

Photography — Electronic still picture imaging — Picture transfer protocol (PTP) for digital still photography devices

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National foreword

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INTERNATIONAL STANDARD

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Photography — Electronic still picture imaging — Picture transfer protocol (PTP) for digital still photography devices

*Photographie — Imagerie des prises de vue électroniques — Protocole
de transfert d'images (PTP) pour les appareils photographiques
électroniques numériques*



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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 15740 was prepared by Technical Committee ISO/TC 42, *Photography*.

Introduction

For the purposes of this International Standard, digital still photography devices (DSPDs) are defined as devices with persistent storage that capture a digital two-dimensional image at a discrete point in time. Most DSPDs include interfaces that can be used to connect to a host computer or other imaging device, such as a printer. A number of high speed interface transports has been developed, including USB, TCP/IP and IEEE 1394 (Firewire). This International Standard is designed to provide requirements for communicating with DSPDs. This includes communications with any type of device, including host computers, direct printers and other DSPDs over a suitable transport. The requirements include standard image referencing behaviour, operations, responses, events, device properties, datasets, and data formats to ensure interoperability. This International Standard also provides optional operations and formats, as well as extension mechanisms.

This International Standard specifies the following:

- behaviour requirements for DSPDs; this includes the baseline features a device needs to support in order to provide interoperability over conforming transports;
- functional requirements needed by a transport to enable the creation of a transport-dependent implementation specification that conforms to this International Standard;
- a high-level protocol for communicating with and between DSPDs consisting of operation, data and response phases;
- sets of suggested data codes and their usages including:
 - OperationCodes
 - ResponseCodes
 - ObjectFormatCodes
 - DevicePropCodes
 - EventCodes
 - required datasets and their usages
 - a means of describing data object associations and filesystems
 - mechanisms for implementing extensibility.

This International Standard does not attempt to define any of the following:

- any sort of device discovery, enumeration or transport aggregation methods; implementation of this functionality is left to the transports and the platforms upon which support for this International Standard is implemented;
- an application programming interface; this is left to the platforms upon which support for this International Standard is implemented.

This International Standard has been designed to appropriately support popular image formats used in digital still cameras, including the Exif and TIFF/EP formats defined in ISO 12234-1 and ISO 12234-2, as well as the Design Rule for Camera Filesystem (DCF) and the Digital Print Order Format (DPOF).

BS ISO 15740:2005

The technical content of this International Standard is closely related to PIMA 15740:2000. The main difference is that PIMA 15740:2000 includes an informative annex describing a USB implementation of ISO 15740. This information is not included in ISO 15740, which instead references the USB still device class document developed by the Device Working Group of the USB Implementers Forum.

Photography — Electronic still picture imaging — Picture transfer protocol (PTP) for digital still photography devices

1 Scope

This International Standard provides a common communication protocol for exchanging images with and between digital still photography devices (DSPDs). This includes communication between DSPDs and host computers, printers, other digital still devices, telecommunications kiosks and image storage and display devices.

This protocol is transport- and platform-independent.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 8601:2004, *Data elements and interchange formats — Information interchange — Representation of dates and times*

ISO 12234-1:2001, *Electronic still-picture imaging — Removable memory — Part 1: Basic removable-memory module*

ISO 12234-2:2001, *Electronic still-picture imaging — Removable memory — Part 2: TIFF/EP image data format*

ISO/IEC 10646-1:1993, *Information technology — Universal Multiple-Octet Coded Character Set (UCS) — Part 1: Architecture and Basic Multilingual Plane*

ISO/IEC 10918-1:1994, *Information technology — Digital compression and coding of continuous-tone still images: Requirements and guidelines*

IEC 61966-2-1:1999, *Multimedia systems and equipment — Colour measurement and management — Part 2-1: Colour management — Default RGB colour space — sRGB*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

album

end-user created object used to logically group data objects according to some user-defined criteria

NOTE An album may or may not be a physical folder in a filesystem. In this International Standard, an album is a type of association.

3.2

Application Programming Interface

API

high-level functional description of a software interface

NOTE An API is typically language-dependent.

3.3

association

logical construct used to expose a relationship between discrete objects

NOTE Associations are used to indicate that separate data objects are related. Associations are represented like folders, and may be nested using a standard branched hierarchical tree structure.

EXAMPLE A time sequence, or user-defined groupings by content or capture session.

3.4

connection

transport-provided mechanism for establishing paths for transferring data between devices

3.5

datacode

16-bit unsigned integer whose Most Significant Nibble (4 bits) is used to indicate the category of code and whether the code value is standard or vendor-extended

3.6

data object

image or other type of data that typically exists in persistent storage of a DSPD or other device

3.7

dataset

transport-independent collection of one or more individual data items with known interpretations

NOTE Data sets are not necessarily opaque nor atomic to transport implementations.

3.8

Design Rule for Camera Filesystem

DCF

standard convention for camera filesystems which specifies the file format, foldering and naming conventions in order to promote file interoperability between conforming digital photography devices

3.9

device discovery

act of determining the set of all devices present on a particular transport or platform that are physically or logically accessible

3.10**Digital Still Photography Device
DSPD**

device with persistent storage that captures a two-dimensional digital still image

3.11**Digital Print Order Format
DPOF**

standardized ASCII file stored on removable media along with the image files that indicates how many copies of which images should be printed

NOTE DPOF also allows index prints, cropping, and text overlays to be specified.

3.12**enumeration**

act of creating an ordered increasing numerical list that contains one representative element for each member of a set

3.13**Exif/JPEG**

compressed file format for digital cameras in which the images are compressed using the baseline JPEG standard described in ISO 12234-2

NOTE In Exif, metadata and thumbnail, images are stored using TIFF tags within an application segment at the beginning of the JPEG file.

3.14**folder**

optional sub-structure in a hierarchical storage area that can contain data objects

3.15**FlashPix**

image file format, defined in *FlashPix Format Specification*, using a structured storage file containing metadata and a tiled, hierarchical image representation

NOTE The tiles in a FlashPix image are normally baseline JPEG images, and individual image tiles of a particular resolution can be easily accessed for rapid display and editing.

3.16**ICC profile**

data file that characterizes the colour characteristics of an image capture or image output device

3.17**IEEE 1394**

high-speed serial bus standardized by the IEEE (Institute of Electrical and Electronics Engineers) currently having clock rates of 100, 200 and 400 Mbits/sec

NOTE IEEE 1394 is often referred to as FireWire.

3.18**image aspect ratio**

ratio of the image width to the image height

3.19**image capture device**

device for converting a scene or a fixed image such as a print, film or transparency, to digital image data

3.20**image output device**

device that can render a digital image to hardcopy or softcopy media

3.21

in-band event

event transmitted on the same logical connection as operations and responses

NOTE Events are only asynchronous to the degree of data precision for which the transport implementation allows event interleaving.

3.22

initiator

device that initiates a conversation by opening a session, and issues all formal operations to the responder

NOTE The initiator is analogous to the client in the client/server paradigm.

3.23

International Imaging Industry Association

I3A

organization that serves to represent the common interests among manufacturers of imaging technology products

NOTE See <http://www.i3a.org>.

3.24

Infrared Data Association

IrDA

infrared wireless communication system that currently supports wireless communication at data rates between 9 600bps and 4Mbps.

3.25

Joint Photographic Experts Group

JPEG

specific image compression method defined in ISO/IEC 10918-1

3.26

LogicalStorageID

least significant sixteen bits of a StorageID

NOTE This value uniquely identifies one logical storage area within the physical store indicated in the PhysicalStorageID.

3.27

Most Significant Nibble

MSN

most-significant four bits of the most-significant byte

3.28

object aggregation

act of taking one or more location-specific lists of objects that exist on a particular device and grouping them together in one set

3.29

ObjectHandle

device-unique 32-bit unsigned integer assigned by a device to each data object in local persistent storage which is provided to external devices

NOTE External recipients of an ObjectHandle must use it to reference that piece of data in subsequent transactions. ObjectHandles are guaranteed to be persistent over at least a session.

3.30**out-of-band event**

event transmitted on a different logical connection as operations and responses

NOTE Out-of-band events are asynchronous from operation transactions.

3.31**Personal Computer****PC**

any personal computing device, which may employ various hardware architectures and operating systems

3.32**PhysicalStorageID**

most significant sixteen bits of a StorageID

NOTE This value uniquely identifies one physical storage area on a device, although there may be more than one logical store per physical store.

3.33**Portable Network Graphics****PNG**

extensible file format for lossless, portable, compressed storage of raster images

NOTE PNG supports indexed-colour, greyscale, truecolour and an optional alpha channel.

3.34**protocol**

defined mechanisms for exchanging data between devices

3.35**pull model**

use paradigm for DSPDs where the object receiver initiates the operation requests to transfer data objects from the sender

3.36**push model**

use paradigm for DSPDs where the object sender initiates the operation requests to transfer data objects to the receiver

3.37**QuickDraw picture**

file format consisting of sequences of saved drawing commands

NOTE QuickDraw files are commonly referred to as PICT files.

3.38**responder**

device that responds to operations from the initiator

NOTE The responder is analogous to a server in the client/server paradigm.

3.39**session**

logical connection between two devices defining a period of time during which obtained state information, such as handle persistence, may be relied upon

3.40**square pixel sampling**

image having equal sample spacing in the two orthogonal sampling directions

3.41

StorageID

device-specific four byte unsigned integer (UINT32) that represents a unique storage area that may contain data objects

NOTE The most significant sixteen bits of a StorageID represent the PhysicalStorageID, whilst the least significant sixteen bits of a StorageID represent the LogicalStorageID.

3.42

transport aggregation

act of taking one or more transport-specific lists of conforming devices that are logically or physically accessible in a system and grouping them in one set that spans all transports across the particular system

3.43

transport

means of attaching the digital capture device to some other digital device including a physical wire or a wireless connection

3.44

Universal Serial Bus

USB

digital interface for connecting up to 127 devices in a tiered-star topology

NOTE See <http://www.usb.org>.

4 Digital Still Photography Device Model

4.1 Overview

Digital Still Photography Devices (DSPDs) are used to acquire digitally encoded still images. These devices include persistent storage capability so that any digital images and other data acquired by the device are preserved across power cycle operations unless they are specifically deleted.

A DSPD might support many different features. This International Standard supports devices with a wide range of potential features. However, a small number of features is required for conformance with this International Standard, while many others are optional. Subclause 4.2 describes the required features and functionality. Annex A describes features that are not required for conformance, but should be implementable using this International Standard and its extension mechanisms.

Standard data formats for datatypes and datasets are described in Clause 5.

Clause 6 describes required and optional support for particular image and non-image formats and metadata. This clause also describes methods for associating data objects.

A particular feature set places requirements on the transports used to connect the DSPD to other devices. Clause 7 describes these requirements.

All DSPDs must store images in some form of storage area. Clause 8 describes the usage of these stores, as well as the methods for referencing them.

Clause 9 describes the roles of devices, sessions and transactions that transports are required to use in order to communicate with and/or between DSPDs. Clause 10 lists the standard operations, their corresponding optional operation codes and their usages. Standard responses to operations are defined in Clause 11. The use of events is mandatory in order to ensure synchronization between devices. Clause 12 describes events and their usages.

In order to expose device controls and manipulate properties in a common way, a standard set of device properties and their usages have been defined in Clause 13.

Clause 14, serves as a summary of the individual operations and events that are required to be supported by particular devices, as well as a checklist that can be used by implementers.

4.2 Baseline requirements

4.2.1 General

The requirements listed in 4.2.2 to 4.2.5 shall be met in order for a DSPD to conform to this International Standard.

4.2.2 Implementation of a suitable transport

The DSPD shall provide appropriate hardware and software support for at least one transport that meets the requirements specified in Clause 7.

4.2.3 Thumbnail support

The DSPS shall provide support for thumbnails as described in 6.2.

4.2.4 Standard Image and Data Reference Behaviour

In order to ensure interoperability, it is necessary to define a standard mechanism for describing image and data objects present on a device. The DSPD shall meet the requirements described in Clause 6.

4.2.5 Asynchronous Event Support

The DSPD shall be capable of generating and reacting to asynchronous events. Clause 12 describes events and their usages.

5 Data Format Specification

5.1 General format

5.1.1 Multibyte data

For the purposes of interpretability, all data fields showing internal content representations shall be read from left to right, in order of decreasing byte significance, commonly referred to as big-endian notation. Therefore, the left-most byte shall represent the Most Significant Byte (MSB), and the right-most byte shall represent the Least Significant Byte (LSB). The most significant four bits of the MSB are referred to as the Most Significant Nibble (MSN), while the least significant four bits of the LSB are referred to as the Least Significant Nibble (LSN). The actual multibyte format used on the wire is transport-specific, while the actual multibyte format used at the application interface is platform-specific.

5.1.2 Bit format

Bit fields presented in this International Standard are numbered so that the least significant bit is at the zero position, holding the right-most position in the field; e.g. the most significant bit of a UINT32 would be referred to as bit 31, while the least significant bit would be referred to as bit 0.

5.1.3 Hexadecimal notation

This International Standard uses hexadecimal notation as a means of concisely describing multibyte fields. All hexadecimal bytfields are represented with the prefix "0x". Following this prefix are pairs of characters, where each pair represents one byte, with the most significant byte appearing first, and the least significant byte appearing last.

5.2 Data types

5.2.1 Data type summary

The types of data that are defined in this International Standard as having specific interpretations of their data content, are listed in Table 1 — Data type summary.

Table 1 — Data type summary

Name	Size (bytes)	Format
OperationCode	2	Datacode (UINT16)
ResponseCode	2	Datacode (UINT16)
EventCode	2	Datacode (UINT16)
DevicePropCode	2	Datacode (UINT16)
ObjectFormatCode	2	Datacode (UINT16)
StorageID	4	Special (UINT32)
ObjectHandle	4	Handle (UINT32)
DateTime	Variable	String
DeviceInfo	Variable	Dataset
StorageInfo	Variable	Dataset
ObjectInfo	Variable	Dataset
DevicePropDesc	Variable	Dataset
DevicePropDescEnum	Variable	Enumerated form of DevicePropDesc
DevicePropDescRange	Variable	Range form of DevicePropDesc
Object	Variable	Variable

5.2.2 Datacodes

Datacodes are 16-bit unsigned integers (UINT16) with specified interpretations, used for the purposes of enumeration. In order to aid in visual interpretation, potential transport debugging, and to simplify some transport implementations, the primary and vendor-defined datacodes for operations, responses, data formats, events, and properties in this International Standard have mutually exclusive values. The most significant four bits of a datacode (Most Significant Nibble) shall have a particular bit pattern that identifies its code type. Therefore the allocation of these four bits to type specification infers that the minimum value of any enumerated datacode is 0 (xxxx0000-00000000) and the maximum value is 4,095 (xxxx1111-11111111).

It is strongly recommended that transport implementations use these codes directly in their binary representations, but this is not mandatory. Particular transport implementations may be unable to use the specified code systems for one or more code types, due to pre-existing structure formats for data-wrapping, or other constraints. Where it is possible to use the codes, they should be used. If one or more particular datacode types cannot be used, the transport implementation specification should still attempt to accommodate those datacode types that can be used. If the binary form suggested in this International Standard is not used for a particular datacode type, an appropriate corresponding enumerated identifier in an alternate form should be made available where possible for each datatype enumeration specified here, each having the same usage and definition as those specified in this International Standard. This allows for transport-aggregating abstractions in host software to use the codes defined in this International Standard, even though a particular code might not be transmitted across the wire for a particular transport in the binary

form specified. Transports may also need to perform multiple transactions over the wire in order to fulfill one operation defined in this International Standard, and therefore one operation code may not be sufficient.

For example, if a transport does not use the 16-bit OperationCodes, it should still provide an equivalent mechanism for the GetObject operation that supports the same usage defined in this International Standard. Another example would be a transport that uses OperationCodes for some operations but not others, because the transport in question possesses a built-in mechanism for performing the equivalent operation, and provides its own operation identification scheme for that operation.

Table 2 — Datacode formats

Bit 15	Bit 14	Bit 13	Bit 12	Bits 11-0	Code type
0	0	0	0	Any	Undefined (not a conforming code)
0	0	0	1	Any	Standard OperationCode
0	0	1	0	Any	Standard ResponseCode
0	0	1	1	Any	Standard ObjectFormatCode
0	1	0	0	Any	Standard EventCode
0	1	0	1	Any	Standard DevicePropCode
0	1	1	0	Any	Reserved
0	1	1	1	Any	Reserved
1	0	0	0	Any	Undefined
1	0	0	1	Any	Vendor-Defined OperationCode
1	0	1	0	Any	Vendor-Defined ResponseCode
1	0	1	1	Any	Vendor-Defined ObjectFormatCode
1	1	0	0	Any	Vendor-Defined EventCode
1	1	0	1	Any	Vendor-Defined DevicePropCode
1	1	1	0	Any	Reserved
1	1	1	1	Any	Reserved

It is a convention of this International Standard that all datacodes shall set bit 15 to 1 in order to indicate that the code value is vendor-specific, and therefore undefined in this International Standard. Codes indicating that they are vendor-defined should be interpreted according to the VendorExtensionID and VendorExtensionVersion fields of the DeviceInfo dataset as described in 5.5.2.

Individual datacode interpretations and usage are described in the appropriate section of this International Standard for each type of datacode.

5.3 Simple types

5.3.1 Simple type summary

The generic datatypes that may be used in this standard are listed in Table 3 — Datatype codes.

Table 3 — Datatype codes

Datatype code	Type	Description
0x0000	UNDEF	Undefined
0x0001	INT8	Signed 8 bit integer
0x0002	UINT8	Unsigned 8 bit integer
0x0003	INT16	Signed 16 bit integer
0x0004	UINT16	Unsigned 16 bit integer
0x0005	INT32	Signed 32 bit integer
0x0006	UINT32	Unsigned 32 bit integer
0x0007	INT64	Signed 64 bit integer
0x0008	UINT64	Unsigned 64 bit integer
0x0009	INT128	Signed 128 bit integer
0x000A	UINT128	Unsigned 128 bit integer
0x4001	AINT8	Array of Signed 8 bit integers
0x4002	AUINT8	Array of Unsigned 8 bit integers
0x4003	AINT16	Array of Signed 16 bit integers
0x4004	AUINT16	Array of Unsigned 16 bit integers
0x4005	AINT32	Array of Signed 32 bit integers
0x4006	AUINT32	Array of Unsigned 32 bit integers
0x4007	AINT64	Array of Signed 64 bit integers
0x4008	AUINT64	Array of Unsigned 64 bit integers
0x4009	AINT128	Array of Signed 128 bit integers
0x400A	AUINT128	Array of Unsigned 128 bit integers
0xFFFF	STR	Variable-length Unicode String
All other values	Undefined	Reserved

All datatypes having bit 14 set to 1 are uniform arrays of individual fixed-length types.

5.3.2 Integers

The most common data type that is required in this International Standard is integer. Integers may be signed or unsigned, and may be placed into arrays.

5.3.3 Handles

Handles are 32-bit device-unique unsigned integers (UINT32) that are exposed externally in order to allow consistent referencing to its logical and/or physical elements by other conforming devices. All handles act as UINT32 datatypes with the added constraint that they have individually unique values relative to the currently open session. Handles shall be persistent over at least a particular session, and may or may not be persistent over an entire power cycle, or even across power cycles. There is no significance to the value of a handle other than it is unique, and therefore they do not need to be consecutively assigned. The values 0x00000000 and 0xFFFFFFFF may not refer to any valid objects, and are reserved for context-specific meanings, such as “no handle,” “default handle,” or “all handles.” Any use of context-specific meanings shall be described in the appropriate clauses.

Handles are used to refer to image and non-image objects that are present on a device as well as objects that are expected to immediately become present, and in this context are referred to as ObjectHandles. ObjectHandles may refer to image or non-image objects that are capable of being retrieved as the response to an operation. The existence of an ObjectHandle infers the ability to produce an ObjectInfo dataset for the object that is referred to, as well as production of the object itself for object types that are not fully qualified by the ObjectInfo dataset. An association (e.g. a generic folder) is an example of an object type that is fully qualified by an ObjectInfo dataset, and therefore possesses no actual object to send. The type of data object that the ObjectHandle refers to may be determined by examining the ObjectFormatCode described in the data object's ObjectInfo dataset described in 5.5.3.

5.3.4 Decimal types

Fixed-point datatypes may be represented using integers by contextually specifying a scalar factor. This protocol does not currently require conventions for handling floating-point data. Transmitted data of this type are typically contained inside a data object that is opaque to this protocol.

5.3.5 Strings

5.3.5.1 String format

All strings shall consist of standard 2-byte Unicode characters (USC-2) encoded with UTF-16 as described in ISO/IEC10646-1, with the added constraint of having a maximum number of characters of 255. Strings shall be represented by a combination of two fields as described in Table 4. An unused string field shall be represented by specifying a length field of zero (0x00) and including no actual string bytes, resulting in a total PTP encoded string length of 1 byte.

Table 4 — String format

Dataset field	Size (bytes)	Data type
NumChars	1	UINT8
StringChars	Variable	Unicode null-terminated string

NumChars: Represents the number of characters in the string, including the terminating null character for non-empty strings. Permitted values are 0 to 255.

StringChars: This field holds the actual Unicode null-terminated string with 2 byte characters. This field shall not contain more than 255 characters, including the terminating null characters. This field is not present for empty strings.

5.3.5.2 DateTime String

When needed, the date and time shall be expressed using a compatible subset of ISO 8601 so that it can be easily parseable. This shall take the form of a Unicode string in the format “YYYYMMDDThhmmss.s” where YYYY is the year, MM is the month 01-12, DD is the day of the month 01-31, T is a constant character, hh is the hours since midnight 00-23, mm is the minutes 00-59 past the hour, and ss.s is the seconds past the minute, with the “.s” being optional tenths of a second past the second. This string can optionally be appended with Z to indicate UTC, or +/-hhmm to indicate that the time is relative to a time zone. Appending neither indicates that the time zone is unspecified.

5.4 Arrays

An array is a concatenation of one or more elements of the same fixed-length type. All array datasets contain a field representing the total number of elements contained in the array. See Table 5. The datatype, element size and interpretation of the individual elements shall be context-specific, and therefore not explicit within the

array structure. An empty array would consist of only a single UINT32 value of 0x00000000. For internal array referencing purposes, arrays shall be treated as zero-based.

Table 5 — Array format

Field	Size (bytes)	Format
NumElements	4	UINT32
ArrayEntry[0]	<i>ElementSize</i>	Special
ArrayEntry[1]	<i>ElementSize</i>	Special
...	<i>ElementSize</i>	...
ArrayEntry[NumElements-1]	<i>ElementSize</i>	Special

NumElements: Represents the total number of elements contained in the array, and therefore is equal to the number of ArrayEntry fields. This value may be 0x00000000, which indicates an empty array that would only be 4 total bytes in size.

ArrayEntry (*n*): The total number of these fields shall equal the value held by the NumElements field. The size and interpretation (i.e. datatype) of each ArrayEntry is context-dependent, but should be the same for all elements in an array. These fields are not present for empty arrays.

5.5 Datasets

5.5.1 Dataset usage

For the purposes of this International Standard, the term dataset is defined as a transport-independent collection of one or more individual data items with defined interpretations. A dataset serves as a set of requirements for the data that must be accounted for by an opposing device as the result of a particular operation or event. Individual data items may hold other embedded data items. A transport implementation may or may not need to place its own wrappers around the dataset, split datasets into multiple pieces, pack the fields a particular way or pass different fields using different mechanisms.

In order to avoid inconsistencies, transport implementations should reference the field ordering in this specification when defining their implementations of the datasets. If the transport is wrapping the dataset completely, it should retain the field ordering defined in this specification unless a distinct benefit can be obtained by not doing so. The particular byte packing mechanism for individual fields must be clearly defined, such as little-endian or big-endian.

All unused fields in all datasets shall initially be set to their default value. If a field does not have an explicit default value, the implicit default value is zero for integer datatypes, and the empty string for strings. Any fields in a dataset which are unused are considered to have no default value, and should be set to zero.

If datasets are changed in future versions of this International Standard, fields will only be added, never deleted. No existing fields will be re-defined in future versions of this International Standard, and the specified field ordering shall remain constant. Unless otherwise indicated, reserved fields in datasets are required to be transmitted by the transport implementation, but should be set to 0x00000000 for integers and to an empty string for strings.

5.5.2 DeviceInfo dataset

See Table 6.

This dataset is used to hold the description information for a device. The initiator can obtain this dataset from the responder without opening a session with the device. This dataset holds data that describe the device and its capabilities. This information is only static if the device capabilities cannot change during a session, which would be indicated by a change in the FunctionalMode value in the dataset; e.g. if the device goes into a sleep mode in which it can still respond to GetDeviceInfo requests, the data in this dataset should reflect the capabilities of the device while it is in that mode only (including any operations and properties needed to change the FunctionalMode, if this is allowed remotely). If the power state or the capabilities of the device change (due to a FunctionalMode change), a DeviceInfoChanged event shall be issued to all sessions in order to indicate how its capabilities have changed.

Table 6 — DeviceInfo dataset

Dataset field	Field order	Size (bytes)	Data type
StandardVersion	1	2	UINT16
VendorExtensionID	2	4	UINT32
VendorExtensionVersion	3	2	UINT16
VendorExtensionDesc	4	Variable	String
FunctionalMode	5	2	UINT16
OperationsSupported	6	Variable	OperationCode Array
EventsSupported	7	Variable	EventCode Array
DevicePropertiesSupported	8	Variable	DevicePropCode Array
CaptureFormats	9	Variable	ObjectFormatCode Array
ImageFormats	10	Variable	ObjectFormatCode Array
Manufacturer	11	Variable	String
Model	12	Variable	String
DeviceVersion	13	Variable	String
SerialNumber	14	Variable	String

All optional strings that are not provided should consist of an empty string. Subclause 5.3.5 describes the use of strings.

Standard Version: highest version of the standard that the device can support. This represents the standard version expressed in hundredths (e.g. 1.32 would be stored as 132).

VendorExtensionID: provides the context for interpretation of any vendor extensions used by this device. If no extensions are supported, this field shall be set to 0x00000000. If vendor-specific codes of any type are used, this field is mandatory, and should not be set to 0x00000000. These IDs are assigned by PIMA, as described in 9.5.

VendorExtensionVersion: the vendor-specific version number of extensions that are supported. This shall be expressed in hundredths (e.g. 1.32 would be stored as 132).

VendorExtensionDesc: an optional string used to hold a human-readable description of the VendorExtensionID. This field should only be used for informational purposes, and not as the context for the interpretation of vendor-extensions.

FunctionalMode: an optional field used to hold the functional mode. This field controls whether the device is in an alternate mode that provides a different set of capabilities (i.e. supported operations, events, etc.). If the device only supports one mode, this value should always be zero. Table 7 describes the standard functional modes.

Table 7 — FunctionalMode values

Value	Description
0x0000	Standard Mode
0x0001	Sleep State
All other values with bit 15 set to zero	Reserved
All values with bit 15 set to 1	Vendor-Defined

The functional mode information is held by the device as a device property. This property is described in 13.5.2. In order to change the functional mode of the device remotely, a session needs to be opened with the device, and the SetDeviceProp operation needs to be used.

OperationsSupported: This field is an array of OperationCodes representing operations that the device is currently supporting, given the FunctionalMode indicated. Subclause 10.3 describes these codes.

EventsSupported: This field is an array of EventCodes representing the events that are currently generated by the device in appropriate situations, given the FunctionalMode indicated. Subclause 12.6 describes these codes.

DevicePropertiesSupported: This field is an array of DevicePropCodes representing DeviceProperties that are currently exposed for reading and/or modification, given the FunctionalMode indicated. Subclause 13.5 describes these codes.

CaptureFormats: the list of data formats in ObjectFormatCode form that the device can create using an InitiateCapture operation and/or an InitiateOpenCapture operation, given the FunctionalMode indicated. These are typically image object formats, but can include any object format that can be fully captured using a single trigger mechanism, or an initiate/terminate mechanism. All image object formats that a device can capture data in shall be listed prior to any non-image object formats, and shall be in preferential order such that the default capture format is first. ObjectFormats are described in Clause 6.

ImageFormats: the list of image formats in ObjectFormatCode form that the device supports in order of highest preference to lowest preference. Support for an image format refers to the ability to interpret image file contents according to that format's specifications, for display and/or manipulation purposes. For image output devices, this field represents the image formats that the output device is capable of outputting. This field does not describe any device format-translation capabilities. Refer to Clause 6 for more information on image format support.

Manufacturer: an optional human-readable string used to hold the responder's manufacturer.

Model: an optional human-readable string used to communicate the responder's model name.

DeviceVersion: an optional string used to communicate the responder's firmware or software version in a vendor-specific way

SerialNumber: an optional string used to communicate the responder's serial number, which is defined as a unique value among all devices sharing identical Model and Device Version fields. If unique serial numbers are not supported, this field shall be set to the empty string. The presence of a non-null string in the SerialNumber field for one device infers that this field is non-zero and unique among all devices of that model and version.

5.5.3 ObjectInfo dataset

See Table 8.

This dataset is used to define the information about data objects in persistent store, as well as optional information if the data is known to be an image or an association object. It is required that these data items be accounted for in response to a GetObjectInfo operation. If the data is not known to be an image, or the image information is unavailable, the image-specific fields shall be set to zero. Objects of type Association are fully qualified by the ObjectInfo dataset.

Table 8 — ObjectInfo Dataset

Dataset field	Field order	Size (bytes)	Data type	Image specific	Association specific
StorageID	1	4	StorageID	No	No
ObjectFormat	2	2	ObjectFormatCode	No	No
ProtectionStatus	3	2	UINT16	No	No
ObjectCompressedSize	4	4	UINT32	No	No
ThumbFormat	5	2	ObjectFormatCode	Yes	No
ThumbCompressedSize	6	4	UINT32	Yes	No
ThumbPixWidth	7	4	UINT32	Yes	No
ThumbPixHeight	8	4	UINT32	Yes	No
ImagePixWidth	9	4	UINT32	Yes	No
ImagePixHeight	10	4	UINT32	Yes	No
ImageBitDepth	11	4	UINT32	Yes	No
ParentObject	12	4	ObjectHandle	No	No
AssociationType	13	2	AssociationCode	No	Yes
AssociationDesc	14	4	AssociationDesc	No	Yes
SequenceNumber	15	4	UINT32	No	No
Filename	16	Variable	String	No	No
CaptureDate	17	Variable	DateTime String	No	No
ModificationDate	18	Variable	DateTime String	No	No
Keywords	19	Variable	String	No	No

StorageID: the StorageID of the device's store in which the image resides. See 8.1 for a description of StorageIDs.

ObjectFormat: indicates ObjectFormatCode of the object. See 6.3 for a list of these codes.

ObjectCompressedSize: the size of the buffer, in bytes, needed to hold the entire binary object. This field may be used for memory allocation purposes in object receivers by transport implementations.

ProtectionStatus: an optional field representing the write-protection status of the data object. Objects that are protected may not be deleted as the result of any operations specified in this International Standard without first separately removing their protection status in a separate transaction. The values are enumerated according to Table 9.

Table 9 — ObjectInfo ProtectionStatus Values

Value	Description
0x0000	No protection
0x0001	Read-only
All other values	Reserved

All values not explicitly defined are reserved for future use. This protection field is distinctly different in scope from the AccessCapability field present in the StorageInfo dataset, described in 5.5.4. If an attempt is made to delete an object, success will only occur if the ProtectionStatus of the object is 0x0000 and the AccessCapability of the store allows deletion. If a device does not support object protection, this field should always be set to 0x0000, and the SetProtection operation should not be supported. Refer to 5.5.4 for a description of the StorageInfo dataset.

ThumbFormat: indicates ObjectFormat of the thumbnail. In order for an object to be referred to as an image, it must be able to produce a thumbnail as the response to a request. Therefore, this value should only be 0x00000000 for the case of non-image objects. Refer to 6.3 for a list of ObjectFormatCodes.

ThumbCompressedSize: the size of the buffer needed to hold the thumbnail. This field may be used for memory allocation purposes. In order for an object to be referred to as an image, it must be able to produce a thumbnail as the response to a request. Therefore, this value should only be 0x00000000 for the case of non-image objects.

ThumbPixWidth: an optional field representing the width of the thumbnail in pixels. If this field is not supported or the object is not an image, the value 0x00000000 shall be used.

ThumbPixHeight: an optional field representing the height of the thumbnail in pixels. If this field is not supported or the object is not an image, the value 0x00000000 shall be used.

ImgPixWidth: an optional field representing the width of the image in pixels. If the data are not known to be an image, this field should be set to 0x00000000. The purpose of this field is to enable an application to provide the width information to a user prior to transferring the image. If this field is not supported, the value 0x00000000 shall be used.

ImgPixHeight: an optional field representing the height of the image in pixels. If the data are not known to be an image, this field should be set to 0x00000000. The purpose of this field is to enable an application to provide the height information to a user prior to transferring the image. If this field is not supported, the value 0x00000000 shall be used.

ImgBitDepth: an optional field representing the total number of bits per pixel of the uncompressed image. If the data are not known to be an image, this field should be set to 0x00000000. The purpose of this field is to enable an application to provide the bit depth information to a user prior to transferring the image. This field does not attempt to specify the number of bits assigned to particular colour channels, but instead represents the total number of bits used to describe one pixel. If this field is not supported, the value 0x00000000 shall be used. This field should not be used for memory allocation purposes, but is strictly information that is typically inside of an image object, that may affect whether or not a user wishes to transfer the image, and therefore is exposed prior to object transfer in the ObjectInfo dataset.

ParentObject: indicates the handle of the object that is the parent of this object. The ParentObject must be of object type association. If the device does not support associations, or the object is in the “root” of the hierarchical store, then this value should be set to 0x00000000.

AssociationType: a field that is only used for objects of type association. This code indicates the type of association. Refer to 6.5 for a description of associations and a list of defined types. If the object is not an association, this field should be set to 0x0000.

AssociationDesc: This field is used to hold a descriptor parameter for the association, and may therefore only be non-zero if the AssociationType is non-zero. The interpretation of this field is dependent upon the particular AssociationType, and is only used for certain types of association. If unused, this field should be set to 0x00000000. Refer to 6.5 for information on this descriptor.

SequenceNumber: This field is optional, and is only used if the object is a member of an association, and only if the association is ordered. If the object is not a member of an ordered association, this value should be set to 0x00000000. These numbers should be created consecutively. However, to be a valid sequence, they do not need to be consecutive, but only monotonically increasing. Therefore, if a data object in the sequence is deleted, the SequenceNumbers of the other objects in the ordered association do not need to be renumbered, and examination of the sequential numbers will indicate a possibly deleted object by the missing sequence number.

Filename: an optional string representing filename information. This field should not include any filesystem path information, but only the name of the file or directory itself. The interpretation of this string is dependent upon the FilenameFormat field in the StorageInfo dataset that describes the logical storage area in which this object is stored. See 5.5.4 for information on this field.

CaptureDate: a static optional field representing the time that the data object was initially captured. This is not necessarily the same as any date held in the ModificationDate field. This dataset uses the DateTime string described in 5.3.5.2.

ModificationDate: an optional field representing the time of last modification of the data object. This is not necessarily the same as the CaptureDate field. This dataset uses the DateTime string described in 5.3.5.2.

Keywords: an optional string representing keywords associated with the image. Each keyword shall be separated by a space. A keyword that consists of more than one word shall use underscore (_) characters to separate individual words within one keyword.

5.5.4 StorageInfo dataset

See Table 10.

This dataset is used to hold the state information for a storage device.

Table 10 — StorageInfo dataset

Dataset field	Field order	Length (bytes)	Data type
StorageType	1	2	UINT16
FilesystemType	2	2	UINT16
AccessCapability	3	2	UINT16
MaxCapacity	4	8	UINT64
FreeSpaceInBytes	5	8	UINT64
FreeSpaceInImages	6	4	UINT32
StorageDescription	7	Variable	String
VolumeLabel	8	Variable	String

StorageType: the code that identifies the type of storage, particularly whether the store is inherently random-access or read-only memory, and whether it is fixed or removable media. See Table 11.

Table 11 — Storage types

Code value	Storage type
0x0000	Undefined
0x0001	Fixed ROM
0x0002	Removable ROM
0x0003	Fixed RAM
0x0004	Removable RAM
All other values	Reserved

All undefined values are reserved for future use.

FilesystemType: This optional code indicates the type of filesystem present on the device. This field may be used to determine the filenaming convention used by the storage device, as well as to determine whether support for a hierarchical system is present. See Table 12. If the storage device is DCF-conformant, it shall be so indicated here.

Table 12 — Filesystemtype values

Value	Description
0x0000	Undefined
0x0001	Generic flat
0x0002	Generic hierarchical
0x0003	DCF
All other values with bit 15 set to 0	Reserved
All values with bit 15 set to 1	Vendor-defined

All values having bit 31 set to zero are reserved for future use. If a proprietary implementation wishes to extend the interpretation of this field, bit 31 should be set to 1.

AccessCapability: This field indicates whether the store is read-write or read-only. If the store is read-only, deletion may or may not be allowed. The permitted values are described in Table 13. Read-write is only valid if the StorageType is non-ROM, as described in the StorageType field above.

Table 13 — StorageInfo AccessCapability values

Value	Description
0x0000	Read-write
0x0001	Read-only without object deletion
0x0002	Read-only with object deletion
All other values	Reserved

All values having bit 15 set to zero are reserved for future use. If a proprietary implementation wishes to extend the interpretation of this field, bit 15 should be set to 1.

MaxCapacity: This is an optional field that indicates the total storage capacity of the store in bytes. If this field is unused, it should report 0xFFFFFFFF.

FreeSpaceInBytes: the amount of free space that is available in the store in bytes. If this value is not useful for the device, it may set this field to 0xFFFFFFFF and rely upon the FreeSpaceInImages field instead.

FreeSpaceInImages: the number of images that may still be captured in this store according to the current image capture settings of the device. If the device does not implement this capability, this field should be set to 0xFFFFFFFF. This field may be used for devices that do not report FreeSpaceInBytes, or the two fields may be used in combination.

StorageDescription: an optional field that may be used for a human-readable text description of the storage device. This should be used for storage-type specific information as opposed to volume-specific information. Examples would be “Type I Compact Flash,” or “3.5-inch 1.44 MB Floppy”. If unused, this field should be set to the empty string.

VolumeLabel: an optional field that may be used to hold the volume label of the storage device, if such a label exists and is known. If unused, this field should be set to the empty string.

6 Image and Data Object Formats

6.1 Object usage

A data object is defined as an image or other type of data that exists in persistent storage of a DSPD or other device. This International Standard specifies how image and data objects are transferred between a digital still photography device (DSPD) and other devices, but it does not specify how they are stored within such devices. A DSPD conforming to this International Standard shall transfer images to other devices using a particular data or datafile format for storage. The DSPD shall identify the data format used for the main (e.g. full size) image transferred, and shall provide a thumbnail (e.g. reduced size) image using one of the two thumbnail image file formats defined in this clause. The image file formats used to transfer the main image shall be either:

- Exif/JPEG version 2.2, the preferred format;
- one of the permitted image file formats listed in Table 14 — ObjectFormatCodes;
- a proprietary image file format.

All devices conforming to this International Standard which receive images, shall be capable of receiving (but not necessarily displaying) image files using any of these file formats. In addition, if the receiving device displays images, it shall be capable of decoding and displaying both of the thumbnail image file formats defined in this clause.

For all image and data objects, an ObjectFormatCode is provided in the ObjectInfo dataset to specify the format, as described in 5.5.3. Setting bit 31 of this code can be used in conjunction with the VendorExtensionID in the DeviceInfo dataset to create a vendor-extended ObjectFormatCode to handle transfer of non-standard file formats.

Table 14 — ObjectFormatCodes

Object FormatCode	Type	Format	Description
0x3000	A	Undefined	Undefined non-image object
0x3001	A	Association	Association (e.g. folder)
0x3002	A	Script	Device-model-specific script
0x3003	A	Executable	Device-model-specific binary executable
0x3004	A	Text	Text file
0x3005	A	HTML	HyperText Markup Language file (text)
0x3006	A	DPOF	Digital Print Order Format file (text)
0x3007	A	AIFF	Audio clip
0x3008	A	WAV	Audio clip
0x3009	A	MP3	Audio clip
0x300A	A	AVI	Video clip
0x300B	A	MPEG	Video clip
0x300C	A	ASF	Microsoft Advanced Streaming Format (video)
0x300D	A	QuickTime	Apple QuickTime Video Format
0x300E	A	XML	eXtensible Markup Language file
0x3800	I	Undefined	Unknown image object
0x3801	I	Exif/JPEG	Exchangeable File Format, JEITA standard
0x3802	I	TIFF/EP	Tag Image File Format for Electronic Photography
0x3803	I	FlashPix	Structured Storage Image Format
0x3804	I	BMP	Microsoft Windows Bitmap file
0x3805	I	CIFF	Canon Camera Image File Format
0x3806	I	Undefined	Reserved
0x3807	I	GIF	Graphics Interchange Format
0x3808	I	JFIF	JPEG File Interchange Format
0x3809	I	PCD	PhotoCD Image Pac
0x380A	I	PICT	Quickdraw Image Format
0x380B	I	PNG	Portable Network Graphics
0x380C	I	Undefined	Reserved
0x380D	I	TIFF	Tag Image File Format
0x380E	I	TIFF/IT	Tag Image File Format for Image Technology
0x380F	I	JP2	JPEG2000 Baseline File Format
0x3810	I	JPX	JPEG2000 Extended File Format
All other codes with MSN of 0011	Any	Undefined	Reserved for future use
All other codes with MSN of 1011	Any	Vendor-defined	Vendor-defined

Type: Image File Format (I); Ancillary Data File Format (A)

6.2 Thumbnail formats

6.2.1 Permitted thumbnail formats

The thumbnail images provided by a DSPD shall be either compressed JPEG images or uncompressed TIFF images. Compressed JPEG images are preferred.

The device may optionally be capable of producing a thumbnail for non-still-image object formats, such as video clips, audio formats, etc. The method that a device should use to generate a thumbnail from these object types is not specified. This capability would be apparent if the device correctly responded to a GetThumb operation request for a data object with a DataFormat that is a non-still-image type.

6.2.2 Compressed JPEG thumbnail image files

The format of compressed thumbnail files shall be a JPEG interchange file using the baseline process specified in Table 1 of ISO/IEC 10918-1:1994. This requires that the image file use:

- DCT-based image compression process;
- 8-bit samples within each component;
- Baseline sequential (non-progressive) process;
- Huffman coding with 2 AC and 2 DC tables.

The baseline image file format is further restricted in that it shall have:

- square pixel sampling;
- a single interleaved scan (e.g. Y, Cr, Cb interleaved blocks);
- sRGB colour space as defined in IEC 61966-2-1;
- 3 colour components: Y, Cr, Cb derived from the sRGB signals as follows, as specified in ITU-R BT.601:

$$Y = 0,299 R + 0,587 G + 0,114 B$$

$$Cb = (-0,299R - 0,587 G + 0,886B) * 0,564 + \text{offset}$$

$$Cr = (-0,701R - 0,587 G + 0,114B) * 0,713 + \text{offset}$$
 or a single (luminance) component;
- either 4:2:2 or 4:2:0 Y:Cb:Cr spatially centered colour subsampling or Y:Cb:Cr co-sited subsampling. Writers may use either option. Readers shall support both options.

NOTE These features are all requirements of the Exif version 2.2 specification.

In addition, it is preferred that the thumbnails meet the thumbnail image data format requirements specified in section 3.3.6 of Design Rule for Camera File system (DCF), version 1.0. These requirements include:

- JPEG compression using 4:2:2 chrominance sampling and the “typical” Huffman table provided in ISO/IEC 10918-1:1994;
- 160 × 120 pixel image record with a 4:3 aspect ratio.

6.2.3 Uncompressed TIFF thumbnail image files

The format of the uncompressed thumbnail images shall meet the requirements for the TIFF/EP format described in ISO 12234-2:2001. The thumbnail image shall have a compression tag value = 1 (no compression) with the thumbnail image contained within IFD0.

6.3 ObjectFormatCodes

A list of object formats is given in Table 14. An ObjectFormatCode is a 16-bit unsigned integer (UNIT16) that represents the format of an image or data object that resides on a DSPD. Setting bit 15 to 1 in the ObjectFormatCode indicates a vendor-defined format. All ObjectFormatCodes that represent image formats shall also have bit 11 set to 1, including those that are vendor-defined.

6.4 Object format version identification

The version of the object format should be contained in the data object in a context-specific manner. Support for a particular ObjectFormatCode implies that the device possesses the capability to read the internal structure of the data object in a way that is particular to its format, and this includes the discovery and interpretation of any version information that may exist. The format for specifying the version information is dependent upon the versioning methodology used by the particular format. Formats that change over time should remain backward compatible with older formats. However, if backward compatibility is not retained for a certain format, the specific format for that version and above should be considered as a separate format, and therefore a new ObjectFormatCode should be assigned to the new versions of that format.

6.5 Data object association

6.5.1 Association usage

This International Standard provides an optional method for associating related image and data objects, and this mechanism is what is used for representing folders and filesystems. Associations are represented using objects that are of type association. All of the objects that are part of an association shall be in the branch of the object tree underneath the corresponding association, in a folder-like manner. The association to which an object belongs may be determined by examining the ParentObject fields of each object's ObjectInfo dataset.

6.5.2 Association sub-types

There are different sub-types of associations. The sub-type is specified in the AssociationType field of the ObjectInfo dataset of the association object. Table 15 lists the various associations that may be used.

Table 15 — Association sub-types

AssociationCode	AssociationType	AssociationDesc interpretation
0x0000	Undefined	Undefined
0x0001	GenericFolder	Unused
0x0002	Album	Reserved
0x0003	TimeSequence	DefaultPlaybackDelta
0x0004	HorizontalPanoramic	Unused
0x0005	VerticalPanoramic	Unused
0x0006	2DPanoramic	ImagesPerRow
0x0007	AncillaryData	Undefined
All other values with bit 15 set to 0	Reserved	Undefined
All values with bit 15 set to 1	Vendor-defined	Vendor-defined

GenericFolder: This association sub-type is used to represent a folder that may hold any type of object, and is analogous to the standard folder present in most filesystems. This association is typically used to represent a local grouping of objects, with no other relationship implied.

Album: This association sub-type is the same as a folder but is used to hold image and data objects that have logical groupings according to content, capture sessions or any other unspecified user-determined grouping. These are typically created by a user or automation technique. Some devices may wish to expose albums to the user but not all generic folders. Devices that do not distinguish between albums and folders should only use the AssociationType of GenericFolder. The AssociationDesc field is reserved for future definition by this International Standard, and for devices that support this version of the specification, shall be set to 0x00000000.

TimeSequence: indicates that the data objects are part of a sequence of data captures that make up a set of time-ordered data of the same subject. This association is used to represent time-lapse or burst sequences. The order is interpreted to be sequential by capture time from first captured to last, and is indicated by the increasing values of the SequenceNumber fields in the ObjectInfo dataset for each object. If known, the AssociationDesc acts as a DefaultPlaybackDelta, and should be set to the desired time in milliseconds in order to delay between each object if exposing them sequentially in real-time. If unknown, this value should be set to 0x00000000.

HorizontalPanoramic: indicates that the associated data objects make up a panoramic series of images that are arranged side-by-side, in a horizontal fashion. The order of the sequence, from left to right when facing the subject, is indicated by the increasing values of the SequenceNumber fields in each object. The AssociationDesc is unused, and should be set to 0x00000000; e.g. four images would have SequenceNumbers assigned as shown in Figure 1.

1	2	3	4
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Figure 1 — HorizontalPanoramic SequenceNumber Example

VerticalPanoramic: indicates that the associated data objects make up a panoramic series of images that are arranged bottom-to-top, in a vertical fashion. The order of the sequence, from bottom to top when facing the subject, is indicated by the increasing values of the SequenceNumber fields in each object. The AssociationDesc is unused, and should be set to 0x00000000; e.g. four images would have SequenceNumbers assigned as shown on Figure 2.

4
3
2
1

Figure 2 — VerticalPanoramic SequenceNumber Example

2DPanoramic: indicates that the associated data objects make up a two-dimensional panoramic series of images that are arranged left-to-right and bottom-to-top in adjacent or overlapping horizontal strips. The order of the sequence, from bottom-left to top-right when facing the subject, is indicated by the increasing values of the SequenceNumber fields in each object. The AssociationDesc is used to indicate the number of images in each row; e.g. sixteen images arranged in a 4 × 4 2DPanoramic would have SequenceNumbers assigned as shown in Figure 3.

13	14	15	16
9	10	11	12
5	6	7	8
1	2	3	4

Figure 3 — 2DPanoramic SequenceNumber Example

AncillaryData: indicate that the association represents one or more non-image objects being associated with an image object; e.g. an image capture that also stores independent audio text files that are temporally related to the image capture may use this type of association to indicate the relationship. Optionally, if the individual objects are ordered (e.g. multiple temporally-related sound files), the SequenceNumber field of each object's ObjectInfo dataset should contain increasing integers. If the individual objects are unordered, the SequenceNumbers for those objects should be set to 0x00000000. In this case, the AssociationDesc fields for those objects are unused, and should be set to 0x00000000.

6.5.3 Unordered Associations

Unordered associations are the standard type of association used to relate data objects non-sequentially, such as filesystem folders, albums, etc. Objects that belong to unordered associations always possess ObjectInfo datasets with SequenceNumber fields equal to zero.

6.5.4 Ordered associations

Ordered associations are an optional mechanism that may be used to represent associated objects, some or all of which are sequential in some context-specific fashion. Objects that are part of the ordered association may or may not have a non-zero SequenceNumber.

- a) Objects of any type may be children of ordered associations, including other ordered or unordered associations.
- b) Sequence numbers are used to order a proper or improper subset of child objects of a particular ordered association.
- c) The value of a sequence number is only relevant between objects at the same level of the same hierarchical tree branch (i.e. siblings with the common ordered association parent).
- d) The value of a sequence number is only persistent while the child/parent relationship is intact. If an object that is part of an ordered association is assigned a new parent, the object's SequenceNumber should be invalidated (i.e. set to zero or to a new appropriate SequenceNumber if the new parent is an ordered association).
- e) Not all child objects of an ordered association need to have a sequence number. Objects without sequence numbers whose parent is an ordered association are considered related to the entire set of sequential objects, but are not a proper part of the sequence.
- f) Non-zero sequence numbers among objects in an ordered association shall be unique.

6.5.5 Associations as Filesystem Folders

Unordered associations may be used to represent filesystem layouts of data objects within a store. This allows representation of filesystems that are not dependent upon particular pathname conventions. Each object contains a ParentObject field in its ObjectInfo dataset. This ParentObject is the ObjectHandle of the association object that "contains" this data object. This mechanism serves to expose a bottom-up singly-linked list that may be used to reconstruct the filesystem hierarchy, which may be stored on the opposing device optionally using a different data structure (e.g. double-linked list, top-down enumerator, etc.) Only objects of type Association may serve as ParentObjects. The bottom-up nature of the child/parent link information results in ParentObjects that are stateless with regard to which objects are their children, and infers that if a child is deleted, the parent and the ObjectInfo dataset describing it do not need to be updated. If the object exists in the "root" of the store, the value 0x00000000 shall be used for its ParentObject. Pathnames may be recreated using the Filename and ParentObject fields of each ObjectInfo dataset, inserting the separators of choice, in a platform-specific manner. Some receiving devices may not support exposing a hierarchical structure, in which case objects of type association would be ignored. In other cases, devices may only wish to show associations of type album as hierarchical. For an example of representing a filesystem using associations, see D.2.

7 Transport requirements

7.1 Disconnection events

The transport shall be capable of notifying the overlying agents or system software that a device has been disconnected from its previous environment. This environment may be either a wire interconnect or a wireless medium.

7.2 Reliable, error-free channel

The transport shall provide a reliable connection between devices comprising a session, assuming that the connection is not physically broken or terminated. This may be provided in a transport-specific manner using error correction codes, retry scenarios and fault recovery.

7.3 Asynchronous event support

Since a conforming device is required to notify other devices about any changes in its operational status, configuration, available objects or stores, the transport shall provide a mechanism that supports the generation of outgoing events and servicing of incoming events asynchronously from operations, responses or data transfers. In order to generate events, some transports may require initiation of an operation while others may require a notification mechanism.

7.4 Device discovery and enumeration

Transports shall possess the capability of discovering and enumerating connected devices.

7.5 Specific transports

7.5.1 USB

Devices using this transport shall conform to the following specifications:

- *USB Specification*, Version 1.1, USB Implementer's Forum, Sept. 23rd, 1998^[2].
- Universal Serial Bus Still Image Capture Device Definition, Version 1.0, USB Implementer's Forum, July 11, 2000^[3].

7.5.2 IEEE 1394

Devices using this transport IEEE 1394 shall conform to the following specifications:

- IEEE Std 1394-1995^[4], Standard for High Performance Serial Bus.
- PTP-on-SBP (Picture Transfer Protocol on Serial Bus Protocol), 1394 Trade Association^[6] (under development).

8 Persistent Storage

8.1 StorageID

Every local persistent storage area on a device is represented by a unique, 4-byte, unsigned integer (UINT32) referred to as a StorageID. Each StorageID has two parts. The sixteen most significant bits represent a physical storage device, while the lower sixteen least significant bits represent a logical storage area within a physical store.