737.4000000
        C_AXIS_RADIUS               = 1737.4000000
        POSITIVE_LONGITUDE_DIRECTION = EAST
        MAP_PROJECTION_TYPE         = "SINUSOIDAL EQUAL AREA"
        MAP_SCALE                   = 0.1000000
        MAP_RESOLUTION              = 303.2334900
        EASTERNMOST_LONGITUDE       = 126.0177002
        WESTERNMOST_LONGITUDE       = 120.0000000
        MINIMUM_LATITUDE            = 20.9867992
        MAXIMUM_LATITUDE            = 28.0000000
        CENTER_LONGITUDE            = 135.0000000
        REFERENCE_LATITUDE          = 0.0000000
        REFERENCE_LONGITUDE         = 0.0000000
        MAP_PROJECTION_ROTATION     = 0.0000000
        LINE_PROJECTION_OFFSET      = -8490.0381188
        SAMPLE_PROJECTION_OFFSET    = -4246.2684059
    END_OBJECT                      = IMAGE_MAP_PROJECTION

END_OBJECT                          = SPECTRAL_QUBE

END
```

H.2 BAND_BIN

The BAND_BIN group provides a mechanism for grouping keywords that describe the properties of each “bin”along a spectral axis. It is primarily designed for use within the SPECTRAL_QUBE object.

See Appendix A.25 for a detailed description of the SPECTRAL_QUBE.

H.2.1 Required Keywords

1. BANDS
2. BAND_BIN_CENTER
3. BAND_BIN_UNIT
4. BAND_BIN_WIDTH

H.2.2 Optional Keywords

1. BAND_BIN_STANDARD_DEVIATION
2. BAND_BIN_DETECTOR
3. BAND_BIN_GRATING_POSITION
4. BAND_BIN_ORIGINAL_BAND
5. BAND_BIN_BAND_NUMBER
6. BAND_BIN_FILTER_NUMBER
7. BAND_BIN_BASE
8. BAND_BIN_MULTIPLIER

H.2.3 Example

The following label fragment shows the BAND_BIN group:

```
GROUP                         = BAND_BIN
    BANDS                     = 3
    BAND_BIN_UNIT             = MICROMETER
    BAND_BIN_FILTER_NUMBER    = (1, 2, 3)
    BAND_BIN_BAND_NUMBER      = (2, 3, 4)
    BAND_BIN_CENTER           = (6.78, 9.35, 14.88)
    BAND_BIN_WIDTH            = (1.01, 1.20, 0.87)
    BAND_BIN_BASE             = (0.0, 0.0, 0.0)
    BAND_BIN_MULTIPLIER       = (1.0, 1.0, 1.0)
END_GROUP                     = BAND_BIN
```

H.3 BAND_SUFFIX

The BAND_SUFFIX group provides a mechanism for grouping keywords that describe the properties of each BAND Suffix plane, or BACKPLANE, of a SPECTRAL_QUBE.

See Appendix A.25 for a detailed description of the SPECTRAL_QUBE.

H.3.1 Required Keywords

1. SUFFIX_NAME
2. SUFFIX_ITEM_BYTES
3. SUFFIX_ITEM_TYPE

H.3.2 Optional Keywords

1. SUFFIX_BASE
2. SUFFIX_MULTIPLIER
3. SUFFIX_VALID_MINIMUM
4. SUFFIX_NULL
5. SUFFIX_LOW_REPR_SAT
6. SUFFIX_LOW_INSTR_SAT
7. SUFFIX_HIGH_REPR_SAT
8. SUFFIX_HIGH_INSTR_SAT
9. SUFFIX_UNIT
10. BIT_MASK

H.3.3 Example

The following label fragment shows the BAND_SUFFIX group:

```
GROUP                          = BAND_SUFFIX
    SUFFIX_NAME                = (LATITUDE, LONGITUDE)
    SUFFIX_UNIT                = (DEGREE, DEGREE)
    SUFFIX_ITEM_BYTES          = (4, 4)
    SUFFIX_ITEM_TYPE           = (IEEE_REAL, IEEE_REAL)
    SUFFIX_BASE                = (0.000000, 0.000000)
    SUFFIX_MULTIPLIER          = (1.000000, 1.000000)
END_GROUP                      = BAND_SUFFIX
```

H.4 LINE_SUFFIX

The LINE_SUFFIX group provides a mechanism for grouping keywords that describe the properties of each LINE Suffix plane, or BOTTOMPLANE, of a SPECTRAL_QUBE.

See Appendix A.25 for a detailed description of the SPECTRAL_QUBE.

H.4.1 Required Keywords

1. SUFFIX_NAME
2. SUFFIX_ITEM_BYTES
3. SUFFIX_ITEM_TYPE

H.4.2 Optional Keywords

1. SUFFIX_BASE
2. SUFFIX_MULTIPLIER
3. SUFFIX_VALID_MINIMUM
4. SUFFIX_NULL
5. SUFFIX_LOW_REPR_SAT
6. SUFFIX_LOW_INSTR_SAT
7. SUFFIX_HIGH_REPR_SAT
8. SUFFIX_HIGH_INSTR_SAT
9. SUFFIX_UNIT
10. BIT_MASK

H.4.3 Example

The following label fragment shows the LINE_SUFFIX group:

```
GROUP                          = LINE_SUFFIX
    SUFFIX_NAME                = VERTICAL_DESTRIPE
    SUFFIX_ITEM_BYTES          = 4
    SUFFIX_ITEM_TYPE           = IEEE_REAL
    SUFFIX_BASE                = 0.000000
    SUFFIX_MULTIPLIER          = 1.000000
    SUFFIX_VALID_MINIMUM       = 16#FFEFFFFF#
    SUFFIX_LOW_REPR_SAT        = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT       = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT       = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT      = 16#FFFCFFFF#
END_GROUP                      = LINE_SUFFIX
```

H.5 SAMPLE_SUFFIX

The SAMPLE_SUFFIX group provides a mechanism for grouping keywords that describe the properties of each SAMPLE Suffix plane, or SIDEPLANE, of a SPECTRAL_QUBE.

See Appendix A.25 for a detailed description of the SPECTRAL_QUBE.

H.5.1 Required Keywords

1. SUFFIX_NAME
2. SUFFIX_ITEM_BYTES
3. SUFFIX_ITEM_TYPE

H.5.2 Optional Keywords

1. SUFFIX_BASE
2. SUFFIX_MULTIPLIER
3. SUFFIX_VALID_MINIMUM
4. SUFFIX_NULL
5. SUFFIX_LOW_REPR_SAT
6. SUFFIX_LOW_INSTR_SAT
7. SUFFIX_HIGH_REPR_SAT
8. SUFFIX_HIGH_INSTR_SAT
9. SUFFIX_UNIT
10. BIT_MASK

H.5.3 Example

The following label fragment shows the SAMPLE_SUFFIX group:

```
GROUP                        = SAMPLE_SUFFIX
    SUFFIX_NAME              = HORIZONTAL_DESTRIPE
    SUFFIX_ITEM_BYTES        = 4
    SUFFIX_ITEM_TYPE         = IEEE_REAL
    SUFFIX_BASE              = 0.000000
    SUFFIX_MULTIPLIER        = 1.000000
    SUFFIX_VALID_MINIMUM     = 16#FFEFFFFF#
    SUFFIX_NULL              = 16#FFFFFFFF#
    SUFFIX_LOW_REPR_SAT      = 16#FFFEFFFF#
    SUFFIX_LOW_INSTR_SAT     = 16#FFFDFFFF#
    SUFFIX_HIGH_REPR_SAT     = 16#FFFBFFFF#
    SUFFIX_HIGH_INSTR_SAT    = 16#FFFCFFFF#
END_GROUP                    = SAMPLE_SUFFIX
```