

UNITED STATES OF AMERICA

v.

KHALID SHAIKH MOHAMMAD, WALID
MUHAMMAD SALIH MUBARAK BIN
'ATTASH, RAMZI BINALSHIBH, ALI
ABDUL AZIZ ALI, MUSTAFA AHMED
ADAM AL HAWSAWI

AE306 (AAA)

Defense Motion to Compel Discovery
Of Metadata from
Electronically Stored Raid Discovery

30 June 2014

1. **Timeliness:** This motion is timely filed.

2. **Relief Sought:** The military commission should compel the government to produce discovery regarding the raids at which it gathered evidence in native file format, which preserves the intact metadata of electronically stored information.

3. **Overview:**

4. **Burden and Standard of Proof:** The burden of persuasion on this motion to compel discovery rests with the defense.¹

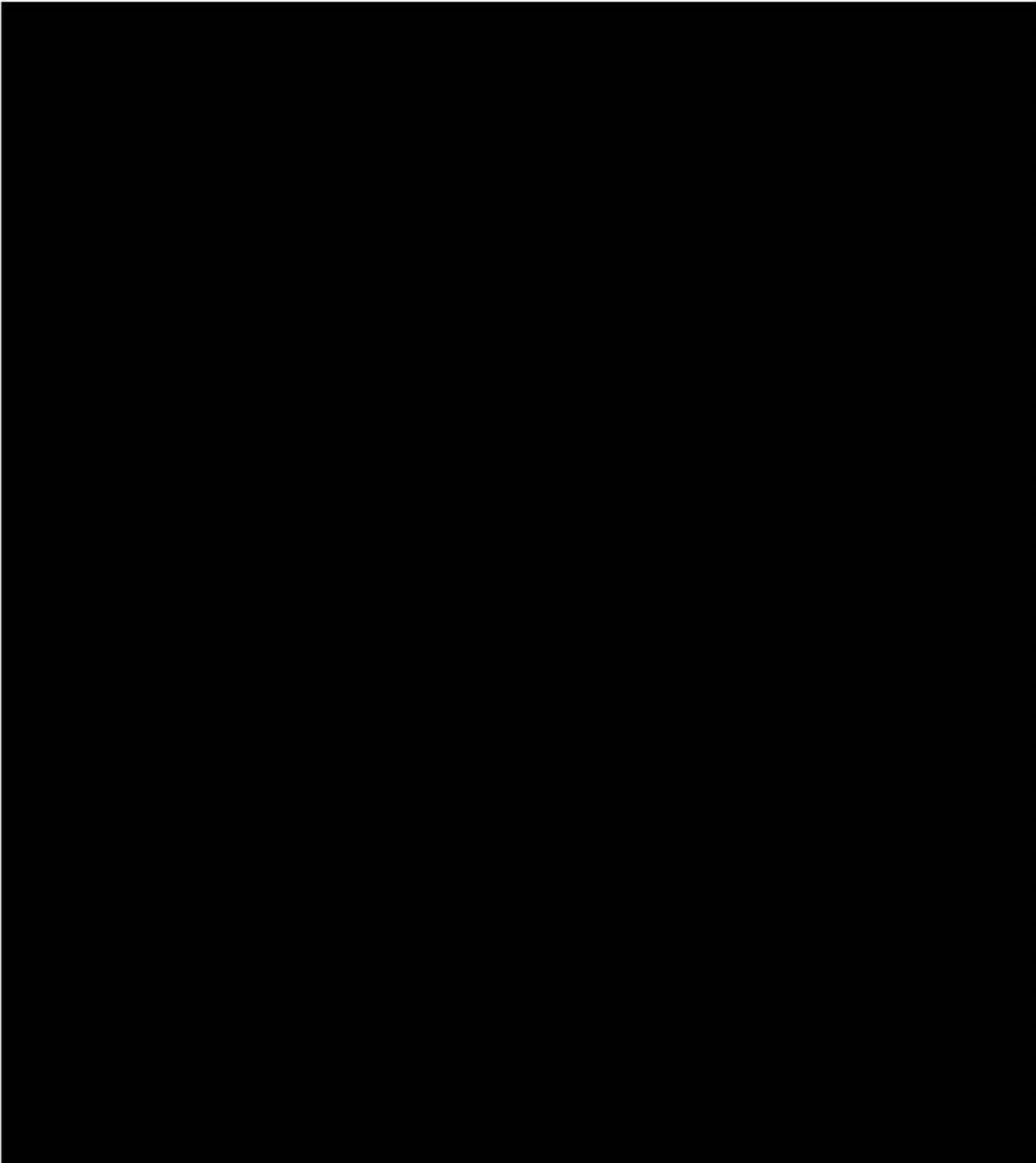
5. **Facts:**

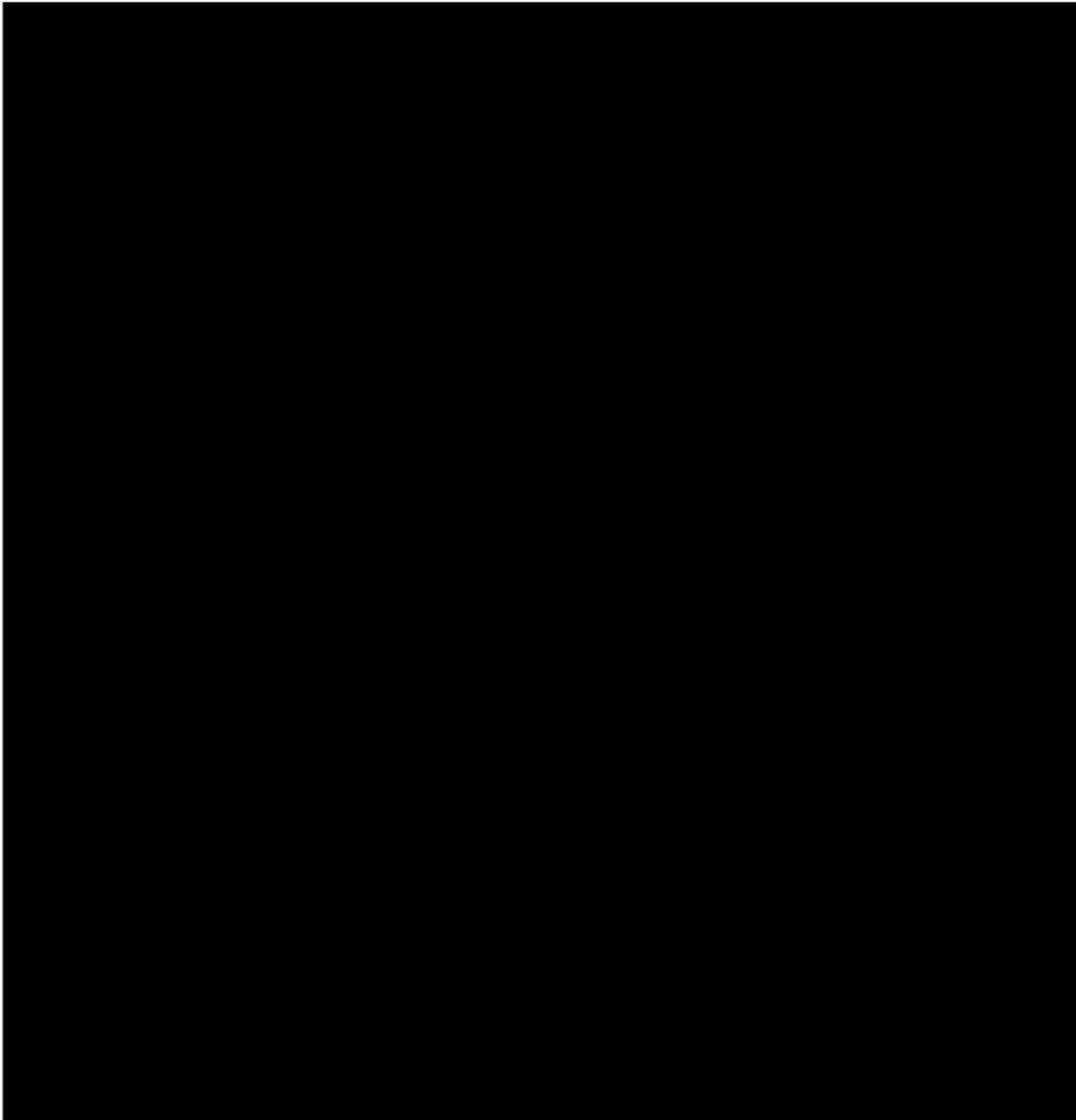
a. The government produced discovery in Portable Document Format on CD's on ten separate raids during which it gathered evidence or arrested suspects. These discovery productions are named by location or target: [REDACTED]

[REDACTED] These productions contained both secret and unclassified documents and were produced as follows:²

¹ RMC 905(c)(2).

² Though the analysis for raid discovery deficiencies is not yet complete, Mr. al Baluchi has notified the government on a rolling basis of missing/omitted classification authorities, improper substitutions of classified information, improper/unauthorized redactions, incomplete copies, and/or discrepancies in page count.





b. As it did with the FBI discovery, the government shuffled the order on the Bates numbering of these documents, making them difficult to follow, especially in comparing classified versus unclassified documents.³ The government magnified the processing challenge

³ By way of example, in the RAW discovery, instead of ordering the documents consecutively (i.e., numbering unclassified documents pages 1-717, and classified documents pages 718 to 1082), the government jumbled the numbering back and forth

by producing separate indices for classified and unclassified information for each trigram, creating apparently random numbering gaps.⁴

c. Most importantly, the government removed all metadata, such as the date photographs were taken, from the discovery documents by converting them all to Portable Document Format (PDF). The process of conversion from native file format to PDF is an intentional extra step; no camera produces photographs in PDF. Instead, since 1995, all digital cameras have produced photographs which include metadata such as the date and time a photograph was taken, and the type of camera used. This photographic metadata comes in a standardized format called Exif.

d. Therefore, on 4 March 2014, defendant propounded discovery,⁵ which in pertinent part requested that as to five raids,⁶ “the government produce this information in its native file format with intact metadata, including but not limited to Exif data for the photographs.” In less than one day, the government refused the request.⁷ It claimed that its production was “in a reasonably usable format,” that the defense would have the opportunity to inspect the physical evidence. The government also replayed its perennial objections as to relevance and materiality.

between unclassified and classified. Here, the unclassified discovery starts out at MEA-RAW-00000001 to 14, 16-52, 68-97, and so on, the classified discovery runs MEA-RAW-00000015, 59-67, 98-100,107-111, and so on.

⁴ The indices were produced separately, one index for classified documents and one index for unclassified documents. There are intermittent, seemingly random gaps in the numbering to account for the government’s placement on different systems. At this point, Mr. al Baluchi has insufficient information to assert whether the prosecution purposely placed the discovery in such a confusing order. It is possible—though not readily discernable—that the records were kept in the ordinary course of business in this order. This again, however, underscores the need for the government to produce the metadata to solve this puzzle.

⁵ Att. B (DR-151-AAA).

⁶ As of 4 March 2014, the prosecution had only produced discovery regarding five of the raids.

⁷ Att. C (Prosecution Response to DR-151-AAA).

e. In April and May 2014, the government produced discovery regarding four additional raids, from which it also removed all metadata.

f. On 6 June 2014, Defendant supplemented its discovery request for similarly information as to other raids: [REDACTED]

[REDACTED]⁸ The government refused this supplemental request and made similar generalized objections.⁹

5. Law and Argument:

Electronically stored information, also called metadata, is itself evidence. The date and time photographs were taken shows the timing and order of the forensic documentation; different kinds of cameras used shows the number of photographers. This type of evidence is especially important with the raids at issue here, which may have been conducted by military or intelligence authorities rather than criminal investigators. By removing the metadata, the government hides evidence of non-standard evidence practices that are extremely useful to the defense.

Metadata, especially the Exif data on digital photographs, is highly material to preparation of the defense and subject to discovery and disclosure. Under RMC 701, an accused is entitled to discover all documents and other tangible items that are “material to preparation of the defense,”¹⁰ or that “reasonably tend to negate the guilt of the accused of an offense charged; reduce the degree of guilt of the accused with respect to an offense charged; or reduce the punishment.”¹¹ The Due Process Clause affords an accused disclosure of all evidence favorable to an accused, where the evidence is material either to guilt or to punishment.”¹² The Eighth

⁸ Att. D (DR-151B-AAA).

⁹ Att. E (Prosecution Response to DR-151B-AAA).

¹⁰ RMC 701(c)(1) and (2).

¹¹ RMC 701(e)(1).

¹² *Brady v. Maryland*, 373 U.S. 83, 87 (1963).

Amendment grants a defendant discovery of information relating to “any aspect of the defendant’s character or record and any of the circumstances of the offense that the defendant proffers as a basis for a sentence less than death.”¹³ All of the information sought by the defense falls under one or more of these categories.

Metadata is “‘data about data’ that that is stored internally in a file, and it helps to describe the contents of the file and the characteristics of the file.”¹⁴ Metadata provides information that a paper document would not provide, and it may “also reveal that a document has been changed or backdated.”¹⁵ Metadata includes “information regarding the date a file was actually created, the date a file went on a system, the last date that the data inside a file was modified, or the last date that that file was accessed by an application. It can also reveal the last person to access a file, or the person who actually created it.”¹⁶ “Metadata may be totally innocuous, such as formatting instructions and margin determinations, but sometimes metadata provides crucial evidence that is not available in a paper document.”¹⁷

Metadata frequently becomes an issue in cases involving digitally stored images, which contain Exif (Exchangeable Image File) tags. Exif is a format that is used for storing information in digital photography image files.¹⁸ Thus, “In digital photos, metadata typically includes ‘the date and time the photo was taken; camera settings, such as aperture and shutter speed; manufacturer make and model and in the case of smartphones - the GPS coordinates of

¹³ *Lockett v. Ohio*, 438 U.S. 586, 604 (1978).

¹⁴ *United States v. Heiser*, 473 Fed. Appx. 161, 164 n.5 (3d Cir. Mar. 30, 2012).

¹⁵ *Country Vinter of North Carolina, LLC v. E. & J. Gallo Winery*, 718 F.3d 249, 253 n.4 (4th Cir. 2013).

¹⁶ *Heiser*, 473 Fed. Appx. at 164 n.5.

¹⁷ *Country Vinter*, 718 F.3d at 253 n.4.

¹⁸ *United States v. Wright*, 2013 WL 164096 at *2 n.1. (W.D. Mich., Jan. 15, 2013) (“Based upon the file storage information (the EXIF data) on the thumb drive [and other evidence] the Court concludes” when and where the images were taken.)

where the photo was taken.”¹⁹ Furthermore, Exif metadata can indicate the program or firmware used to create the file.²⁰

Internally embedded, metadata is not explicitly defined by the user. In most cases, this information is automatically embedded in digital pictures unless the user opts out of the features that capture the information.²¹ An eponymous industry standard regarding Exif data for digital images governed production of digital cameras during the period the government took the photographs it produced in discovery.²²

Under the current framework set by the Military Commissions Act (MCA) of 2009, Mr. al Baluchi is assured at least the same ‘floor’ of discovery rights as in courts-martial and federal criminal courts. In both the federal and military systems, *materiality*, for discovery purposes, is normally “not a heavy burden.”²³ Information is material “as long as there is a strong indication that it will play an important role in uncovering admissible evidence, aiding witness preparation, corroborating testimony, or assisting impeachment or rebuttal.”²⁴ It includes information that is unfavorable, as “a defendant in possession of such evidence may alter the quantum of proof in his favor in several ways: by preparing a strategy to confront the damaging evidence at trial; by conducting an investigation to attempt to discredit that evidence; or by not presenting a defense

¹⁹ *United States v. Post*, 2014 WL 345992 at *2 (S.D.Tex., Jan. 30, 2014) (denying defendant’s motion to suppress metadata from an embedded image).

²⁰ *United States v. Hager*, 710 F.3d 830, 832 n.2 (8th Cir. 2013); *see also Post*, 2014 WL 345992 at *2.

²¹ *United States v. Post*, 2014 WL 345992 at *2.

²² Attachment F (Excerpts from JEITA CP-3451, *Exchangeable image file format for digital still cameras Exif Version 2.2* (Standard of Japan Electronics and Information Technology Industries Association), April 2002).

²³ *United States v. Lloyd*, 992 F.2d 348, 351 (D.C. Cir. 1993) (quoting *United States v. George*, 786 F. Supp. 56, 58 (D.D.C.1992)); *see also United States v. NYNEX Corp.*, 781 F. Supp. 19, 25 n.8 (D.D.C. 1991).

²⁴ *United States v. Lloyd*, 992 F.2d 348, 351 (D.C. Cir. 1993) (internal quotations omitted); *see, also United States v. Caro*, 597 F.3d 609, 621 (4th Cir. 2010) (citing *Lloyd*); *see also Stone*, 40 M.J. at 422 n.1 (same); *United States v. Marshall*, 132 F.3d 63, 68 (D.C. Cir. 1998) (same).

which is undercut by such evidence.”²⁵ Beyond its standard discovery obligations under Rule 701(c), the government is obliged to disclose information that may be exculpatory at both findings and sentencing phases under the 2009 MCA,²⁶ Rule 701(e),²⁷ and the Constitution.²⁸

Metadata for the raid discovery is clearly material, and is likely to be exculpatory. PDF is essentially a paper document in electronic format, but native format files like .raw or .jpg provide much more information.²⁹ The metadata for the government’s raid photographs potentially includes the following:

- the date and time each photo was taken/created,
- camera settings (aperture, shutter speed);
- manufacturer make and model;
- the date an image file went on a system,
- the last date that the data inside a file was modified, or the last date that that file was accessed by an application.
- last person to access a file, or the person who actually created it.
- the GPS coordinates of where the photo was taken.

This metadata is important. There is an enormous difference between the probative value of a photograph taken contemporaneously with a search and a photograph taken years later and thousands of miles away. Even the order the photographs were taken is important, documenting the course of the investigation in much more detail than any report.

For example, in the discovery context, the government’s sloppy handling of metadata can be a basis in part to grant a suppression motion. In *United States v. Cross*,³⁰ the defendant sought to discredit a government witness due to *inter alia*, his failure to search for metadata,

²⁵ *Marshall*, 132 F.3d at 68.

²⁶ 10 U.S.C. § 949j(b).

²⁷ RMC 701(e).

²⁸ *Brady v. Maryland*, 373 U.S. 83, 87 (1963).

²⁹ *Country Vinter*, 718 F.3d at 253 n.4 (Metadata can provide “crucial evidence that is not available in a paper document.”)

³⁰ 2009 WL 3233267 (E.D.N.Y., Oct. 2, 2009).

[the government witness] created this document electronically, using Microsoft Word. Even if he had misplaced the hard copy, he should have searched for the electronic copy. The electronic file would contain metadata, including its creation date and last modified date. . . . The United States Attorney's Office for the Eastern District of New York is certainly no stranger to computer searches and metadata. . . . If the [witness's] testimony was truthful, one would expect that the government would still attempt to locate the electronic file because the metadata would corroborate his testimony. Such corroboration is particularly important given the questionable assertions about the alleged identification and [defendant's] concerns regarding the authenticity of the array. Under these circumstances, the witness and the government's failure to do so raises further suspicion. Indeed, the government has not submitted anything regarding the electronic file.³¹

Ultimately the *Cross* court granted the suppression motion because it was "troubled by the government's handling of the discovery. . . . [its] belated discovery, the nature of this discovery, and the piecemeal fashion in which the government produced the discovery, significantly calls into question the veracity of its assertions."³²

Finally, it bears noting that the defense is not asking the government to create anything new. Rather, the government had to take affirmative steps to convert the native files into PDF and strip them of their metadata. In other contexts, the government has produced native files, and there is no reason it cannot do so here.

6. **Request for Oral Argument:** The defense requests oral argument.
7. **Request for Witnesses:** None.
8. **Conference with Opposing Counsel:** The government position is stated in

Attachments C and E.

9. **Attachments:**
 - A. Certificate of Service;
 - B. DR-151-AAA

³¹ *Id.* at *8.

³² *Id.* at *11.

C. Prosecution Response to DR-151-AAA

D. DR-151B-AAA

E. Prosecution Response to DR-151B-AAA

F. Excerpts from JEITA CP-3451, *Exchangeable image file format for digital still cameras Exif Version 2.2* (Standard of Japan Electronics and Information Technology Industries Association), April 2002

Very respectfully,

//s//
JAMES G. CONNELL, III
Learned Counsel

Counsel for Mr. al Baluchi

//s//
STERLING R. THOMAS
Lt Col, USAF
Defense Counsel

Attachment A

CERTIFICATE OF SERVICE

I certify that on the 30th day of June, 2014, I electronically filed the foregoing document with the Clerk of the Court and served the foregoing on all counsel of record by email.

//s//
STERLING R. THOMAS
Lt Col, USAF
Defense Counsel

Attachment B



DEPARTMENT OF DEFENSE
OFFICE OF THE CHIEF DEFENSE COUNSEL
OFFICE OF MILITARY COMMISSIONS
1620 DEFENSE PENTAGON
WASHINGTON, DC 20301-1620

4 March 2014

MEMORANDUM FOR Trial Counsel

FROM: Sterling R. Thomas, Lt Col, USAF, Defense Counsel for Mr. al Baluchi

SUBJECT: DEFENSE REQUEST FOR DISCOVERY
(ESI on Raids: TRQ, RAW, ABS, H138, and KAC)

Defendant, by and through undersigned counsel pursuant to RMC 701, 10 U.S.C. § 949p-4, Common Article III to Geneva Convention (III) Relative to the Treatment of Prisoners of War, Aug. 12, 1949, the Due Process Clause of the Fifth Amendment, the Confrontation Clause to the Sixth Amendment, and the Compulsory Process Clause of the Sixth Amendment to the United States Constitution, hereby requests that the government produce the following discovery:

Discovery Request

The government has produced the following discovery in PDF format:

<i>Date</i>	<i>Trigram (Description)</i>
11/7/13	TRQ (Tariq Road Raid)
11/27/13	RAW (Rawalpindi Raid)
12/13/13	ABS (Abu Badr Raid)
1/17/14	H138 (House 138 Raid)
2/18/14	KAC (Khallad-Ammar Capture)

Mr. al Baluchi respectfully requests that the government produce this information in its native file format with intact metadata, including but not limited to EXIF data for the photographs.

Thank you for your attention to this matter. If you have any questions about this request or would like to discuss further, please feel free to contact me.

Respectfully Submitted,

//s//
Sterling R. Thomas
Lt Col, USAF
Counsel for Mr. al Baluchi

Attachment C



OFFICE OF THE
CHIEF PROSECUTOR

DEPARTMENT OF DEFENSE
OFFICE OF THE CHIEF PROSECUTOR OF MILITARY COMMISSIONS
1610 DEFENSE PENTAGON
WASHINGTON, DC 20301-1610

5 March 2014

MEMORANDUM FOR Defense Counsel for Ali Abdul Aziz Ali

SUBJECT: Prosecution Response to 4 March 2014 Request for
Discovery (DR-151-AAA)

1. The Prosecution received the Defense request for discovery on 4 March 2014. The Prosecution hereby responds to the Defense request.
2. Noting that the government has produced specific discovery in PDF format, the Defense requests "that the government produce this information in its native file format with intact metadata, including but not limited to EXIF data for the photographs." The Prosecution responds as follows, in bold:

The Defense in its request lists general categories of discovery that has been produced. The materials were produced to counsel in a reasonably usable format. The Prosecution notes that the Defense will have an opportunity to inspect the physical evidence.

Furthermore, the Defense does not cite to any specific theory of relevance that would reasonably warrant production of the same discovery in its native file format, nor does counsel demonstrate a particularized need for the data. The Defense request does not appear to be material to the preparation of the defense, pursuant to R.M.C. 701. Absent additional information, the Prosecution respectfully declines to the produce the requested material.

Respectfully submitted,

//s//

Michael J. Lebowitz
Captain, JA, USA
Assistant Trial Counsel

Attachment D



DEPARTMENT OF DEFENSE
OFFICE OF THE CHIEF DEFENSE COUNSEL
OFFICE OF MILITARY COMMISSIONS
1620 DEFENSE PENTAGON
WASHINGTON, DC 20301-1620

6 June 2014

MEMORANDUM FOR Trial Counsel

FROM: Sterling R. Thomas, Lt Col, USAF, Defense Counsel for Mr. al Baluchi

SUBJECT: DEFENSE REQUEST FOR DISCOVERY
(ESI & Metadata on Raids/trigrams: SPN, TTP, HAW, AHH)

Defendant, by and through undersigned counsel pursuant to RMC 701, 10 U.S.C. § 949p-4, Common Article III to Geneva Convention (III) Relative to the Treatment of Prisoners of War, Aug. 12, 1949, the Due Process Clause of the Fifth Amendment, the Confrontation Clause to the Sixth Amendment, and the Compulsory Process Clause of the Sixth Amendment to the United States Constitution, hereby requests that the government produce the following discovery:

Discovery Request

The government has produced the following discovery in PDF format:

<i>Date</i>	<i>Trigram (Description)</i>
4/1/14	SPN (Spain)
5/15/14	TTP (Takeh Pohl Raid)
5/30/14	TTP (Takeh Pohl Raid)
5/30/14	HAW (Hawsawi Apartment)
5/30/14	AHH (Abu Hafs)

Mr. al Baluchi respectfully requests that the government produce this information in its native file format with intact metadata, including but not limited to EXIF data for the photographs.

Thank you for your attention to this matter. If you have any questions about this request or would like to discuss further, please feel free to contact me.

Respectfully Submitted,

//s//
Sterling R. Thomas
Lt Col, USAF
Counsel for Mr. al Baluchi

Attachment E



OFFICE OF THE
CHIEF PROSECUTOR

DEPARTMENT OF DEFENSE
OFFICE OF THE CHIEF PROSECUTOR OF MILITARY COMMISSIONS
1610 DEFENSE PENTAGON
WASHINGTON, DC 20301-1610

17 June 2014

MEMORANDUM FOR Defense Counsel for Ali Abdul Aziz Ali

SUBJECT: Prosecution Response to 6 June 2014 Request for
Discovery (DR-151B-AAA)

1. The Prosecution received the Defense request for discovery on 6 June 2014. The Prosecution hereby responds to the Defense request.
2. Noting that the government has produced specific discovery in PDF format, the Defense requests "that the government produce this information in its native file format with intact metadata, including but not limited to EXIF data for the photographs." The Prosecution responds as follows, in bold:

The Defense in its request lists general categories of discovery that has been produced. The materials were produced to counsel in a reasonably usable format. The Prosecution directed its agents to photograph these materials for your convenience in the discovery process. The Prosecution notes that the Defense will have an opportunity to inspect the actual physical evidence as well.

Furthermore, the Defense does not cite to any specific theory of relevance that would reasonably warrant production of the same discovery in its native file format, nor does counsel demonstrate a particularized need for the data. The Defense request does not appear to be material to the preparation of the defense, pursuant to R.M.C. 701. Absent additional information, the Prosecution respectfully declines to the produce the requested material.

Respectfully submitted,

//s//

Nicole A. Tate
Assistant Trial Counsel

Attachment F

Standard of Japan Electronics and Information Technology Industries Association

JEITA CP-3451

Exchangeable image file format
for digital still cameras:
Exif Version 2.2

Established in April, 2002

Prepared by

Technical Standardization Committee on AV & IT Storage Systems and Equipment

Published by

Japan Electronics and Information Technology Industries Association

4.6 Tags

4.6.1 Features of Attribute Information

RGB data conforms to Baseline TIFF Rev. 6.0 RGB Full Color Images, and YCbCr data to TIFF Rev. 6.0 Extensions YCbCr Images. Accordingly, the parts that follow the TIFF structure shall be recorded in conformance to the TIFF standard. In addition to the attribute information indicated as mandatory in the TIFF standard, this Exif standard adds the TIFF optional tags that can be used in a DSC or other system, Exif-specific tags for recording DSC-specific attribute information, and GPS tags for recording position information. There are also Exif-original specifications not found in the TIFF standard for compressed recording of thumbnails.

Recording of compressed data differs from uncompressed data in the following respects:

- When the primary image data is recorded in compressed form, there is no tag indicating the primary image itself or its address (pointer).
- When thumbnail data is recorded in compressed form, address and size are designated using Exif-specific tags.
- Tags that duplicate information given in the JPEG Baseline are not recorded (for either primary images or thumbnails).
- Information relating to compression can be recorded using the tags for this purpose.

4.6.2 IFD Structure

The IFD used in this standard consists of a 2-byte count (number of fields), 12-byte field Interoperability arrays, and 4-byte offset to the next IFD, in conformance with TIFF Rev. 6.0.

Each of the 12-byte field Interoperability consists of the following four elements respectively.

Bytes 0-1	Tag
Bytes 2-3	Type
Bytes 4-7	Count
Bytes 8-11	Value Offset

Each element is explained briefly below. For details see TIFF Rev. 6.0.

JEITA CP-3451

Tag

Each tag is assigned a unique 2-byte number to identify the field. The tag numbers in the Exif 0th IFD and 1st IFD are all the same as the TIFF tag numbers.

Type

The following types are used in Exif:

1 = BYTE	An 8-bit unsigned integer.,
2 = ASCII	An 8-bit byte containing one 7-bit ASCII code. The final byte is terminated with NULL.,
3 = SHORT	A 16-bit (2-byte) unsigned integer,
4 = LONG	A 32-bit (4-byte) unsigned integer,
5 = RATIONAL	Two LONGs. The first LONG is the numerator and the second LONG expresses the denominator.,
7 = UNDEFINED	An 8-bit byte that can take any value depending on the field definition,
9 = SLONG	A 32-bit (4-byte) signed integer (2's complement notation),
10 = SRATIONAL	Two SLONGs. The first SLONG is the numerator and the second SLONG is the denominator.

Count

The number of values. It should be noted carefully that the count is not the sum of the bytes. In the case of one value of SHORT (16 bits), for example, the count is '1' even though it is 2 bytes.

Value Offset

This tag records the offset from the start of the TIFF header to the position where the value itself is recorded. In cases where the value fits in 4 bytes, the value itself is recorded. If the value is smaller than 4 bytes, the value is stored in the 4-byte area starting from the left, i.e., from the lower end of the byte offset area. For example, in big endian format, if the type is SHORT and the value is 1, it is recorded as 00010000.H.

Note that field Interoperability shall be recorded in sequence starting from the smallest tag number. There is no stipulation regarding the order or position of tag value (Value) recording.

4.6.3 Exif-specific IFD

A. Exif IFD

Exif IFD is a set of tags for recording Exif-specific attribute information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by an Exif private tag value.

Exif IFD Pointer

Tag	= 34665 (8769.H)
Type	= LONG
Count	= 1
Default	= none

A pointer to the Exif IFD. Interoperability, Exif IFD has the same structure as that of the IFD specified in TIFF. Ordinarily, however, it does not contain image data as in the case of TIFF.

B. GPS IFD

GPS IFD is a set of tags for recording GPS information. It is pointed to by the offset from the TIFF header (Value Offset) indicated by a GPS private tag value.

GPS Info IFD Pointer

Tag	= 34853 (8825.H)
Type	= LONG
Count	= 1
Default	= none

A pointer to the GPS Info IFD. The Interoperability structure of the GPS Info IFD, like that of Exif IFD, has no image data.

C. Interoperability IFD

Interoperability IFD is composed of tags which stores the information to ensure the Interoperability and pointed by the following tag located in Exif IFD.

Interoperability IFD Pointer

Tag	= 40965 (A005.H)
Type	= LONG
Count	= 1
Default	= None

The Interoperability structure of Interoperability IFD is same as TIFF defined IFD structure but does not contain the image data characteristically compared with normal TIFF IFD.

JEITA CP-3451

4.6.4 TIFF Rev. 6.0 Attribute Information

Table 3 lists the attribute information used in Exif, including the attributes given as mandatory in Baseline TIFF Rev. 6.0 RGB Full Color Images and TIFF Rev. 6.0 Extensions YCbCr Images, as well as the optional TIFF tags used by DSC and other systems. The contents are explained below.

Table 3 TIFF Rev. 6.0 Attribute Information Used in Exif

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags relating to image data structure					
Image width	ImageWidth	256	100	SHORT or LONG	1
Image height	ImageLength	257	101	SHORT or LONG	1
Number of bits per component	BitsPerSample	258	102	SHORT	3
Compression scheme	Compression	259	103	SHORT	1
Pixel composition	PhotometricInterpretation	262	106	SHORT	1
Orientation of image	Orientation	274	112	SHORT	1
Number of components	SamplesPerPixel	277	115	SHORT	1
Image data arrangement	PlanarConfiguration	284	11C	SHORT	1
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	SHORT	2
Y and C positioning	YCbCrPositioning	531	213	SHORT	1
Image resolution in width direction	XResolution	282	11A	RATIONAL	1
Image resolution in height direction	YResolution	283	11B	RATIONAL	1
Unit of X and Y resolution	ResolutionUnit	296	128	SHORT	1
B. Tags relating to recording offset					
Image data location	StripOffsets	273	111	SHORT or LONG	*S
Number of rows per strip	RowsPerStrip	278	116	SHORT or LONG	1
Bytes per compressed strip	StripByteCounts	279	117	SHORT or LONG	*S
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	LONG	1
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	LONG	1
C. Tags relating to image data characteristics					
Transfer function	TransferFunction	301	12D	SHORT	3 * 256
White point chromaticity	WhitePoint	318	13E	RATIONAL	2
Chromaticities of primaries	PrimaryChromaticities	319	13F	RATIONAL	6
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	RATIONAL	3
Pair of black and white reference values	ReferenceBlackWhite	532	214	RATIONAL	6
D. Other tags					
File change date and time	DateTime	306	132	ASCII	20
Image title	ImageDescription	270	10E	ASCII	Any
Image input equipment manufacturer	Make	271	10F	ASCII	Any
Image input equipment model	Model	272	110	ASCII	Any
Software used	Software	305	131	ASCII	Any
Person who created the image	Artist	315	13B	ASCII	Any
Copyright holder	Copyright	33432	8298	ASCII	Any

*S Chunky format: StripsPerImage
 Planar format: SamplesPerImage * StripsPerImage
 $StripsPerImage = \text{floor}((ImageLength + RowsPerStrip - 1) / RowsPerStrip)$

A. Tags relating to image data structure***ImageWidth***

The number of columns of image data, equal to the number of pixels per row. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 256 (100.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

ImageLength

The number of rows of image data. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 257 (101.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

BitsPerSample

The number of bits per image component. In this standard each component of the image is 8 bits, so the value for this tag is 8. See also *SamplesPerPixel*. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 258 (102.H)
 Type = SHORT
 Count = 3
 Default = 8 8 8

Compression

The compression scheme used for the image data. When a primary image is JPEG compressed, this designation is not necessary and is omitted. When thumbnails use JPEG compression, this tag value is set to 6.

Tag = 259 (103.H)
 Type = SHORT
 Count = 1
 Default = none
 1 = uncompressed
 6 = JPEG compression (thumbnails only)
 Other = reserved

PhotometricInterpretation

The pixel composition. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag = 262 (106.H)
 Type = SHORT
 Count = 1
 Default = none
 2 = RGB
 6 = YCbCr
 Other = reserved

JEITA CP-3451

Orientation

The image orientation viewed in terms of rows and columns.

Tag	=	274 (112.H)
Type	=	SHORT
Count	=	1
Default	=	1
1	=	The 0th row is at the visual top of the image, and the 0th column is the visual left-hand side.
2	=	The 0th row is at the visual top of the image, and the 0th column is the visual right-hand side.
3	=	The 0th row is at the visual bottom of the image, and the 0th column is the visual right-hand side.
4	=	The 0th row is at the visual bottom of the image, and the 0th column is the visual left-hand side.
5	=	The 0th row is the visual left-hand side of the image, and the 0th column is the visual top.
6	=	The 0th row is the visual right-hand side of the image, and the 0th column is the visual top.
7	=	The 0th row is the visual right-hand side of the image, and the 0th column is the visual bottom.
8	=	The 0th row is the visual left-hand side of the image, and the 0th column is the visual bottom.
Other	=	reserved

SamplesPerPixel

The number of components per pixel. Since this standard applies to RGB and YCbCr images, the value set for this tag is 3. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag	=	277 (115.H)
Type	=	SHORT
Count	=	1
Default	=	3

PlanarConfiguration

Indicates whether pixel components are recorded in chunky or planar format. In JPEG compressed files a JPEG marker is used instead of this tag. If this field does not exist, the TIFF default of 1 (chunky) is assumed.

Tag	=	284 (11C.H)
Type	=	SHORT
Count	=	1
1	=	chunky format
2	=	planar format
Other	=	reserved

YCbCrSubSampling

The sampling ratio of chrominance components in relation to the luminance component. In JPEG compressed data a JPEG marker is used instead of this tag.

Tag	=	530 (212.H)
Type	=	SHORT
Count	=	2
[2, 1]	=	YCbCr4:2:2
[2, 2]	=	YCbCr4:2:0
Other	=	reserved

YCbCrPositioning

The position of chrominance components in relation to the luminance component. This field is designated only for

JEITA CP-3451

JPEG compressed data or uncompressed YCbCr data. The TIFF default is 1 (centered); but when Y:Cb:Cr = 4:2:2 it is recommended in this standard that 2 (co-sited) be used to record data, in order to improve the image quality when viewed on TV systems. When this field does not exist, the reader shall assume the TIFF default. In the case of Y:Cb:Cr = 4:2:0, the TIFF default (centered) is recommended. If the reader does not have the capability of supporting both kinds of *YCbCrPositioning*, it shall follow the TIFF default regardless of the value in this field. It is preferable that readers be able to support both centered and co-sited positioning.

Tag = 531 (213.H)
 Type = SHORT
 Count = 1
 Default = 1
 1 = centered
 2 = co-sited
 Other = reserved

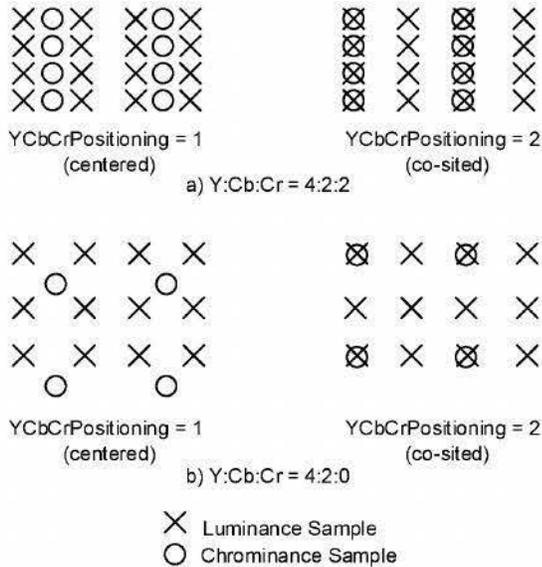


Figure 8 YCbCrPositioning

XResolution

The number of pixels per *ResolutionUnit* in the *ImageWidth* direction. When the image resolution is unknown, 72 [dpi] is designated.

Tag = 282 (11A.H)
 Type = RATIONAL
 Count = 1
 Default = 72

YResolution

The number of pixels per *ResolutionUnit* in the *ImageLength* direction. The same value as *XResolution* is designated.

Tag = 283 (11B.H)
 Type = RATIONAL
 Count = 1

JEITA CP-3451

Default = 72

ResolutionUnit

The unit for measuring *XResolution* and *YResolution*. The same unit is used for both *XResolution* and *YResolution*. If the image resolution is unknown, 2 (inches) is designated.

Tag	=	296 (128.H)
Type	=	SHORT
Count	=	1
Default	=	2
2	=	inches
3	=	centimeters
Other	=	reserved

B. Tags relating to recording offset**StripOffsets**

For each strip, the byte offset of that strip. It is recommended that this be selected so the number of strip bytes does not exceed 64 Kbytes. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag	=	273 (111.H)
Type	=	SHORT or LONG
Count	=	StripsPerImage (when PlanarConfiguration = 1)
	=	SamplesPerPixel * StripsPerImage (when PlanarConfiguration = 2)
Default	=	none

RowsPerStrip

The number of rows per strip. This is the number of rows in the image of one strip when an image is divided into strips. With JPEG compressed data this designation is not needed and is omitted. See also *RowsPerStrip* and *StripByteCounts*.

Tag	=	278 (116.H)
Type	=	SHORT or LONG
Count	=	1
Default	=	none

StripByteCounts

The total number of bytes in each strip. With JPEG compressed data this designation is not needed and is omitted.

Tag	=	279 (117.H)
Type	=	SHORT or LONG
Count	=	StripsPerImage (when PlanarConfiguration = 1)
	=	SamplesPerPixel * StripsPerImage (when PlanarConfiguration = 2)
Default	=	none

JPEGInterchangeFormat

The offset to the start byte (SOI) of JPEG compressed thumbnail data. This is not used for primary image JPEG data.

Tag	=	513 (201.H)
-----	---	-------------

Type = LONG
 Default = none

JPEGInterchangeFormatLength

The number of bytes of JPEG compressed thumbnail data. This is not used for primary image JPEG data. JPEG thumbnails are not divided but are recorded as a continuous JPEG bitstream from SOI to EOI. APPn and COM markers should not be recorded. Compressed thumbnails shall be recorded in no more than 64 Kbytes, including all other data to be recorded in APP1.

Tag = 514 (202.H)
 Type = LONG
 Default = none

C. Tags Relating to Image Data Characteristics**TransferFunction**

A transfer function for the image, described in tabular style. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 301 (12D.H)
 Type = SHORT
 Count = 3 * 256
 Default = none

WhitePoint

The chromaticity of the white point of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 318 (13E.H)
 Type = RATIONAL
 Count = 2
 Default = none

PrimaryChromaticities

The chromaticity of the three primary colors of the image. Normally this tag is not necessary, since color space is specified in the color space information tag (*ColorSpace*).

Tag = 319 (13F.H)
 Type = RATIONAL
 Count = 6
 Default = none

YCbCrCoefficients

The matrix coefficients for transformation from RGB to YCbCr image data. No default is given in TIFF; but here the characteristics given in Annex E, "Color Space Guidelines," is used as the default.

Tag = 529 (211.H)
 Type = RATIONAL
 Count = 3
 Default = See Annex E

JEITA CP-3451

ReferenceBlackWhite

The reference black point value and reference white point value. No defaults are given in TIFF, but the values below are given as defaults here. The color space is declared in a color space information tag, with the default being the value that gives the optimal image characteristics Interoperability these conditions.

Tag	=	532 (214.H)	
Type	=	RATIONAL	
Count	=	6	
Default	=	[0, 255, 0, 255, 0, 255]	(when PhotometricInterpretation is RGB)
		[0, 255, 0, 128, 0, 128]	(when PhotometricInterpretation is YCbCr)

D. Other Tags**DateTime**

The date and time of image creation. In this standard it is the date and time the file was changed. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag	=	306 (132.H)
Type	=	ASCII
Count	=	20
Default	=	none

ImageDescription

A character string giving the title of the image. It may be a comment such as "1988 company picnic" or the like. Two-byte character codes cannot be used. When a 2-byte code is necessary, the Exif Private tag *UserComment* is to be used.

Tag	=	270 (10E.H)
Type	=	ASCII
Count	=	Any
Default	=	none

Make

The manufacturer of the recording equipment. This is the manufacturer of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.

Tag	=	271 (10F.H)
Type	=	ASCII
Count	=	Any
Default	=	none

Model

The model name or model number of the equipment. This is the model name or number of the DSC, scanner, video digitizer or other equipment that generated the image. When the field is left blank, it is treated as unknown.

Tag	=	272 (110.H)
Type	=	ASCII
Count	=	Any

Default = none

Software

This tag records the name and version of the software or firmware of the camera or image input device used to generate the image. The detailed format is not specified, but it is recommended that the example shown below be followed. When the field is left blank, it is treated as unknown.

Ex.) "Exif Software Version 1.00a"

Tag = 305 (131h)
 Type = ASCII
 Count = Any
 Default = none

Artist

This tag records the name of the camera owner, photographer or image creator. The detailed format is not specified, but it is recommended that the information be written as in the example below for ease of Interoperability. When the field is left blank, it is treated as unknown.

Ex.) "Camera owner, John Smith; Photographer, Michael Brown; Image creator, Ken James"

Tag = 315 (13Bh)
 Type = ASCII
 Count = Any
 Default = none

Copyright

Copyright information. In this standard the tag is used to indicate both the photographer and editor copyrights. It is the copyright notice of the person or organization claiming rights to the image. The Interoperability copyright statement including date and rights should be written in this field; e.g., "Copyright, John Smith, 19xx. All rights reserved." In this standard the field records both the photographer and editor copyrights, with each recorded in a separate part of the statement. When there is a clear distinction between the photographer and editor copyrights, these are to be written in the order of photographer followed by editor copyright, separated by NULL (in this case, since the statement also ends with a NULL, there are two NULL codes) (see example 1). When only the photographer copyright is given, it is terminated by one NULL code (see example 2). When only the editor copyright is given, the photographer copyright part consists of one space followed by a terminating NULL code, then the editor copyright is given (see example 3). When the field is left blank, it is treated as unknown.

Ex. 1) When both the photographer copyright and editor copyright are given.

Photographer copyright + NULL[00.H] + editor copyright + NULL[00.H]

Ex. 2) When only the photographer copyright is given.

Photographer copyright + NULL[00.H]

Ex. 3) When only the editor copyright is given.

Space[20.H] + NULL[00.H] + editor copyright + NULL[00.H]

Tag = 33432 (8298.H)
 Type = ASCII
 Count = Any
 Default = none

JEITA CP-3451

4.6.5 Exif IFD Attribute Information

The attribute information (field names and codes) recorded in the Exif IFD is given in Table 4 and Table 5 followed by an explanation of the contents.

Table 4 Exif IFD Attribute Information (1)

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to Version					
Exif version	ExifVersion	36864	9000	UNDEFINED	4
Supported Flashpix version	FlashpixVersion	40960	A000	UNDEFINED	4
B. Tag Relating to Image Data Characteristics					
Color space information	ColorSpace	40961	A001	SHORT	1
C. Tags Relating to Image Configuration					
Meaning of each component	ComponentsConfiguration	37121	9101	UNDEFINED	4
Image compression mode	CompressedBitsPerPixel	37122	9102	RATIONAL	1
Valid image width	PixelXDimension	40962	A002	SHORT or LONG	1
Valid image height	PixelYDimension	40963	A003	SHORT or LONG	1
D. Tags Relating to User Information					
Manufacturer notes	MakerNote	37500	927C	UNDEFINED	Any
User comments	UserComment	37510	9286	UNDEFINED	Any
E. Tag Relating to Related File Information					
Related audio file	RelatedSoundFile	40964	A004	ASCII	13
F. Tags Relating to Date and Time					
Date and time of original data generation	DateTimeOriginal	36867	9003	ASCII	20
Date and time of digital data generation	DateTimeDigitized	36868	9004	ASCII	20
DateTime subseconds	SubSecTime	37520	9290	ASCII	Any
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	ASCII	Any
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	ASCII	Any
G. Tags Relating to Picture-Taking Conditions					
See Table 5					
H. Other Tags					
Unique image ID	ImageUniqueID	42016	A420	ASCII	33

Table 5 Exif IFD Attribute Information (2)

G. Tags Relating to Picture-Taking Conditions					
Exposure time	ExposureTime	33434	829A	RATIONAL	1
F number	FNumber	33437	829D	RATIONAL	1
Exposure program	ExposureProgram	34850	8822	SHORT	1
Spectral sensitivity	SpectralSensitivity	34852	8824	ASCII	Any
ISO speed rating	ISOSpeedRatings	34855	8827	SHORT	Any
Optoelectric conversion factor	OECF	34856	8828	UNDEFINED	Any
Shutter speed	ShutterSpeedValue	37377	9201	SRATIONAL	1
Aperture	ApertureValue	37378	9202	RATIONAL	1
Brightness	BrightnessValue	37379	9203	SRATIONAL	1
Exposure bias	ExposureBiasValue	37380	9204	SRATIONAL	1
Maximum lens aperture	MaxApertureValue	37381	9205	RATIONAL	1
Subject distance	SubjectDistance	37382	9206	RATIONAL	1
Metering mode	MeteringMode	37383	9207	SHORT	1
Light source	LightSource	37384	9208	SHORT	1
Flash	Flash	37385	9209	SHORT	1
Lens focal length	FocalLength	37386	920A	RATIONAL	1
Subject area	SubjectArea	37396	9214	SHORT	2 or 3 or 4
Flash energy	FlashEnergy	41483	A20B	RATIONAL	1
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	UNDEFINED	Any
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	RATIONAL	1
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	RATIONAL	1
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	SHORT	1
Subject location	SubjectLocation	41492	A214	SHORT	2
Exposure index	ExposureIndex	41493	A215	RATIONAL	1
Sensing method	SensingMethod	41495	A217	SHORT	1
File source	FileSource	41728	A300	UNDEFINED	1
Scene type	SceneType	41729	A301	UNDEFINED	1
CFA pattern	CFAPattern	41730	A302	UNDEFINED	Any
Custom image processing	CustomRendered	41985	A401	SHORT	1
Exposure mode	ExposureMode	41986	A402	SHORT	1
White balance	WhiteBalance	41987	A403	SHORT	1
Digital zoom ratio	DigitalZoomRatio	41988	A404	RATIONAL	1
Focal length in 35 mm film	FocalLengthIn35mmFilm	41989	A405	SHORT	1
Scene capture type	SceneCaptureType	41990	A406	SHORT	1
Gain control	GainControl	41991	A407	RATIONAL	1
Contrast	Contrast	41992	A408	SHORT	1
Saturation	Saturation	41993	A409	SHORT	1
Sharpness	Sharpness	41994	A40A	SHORT	1
Device settings description	DeviceSettingDescription	41995	A40B	UNDEFINED	Any
Subject distance range	SubjectDistanceRange	41996	A40C	SHORT	1

JEITA CP-3451

A. Tags Relating to Version***ExifVersion***

The version of this standard supported. Nonexistence of this field is taken to mean nonconformance to the standard (see section 4.2). Conformance to this standard is indicated by recording "0220" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 36864 (9000.H)
 Type = UNDEFINED
 Count = 4
 Default = "0220"

FlashpixVersion

The Flashpix format version supported by a FPXR file. If the FPXR function supports Flashpix format Ver. 1.0, this is indicated similarly to *ExifVersion* by recording "0100" as 4-byte ASCII. Since the type is UNDEFINED, there is no NULL for termination.

Tag = 40960(A000.H)
 Type = UNDEFINED
 Count = 4
 Default = "0100"
 0100 = Flashpix Format Version 1.0
 Other = reserved

B. Tag Relating to Color Space***ColorSpace***

The color space information tag (*ColorSpace*) is always recorded as the color space specifier.

Normally sRGB (=1) is used to define the color space based on the PC monitor conditions and environment. If a color space other than sRGB is used, Uncalibrated (=FFFF.H) is set. Image data recorded as Uncalibrated can be treated as sRGB when it is converted to Flashpix. On sRGB see Annex E.

Tag = 40961 (A001.H)
 Type = SHORT
 Count = 1
 1 = sRGB
 FFFF.H = Uncalibrated
 Other = reserved

C. Tags Relating to Image Configuration***PixelXDimension***

Information specific to compressed data. When a compressed file is recorded, the valid width of the meaningful image shall be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Annex F.

Tag = 40962 (A002.H)
 Type = SHORT or LONG
 Count = 1
 Default = none

PixelYDimension

Information specific to compressed data. When a compressed file is recorded, the valid height of the meaningful image shall be recorded in this tag, whether or not there is padding data or a restart marker. This tag should not exist in an uncompressed file. For details see section 2.8.1 and Annex F. Since data padding is unnecessary in the vertical direction, the number of lines recorded in this valid image height tag will in fact be the same as that recorded in the SOF.

Tag = 40963 (A003.H)
 Type = SHORT of LONG
 Count = 1

ComponentsConfiguration

Information specific to compressed data. The channels of each component are arranged in order from the 1st component to the 4th. For uncompressed data the data arrangement is given in the *PhotometricInterpretation* tag. However, since *PhotometricInterpretation* can only express the order of Y,Cb and Cr, this tag is provided for cases when compressed data uses components other than Y, Cb, and Cr and to enable support of other sequences.

Tag = 37121 (9101.H)
 Type = UNDEFINED
 Count = 4
 Default = 4 5 6 0 (if RGB uncompressed)
 1 2 3 0 (other cases)
 0 = does not exist
 1 = Y
 2 = Cb
 3 = Cr
 4 = R
 5 = G
 6 = B
 Other = reserved

CompressedBitsPerPixel

Information specific to compressed data. The compression mode used for a compressed image is indicated in unit bits per pixel.

Tag = 37122 (9102.H)
 Type = RATIONAL
 Count = 1
 Default = none

D. Tags Relating to User Information**MakerNote**

A tag for manufacturers of Exif writers to record any desired information. The contents are up to the manufacturer, but this tag should not be used for any other than its intended purpose.

Tag = 37500 (927C.H)
 Type = UNDEFINED
 Count = Any
 Default = none

JEITA CP-3451

UserComment

A tag for Exif users to write keywords or comments on the image besides those in *ImageDescription*, and without the character code limitations of the *ImageDescription* tag.

Tag = 37510 (9286.H)
 Type = UNDEFINED
 Count = Any
 Default = none

The character code used in the *UserComment* tag is identified based on an ID code in a fixed 8-byte area at the start of the tag data area. The unused portion of the area is padded with NULL ("00.H"). ID codes are assigned by means of registration. The designation method and references for each character code are given in Table 6. The value of Count N is determined based on the 8 bytes in the character code area and the number of bytes in the user comment part. Since the TYPE is not ASCII, NULL termination is not necessary (see Figure 9).

Table 6 Character Codes and their Designation

Character Code	Code Designation (8 Bytes)	References
ASCII	41.H, 53.H, 43.H, 49.H, 49.H, 00.H, 00.H, 00.H	ITU-T T.50 IA5
JIS	4A.H, 49.H, 53.H, 00.H, 00.H, 00.H, 00.H, 00.H	JIS X208-1990
Unicode	55.H, 4E.H, 49.H, 43.H, 4F.H, 44.H, 45.H, 00.H	Unicode Standard
Undefined	00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H, 00.H	Undefined

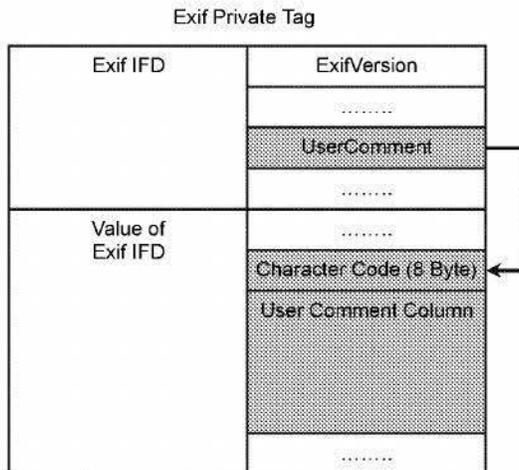


Figure 9 User Comment Tag

The ID code for the *UserComment* area may be a Defined code such as JIS or ASCII, or may be Undefined. The Undefined name is *UndefinedText*, and the ID code is filled with 8 bytes of all "NULL" ("00.H"). An Exif reader that reads the *UserComment* tag shall have a function for determining the ID code. This function is not required in Exif readers that do not use the *UserComment* tag (see Table 7).

Table 7 Implementation of Defined and Undefined Character Codes

ID Code	Exif Reader Implementation
Defined (JIS, ASCII, etc.)	Determines the ID code and displays it in accord with the reader capability.
Undefined (all NULL)	Depends on the localized PC in each country. (If a character code is used for which there is no clear specification like Shift-JIS in Japan, Undefined is used.) Although the possibility of unreadable characters exists, display of these characters is left as a matter of reader implementation.

When a *UserComment* area is set aside, it is recommended that the ID code be ASCII and that the following user comment part be filled with blank characters [20.H].

E. Tag Relating to Related File

RelatedSoundFile

This tag is used to record the name of an audio file related to the image data. The only relational information recorded here is the Exif audio file name and extension (an ASCII string consisting of 8 characters + '.' + 3 characters). The path is not recorded. Stipulations on audio are given in section 0. File naming conventions are given in section 0.

When using this tag, audio files shall be recorded in conformance to the Exif audio format. Writers are also allowed to store the data such as Audio within APP2 as Flashpix extension stream data.

Audio files shall be recorded in conformance to the Exif audio format.

The mapping of Exif image files and audio files is done in any of the three ways shown in Table 8. If multiple files are mapped to one file as in [2] or [3] of this table, the above format is used to record just one audio file name. If there are multiple audio files, the first recorded file is given.

In the case of [3] in Table 8, for example, for the Exif image file "DSC00001.JPG" only "SND00001.WAV" is given as the related Exif audio file.

When there are three Exif audio files "SND00001.WAV", "SND00002.WAV" and "SND00003.WAV", the Exif image file name for each of them, "DSC00001.JPG," is indicated. By combining multiple relational information, a variety of playback possibilities can be supported. The method of using relational information is left to the implementation on the playback side. Since this information is an ASCII character string, it is terminated by NULL.

Table 8 Mapping between Image and Audio Files

	Relationship	Exif Image File	Exif Audio File
[1]	1 to 1	DSC00001.JPG	SND00001.WAV
[2]	Plural to 1	DSC00001.JPG DSC00002.JPG DSC00003.JPG	SND00001.WAV
[3]	1 to plural	DSC00001.JPG	SND00001.WAV SND00002.WAV SND00003.WAV

JEITA CP-3451

When this tag is used to map audio files, the relation of the audio file to image data shall also be indicated on the audio file end.

Tag = 40964 (A004.H)
 Type = ASCII
 Count = 13
 Default = none

F. Tags Relating to Date and Time

DateTimeOriginal

The date and time when the original image data was generated. For a DSC the date and time the picture was taken are recorded. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36867 (9003.H)
 Type = ASCII
 Count = 20
 Default = none

DateTimeDigitized

The date and time when the image was stored as digital data. If, for example, an image was captured by DSC and at the same time the file was recorded, then the *DateTimeOriginal* and *DateTimeDigitized* will have the same contents. The format is "YYYY:MM:DD HH:MM:SS" with time shown in 24-hour format, and the date and time separated by one blank character [20.H]. When the date and time are unknown, all the character spaces except colons (":") may be filled with blank characters, or else the Interoperability field may be filled with blank characters. The character string length is 20 bytes including NULL for termination. When the field is left blank, it is treated as unknown.

Tag = 36868 (9004.H)
 Type = ASCII
 Count = 20
 Default = none

SubsecTime

A tag used to record fractions of seconds for the *DateTime* tag.

Tag = 37520 (9290.H)
 Type = ASCII
 Count = Any
 Default = none

SubsecTimeOriginal

A tag used to record fractions of seconds for the *DateTimeOriginal* tag.

Tag = 37521 (9291.H)
 Type = ASCII
 N = Any
 Default = none

SubsecTimeDigitized

A tag used to record fractions of seconds for the *DateTimeDigitized* tag.

Tag = 37522 (9292.H)
 Type = ASCII
 N = Any
 Default = none

Note—Recording subsecond data (*SubsecTime*, *SubsecTimeOriginal*, *SubsecTimeDigitized*)

The tag type is ASCII and the string length including NULL is variable length. When the number of valid digits is up to the second decimal place, the subsecond value goes in the Value position. When it is up to four decimal places, an address value is Interoperability, with the subsecond value put in the location pointed to by that address. (Since the count of ASCII type field Interoperability is a value that includes NULL, when the number of valid digits is up to four decimal places the count is 5, and the offset value goes in the Value Offset field. See section 2.6.2.) Note that the subsecond tag differs from the *DateTime* tag and other such tags already defined in TIFF Rev. 6.0, and that both are recorded in the Exif IFD.

Ex.: September 9, 1998, 9:15:30.130 (the number of valid digits is up to the third decimal place)

DateTime 1996:09:01 09:15:30 [NULL]
 SubSecTime 130 [NULL]

If the string length is longer than the number of valid digits, the digits are aligned with the start of the area and the rest is filled with blank characters [20.H]. If the subsecond data is unknown, the Interoperability area can be filled with blank characters.

Examples when subsecond data is 0.130 seconds:

Ex. 1) '1','3','0',[NULL]
 Ex. 2) '1','3','0',[20.H],[NULL]
 Ex. 3) '1','3','0', [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

Example when subsecond data is unknown:

Ex. 4) [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [20.H], [NULL]

G. Tags Relating to Picture-Taking Conditions**ExposureTime**

Exposure time, given in seconds (sec).

Tag = 33434 (829A.H)
 Type = RATIONAL
 Count = 1
 Default = none

FNumber

The F number.

Tag = 33437 (829D.H)
 Type = RATIONAL
 Count = 1
 Default = none

JEITA CP-3451

ExposureProgram

The class of the program used by the camera to set exposure when the picture is taken. The tag values are as follows.

Tag	=	34850 (8822.H)
Type	=	SHORT
Count	=	1
Default	=	0
0	=	Not defined
1	=	Manual
2	=	Normal program
3	=	Aperture priority
4	=	Shutter priority
5	=	Creative program (biased toward depth of field)
6	=	Action program (biased toward fast shutter speed)
7	=	Portrait mode (for closeup photos with the background out of focus)
8	=	Landscape mode (for landscape photos with the background in focus)
Other	=	reserved

SpectralSensitivity

Indicates the spectral sensitivity of each channel of the camera used. The tag value is an ASCII string compatible with the standard developed by the ASTM Technical committee.

Tag	=	34852 (8824.H)
Type	=	ASCII
Count	=	Any
Default	=	none

ISOSpeedRatings

Indicates the ISO Speed and ISO Latitude of the camera or input device as specified in ISO 12232.

Tag	=	34855 (8827.H)
Type	=	SHORT
Count	=	Any
Default	=	none

OECF

Indicates the Opto-Electric Conversion Function (OECF) specified in ISO 14524. *OECF* is the relationship between the camera optical input and the image values.

Tag	=	34856 (8828.H)
Type	=	UNDEFINED
Count	=	ANY
Default	=	none

When this tag records an *OECF* of *m* rows and *n* columns, the values are as in Figure 10.

Length	Type	Meaning
2	SHORT	Columns = <i>n</i>
2	SHORT	Rows = <i>m</i>
Any	ASCII	0th column item name (NULL terminated)
:	:	:
Any	ASCII	<i>n</i> -1th column item name (NULL terminated)
8	SRATIONAL	OECF value [0,0]
:	:	:
8	SRATIONAL	OECF value [<i>n</i> -1,0]
8	SRATIONAL	OECF value [0, <i>m</i> -1]
:	:	:
8	SRATIONAL	OECF value [<i>n</i> -1, <i>m</i> -1]

Figure 10 OECF Description

Table 9 gives a simple example.

Table 9 Example of Exposure and RGB Output Level

Camera log Aperture	R Output Level	G Output Level	B Output Level
-3.0	10.2	12.4	8.9
-2.0	48.1	47.5	48.3
-1.0	150.2	152.0	149.8

ShutterSpeedValue

Shutter speed. The unit is the APEX (Additive System of Photographic Exposure) setting (see Annex C).

Tag = 37377 (9201.H)
 Type = SRATIONAL
 Count = 1
 Default = none

ApertureValue

The lens aperture. The unit is the APEX value.

Tag = 37378 (9202.H)
 Type = RATIONAL
 Count = 1
 Default = none

BrightnessValue

The value of brightness. The unit is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99. Note that if the numerator of the recorded value is FFFFFFFF.H, Unknown shall be indicated.

Tag = 37379 (9203.H)
 Type = SRATIONAL
 Count = 1
 Default = none

JEITA CP-3451

ExposureBiasValue

The exposure bias. The unit is the APEX value. Ordinarily it is given in the range of -99.99 to 99.99.

Tag = 37380 (9204.H)
 Type = SRATIONAL
 Count = 1
 Default = none

MaxApertureValue

The smallest F number of the lens. The unit is the APEX value. Ordinarily it is given in the range of 00.00 to 99.99, but it is not limited to this range.

Tag = 37381 (9205.H)
 Type = RATIONAL
 Count = 1
 Default = none

SubjectDistance

The distance to the subject, given in meters. Note that if the numerator of the recorded value is FFFFFFFF.H, Infinity shall be indicated; and if the numerator is 0, Distance unknown shall be indicated.

Tag = 37382 (9206.H)
 Type = RATIONAL
 Count = 1
 Default = none

MeteringMode

The metering mode.

Tag = 37383 (9207.H)
 Type = SHORT
 Count = 1
 Default = 0

0	=	unknown
1	=	Average
2	=	CenterWeightedAverage
3	=	Spot
4	=	MultiSpot
5	=	Pattern
6	=	Partial
Other	=	reserved
255	=	other

LightSource

The kind of light source.

Tag = 37384 (9208.H)
 Type = SHORT
 Count = 1
 Default = 0

0	=	unknown
---	---	---------

- 1 = Daylight
- 2 = Fluorescent
- 3 = Tungsten (incandescent light)
- 4 = Flash
- 9 = Fine weather
- 10 = Cloudy weather
- 11 = Shade
- 12 = Daylight fluorescent (D 5700 – 7100K)
- 13 = Day white fluorescent (N 4600 – 5400K)
- 14 = Cool white fluorescent (W 3900 – 4500K)
- 15 = White fluorescent (WW 3200 – 3700K)
- 17 = Standard light A
- 18 = Standard light B
- 19 = Standard light C
- 20 = D55
- 21 = D65
- 22 = D75
- 23 = D50
- 24 = ISO studio tungsten
- 255 = other light source
- Other = reserved

Flash

This tag indicates the status of flash when the image was shot. Bit 0 indicates the flash firing status, bits 1 and 2 indicate the flash return status, bits 3 and 4 indicate the flash mode, bit 5 indicates whether the flash function is present, and bit 6 indicates "red eye" mode (see Figure 11).

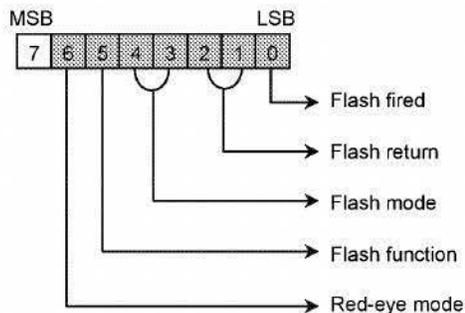


Figure 11 Bit Coding of the Flash Tag

Tag = 37385 (9209.H)
 Type = SHORT
 Count = 1

Values for bit 0 indicating whether the flash fired.

0b = Flash did not fire.
 1b = Flash fired.

Values for bits 1 and 2 indicating the status of returned light.

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00b	=	No strobe return detection function
01b	=	reserved
10b	=	Strobe return light not detected.
11b	=	Strobe return light detected.

Values for bits 3 and 4 indicating the camera's flash mode.

00b	=	unknown
01b	=	Compulsory flash firing
10b	=	Compulsory flash suppression
11b	=	Auto mode

Values for bit 5 indicating the presence of a flash function.

0b	=	Flash function present
1b	=	No flash function

Values for bit 6 indicating the camera's red-eye mode.

0b	=	No red-eye reduction mode or unknown
1b	=	Red-eye reduction supported

Resulting Flash tag values.

0000.H	=	Flash did not fire.
0001.H	=	Flash fired.
0005.H	=	Strobe return light not detected.
0007.H	=	Strobe return light detected.
0009.H	=	Flash fired, compulsory flash mode
000D.H	=	Flash fired, compulsory flash mode, return light not detected
000F.H	=	Flash fired, compulsory flash mode, return light detected
0010.H	=	Flash did not fire, compulsory flash mode
0018.H	=	Flash did not fire, auto mode
0019.H	=	Flash fired, auto mode
001D.H	=	Flash fired, auto mode, return light not detected
001F.H	=	Flash fired, auto mode, return light detected
0020.H	=	No flash function
0041.H	=	Flash fired, red-eye reduction mode
0045.H	=	Flash fired, red-eye reduction mode, return light not detected
0047.H	=	Flash fired, red-eye reduction mode, return light detected
0049.H	=	Flash fired, compulsory flash mode, red-eye reduction mode
004D.H	=	Flash fired, compulsory flash mode, red-eye reduction mode, return light not detected
004F.H	=	Flash fired, compulsory flash mode, red-eye reduction mode, return light detected
0059.H	=	Flash fired, auto mode, red-eye reduction mode
005D.H	=	Flash fired, auto mode, return light not detected, red-eye reduction mode
005F.H	=	Flash fired, auto mode, return light detected, red-eye reduction mode
Other	=	reserved

SubjectArea

This tag indicates the location and area of the main subject in the overall scene.

Tag = 37396 (9214.H)
Type = SHORT
Count = 2 or 3 or 4
Default = none

The subject location and area are defined by Count values as follows.

Count = 2 Indicates the location of the main subject as coordinates. The first value is the X coordinate and the second is the Y coordinate.

Count = 3 The area of the main subject is given as a circle. The circular area is expressed as center coordinates and diameter. The first value is the center X coordinate, the second is the center Y coordinate, and the third is the diameter. (See Figure 12.)

Count = 4 The area of the main subject is given as a rectangle. The rectangular area is expressed as center coordinates and area dimensions. The first value is the center X coordinate, the second is the center Y coordinate, the third is the width of the area, and the fourth is the height of the area. (See Figure 13.)

Note that the coordinate values, width, and height are expressed in relation to the upper left as origin, prior to rotation processing as per the Rotation tag.

JEITA CP-3451

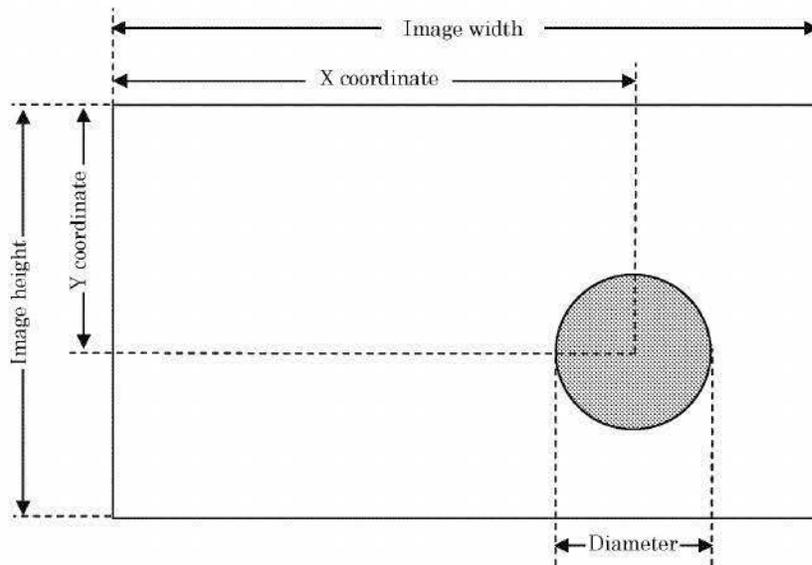


Figure 12 Circular area designation

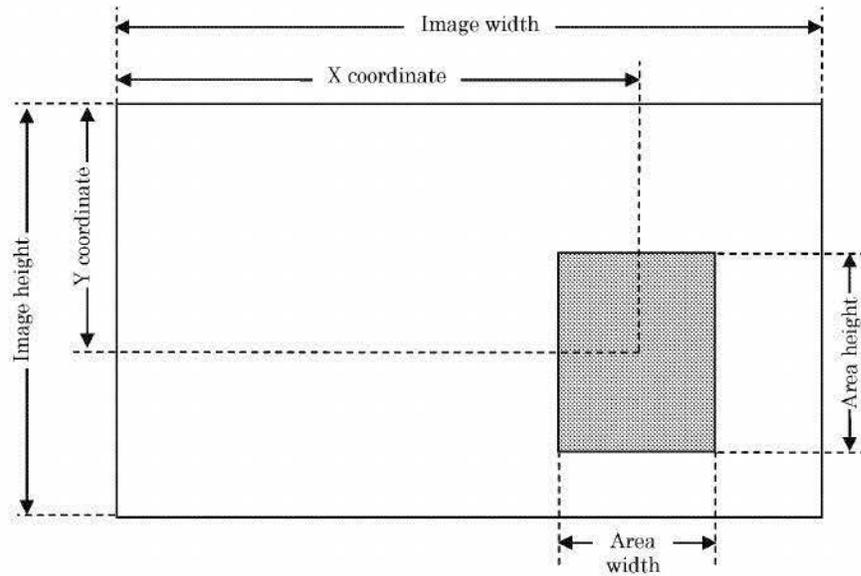


Figure 13 Rectangular area designation

FocalLength

The actual focal length of the lens, in mm. Conversion is not made to the focal length of a 35 mm film camera.

Tag = 37386 (920A.H)
Type = RATIONAL
Count = 1
Default = none

FlashEnergy

Indicates the strobe energy at the time the image is captured, as measured in Beam Candle Power Seconds (BCPS).

Tag = 41483 (A20B.H)
 Type = RATIONAL
 Count = 1
 Default = none

SpatialFrequencyResponse

This tag records the camera or input device spatial frequency table and SFR values in the direction of image width, image height, and diagonal direction, as specified in ISO 12233.

Tag = 41484 (A20CH)
 Type = UNDEFINED
 Count = ANY
 Default = none

When the spatial frequency response for m rows and n columns is recorded, the values are as shown in Figure 14.

Length	Type	Meaning
2	SHORT	Columns = n
2	SHORT	Rows = m
Any	ASCII	0th column item name (NULL terminated)
:	:	:
Any	ASCII	n-1th column item name (NULL terminated)
8	RATIONAL	SFR value [0,0]
:	:	:
8	RATIONAL	SFR value [n-1,0]
8	RATIONAL	SFR value [0,m-1]
:	:	:
8	RATIONAL	SFR value [n-1,m-1]

Figure 14 Spatial Frequency Response Description

Table 10 gives a simple example.

Table 10 Example of Spatial Frequency Response

Spatial Frequency (lw/ph)	Along Image Width	Along Image Height
0.1	1.00	1.00
0.2	0.90	0.95
0.3	0.80	0.85

FocalPlaneXResolution

Indicates the number of pixels in the image width (X) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

Tag = 41486 (A20E.H)
 Type = RATIONAL
 Count = 1
 Default = none

FocalPlaneYResolution

Indicates the number of pixels in the image height (Y) direction per *FocalPlaneResolutionUnit* on the camera focal plane.

JEITA CP-3451

Tag = 41487 (A20F.H)
 Type = RATIONAL
 Count = 1
 Default = none

FocalPlaneResolutionUnit

Indicates the unit for measuring *FocalPlaneXResolution* and *FocalPlaneYResolution*. This value is the same as the *ResolutionUnit*.

Tag = 41488 (A210.H)
 Type = SHORT
 Count = 1
 Default = 2 (inch)

Note on use of tags concerning focal plane resolution

These tags record the actual focal plane resolutions of the main image which is written as a file after processing instead of the pixel resolution of the image sensor in the camera. It should be noted carefully that the data from the image sensor is resampled.

These tags are used at the same time as a *FocalLength* tag when the angle of field of the recorded image is to be calculated precisely.

SubjectLocation

Indicates the location of the main subject in the scene. The value of this tag represents the pixel at the center of the main subject relative to the left edge, prior to rotation processing as per the *Rotation* tag. The first value indicates the X column number and second indicates the Y row number.

Tag = 41492 (A214.H)
 Type = SHORT
 Count = 2
 Default = none

When a camera records the main subject location, it is recommended that the *SubjectArea* tag be used instead of this tag.

ExposureIndex

Indicates the exposure index selected on the camera or input device at the time the image is captured.

Tag = 41493 (A215.H)
 Type = RATIONAL
 Count = 1
 Default = none

SensingMethod

Indicates the image sensor type on the camera or input device. The values are as follows.

Tag = 41495 (A217.H)
 Type = SHORT
 Count = 1
 Default = none

1 = Not defined
 2 = One-chip color area sensor
 3 = Two-chip color area sensor

- 4 = Three-chip color area sensor
- 5 = Color sequential area sensor
- 7 = Trilinear sensor
- 8 = Color sequential linear sensor
- Other = reserved

FileSource

Indicates the image source. If a DSC recorded the image, this tag value of this tag always be set to 3, indicating that the image was recorded on a DSC.

- Tag = 41728 (A300.H)
- Type = UNDEFINED
- Count = 1
- Default = 3
- 3 = DSC
- Other = reserved

SceneType

Indicates the type of scene. If a DSC recorded the image, this tag value shall always be set to 1, indicating that the image was directly photographed.

- Tag = 41729 (A301.H)
- Type = UNDEFINED
- Count = 1
- Default = 1
- 1 = A directly photographed image
- Other = reserved

CFAPattern

Indicates the color filter array (CFA) geometric pattern of the image sensor when a one-chip color area sensor is used. It does not apply to all sensing methods.

- Tag = 41730 (A302.H)
- Type = UNDEFINED
- Count = ANY
- Default = none

Figure 15 shows how a CFA pattern is recorded for a one-chip color area sensor when the color filter array is repeated in m x n (vertical x lateral) pixel units.

Length	Type	Meaning
2	SHORT	Horizontal repeat pixel unit = n
2	SHORT	Vertical repeat pixel unit = m
1	BYTE	CFA value [0.0]
:	:	:
1	BYTE	CFA value [n-1.0]
1	BYTE	CFA value [0.m-1]
:	:	:
1	BYTE	CFA value [n-1.m-1]

Figure 15 CFA Pattern Description

JEITA CP-3451

The relation of color filter color to CFA value is shown in Table 11.

Table 11 Color Filter Color and CFA Value

Filter Color	CFA Value
RED	00.H
GREEN	01.H
BLUE	02.H
CYAN	03.H
MAGENTA	04.H
YELLOW	05.H
WHITE	06.H

For example, when the CFA pattern values are {0002.H, 0002.H, 01.H, 00.H, 02.H, 01.H}, the color filter array is as shown in Figure 16.

G	R	G	R
B	G	B	G
G	R	G	R
B	G	B	G
⋮	⋮	⋮	⋮	

Figure 16 Color Filter Array

CustomRendered

This tag indicates the use of special processing on image data, such as rendering geared to output. When special processing is performed, the reader is expected to disable or minimize any further processing.

- Tag = 41985 (A401.H)
- Type = SHORT
- Count = 1
- Default = 0
- 0 = Normal process
- 1 = Custom process
- Other = reserved

ExposureMode

This tag indicates the exposure mode set when the image was shot. In auto-bracketing mode, the camera shoots a series of frames of the same scene at different exposure settings.

- Tag = 41986 (A402.H)
- Type = SHORT
- Count = 1
- Default = none
- 0 = Auto exposure
- 1 = Manual exposure
- 2 = Auto bracket
- Other = reserved

WhiteBalance

This tag indicates the white balance mode set when the image was shot.

Tag	=	41987 (A403.H)
Type	=	SHORT
Count	=	1
Default	=	none
0	=	Auto white balance
1	=	Manual white balance
Other	=	reserved

DigitalZoomRatio

This tag indicates the digital zoom ratio when the image was shot. If the numerator of the recorded value is 0, this indicates that digital zoom was not used.

Tag	=	41988 (A404.H)
Type	=	RATIONAL
Count	=	1
Default	=	none

FocalLengthIn35mmFilm

This tag indicates the equivalent focal length assuming a 35mm film camera, in mm. A value of 0 means the focal length is unknown. Note that this tag differs from the FocalLength tag.

Tag	=	41989 (A405.H)
Type	=	SHORT
Count	=	1
Default	=	none

SceneCaptureType

This tag indicates the type of scene that was shot. It can also be used to record the mode in which the image was shot. Note that this differs from the scene type (SceneType) tag.

Tag	=	41990 (A406.H)
Type	=	SHORT
Count	=	1
Default	=	0
0	=	Standard
1	=	Landscape
2	=	Portrait
3	=	Night scene
Other	=	reserved

GainControl

This tag indicates the degree of overall image gain adjustment.

Tag	=	41991 (A407.H)
Type	=	SHORT
Count	=	1
Default	=	none
0	=	None

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1 = Low gain up
 2 = High gain up
 3 = Low gain down
 4 = High gain down
 Other = reserved

Contrast

This tag indicates the direction of contrast processing applied by the camera when the image was shot.

Tag = 41992 (A408.H)
 Type = SHORT
 Count = 1
 Default = 0
 0 = Normal
 1 = Soft
 2 = Hard
 Other = reserved

Saturation

This tag indicates the direction of saturation processing applied by the camera when the image was shot.

Tag = 41993 (A409.H)
 Type = SHORT
 Count = 1
 Default = 0
 0 = Normal
 1 = Low saturation
 2 = High saturation
 Other = reserved

Sharpness

This tag indicates the direction of sharpness processing applied by the camera when the image was shot.

Tag = 41994 (A40A.H)
 Type = SHORT
 Count = 1
 Default = 0
 0 = Normal
 1 = Soft
 2 = Hard
 Other = reserved

DeviceSettingDescription

This tag indicates information on the picture-taking conditions of a particular camera model. The tag is used only to indicate the picture-taking conditions in the reader.

Tag = 41995 (A40B.H)
 Type = UNDEFINED
 Count = Any
 Default = none

The information is recorded in the format shown in Figure 17. The data is recorded in Unicode using SHORT type for the number of display rows and columns and UNDEFINED type for the camera settings. The Unicode (UCS-2) string including Signature is NULL terminated. The specifics of the Unicode string are as given in ISO/IEC 10464-1.

Length	Type	Meaning
2	SHORT	Display columns
2	SHORT	Display rows
Any	UNDEFINED	Camera setting-1
Any	UNDEFINED	Camera setting-2
:	:	:
Any	UNDEFINED	Camera setting-n

Figure 17 Format used to record picture-taking conditions

SubjectDistanceRange

This tag indicates the distance to the subject.

Tag	=	41996 (A40C.H)
Type	=	SHORT
Count	=	1
Default	=	none
0	=	unknown
1	=	Macro
2	=	Close view
3	=	Distant view
Other	=	reserved

H. Other tags

ImageUniqueID

This tag indicates an identifier assigned uniquely to each image. It is recorded as an ASCII string equivalent to hexadecimal notation and 128-bit fixed length.

Tag	=	42016 (A420.H)
Type	=	ASCII
Count	=	33
Default	=	none

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4.6.6 GPS Attribute Information

The attribute information (field names and codes) recorded in the GPS Info IFD is given in Table 12, followed by an explanation of the contents.

Table 12 GPS Attribute Information

Tag Name	Field Name	Tag ID		Type	Count
		Dec	Hex		
A. Tags Relating to GPS					
GPS tag version	GPSVersionID	0	0	BYTE	4
North or South Latitude	GPSLatitudeRef	1	1	ASCII	2
Latitude	GPSLatitude	2	2	RATIONAL	3
East or West Longitude	GPSLongitudeRef	3	3	ASCII	2
Longitude	GPSLongitude	4	4	RATIONAL	3
Altitude reference	GPSAltitudeRef	5	5	BYTE	1
Altitude	GPSAltitude	6	6	RATIONAL	1
GPS time (atomic clock)	GPSTimeStamp	7	7	RATIONAL	3
GPS satellites used for measurement	GPSSatellites	8	8	ASCII	Any
GPS receiver status	GPSStatus	9	9	ASCII	2
GPS measurement mode	GPSMeasureMode	10	A	ASCII	2
Measurement precision	GPSDOP	11	B	RATIONAL	1
Speed unit	GPSSpeedRef	12	C	ASCII	2
Speed of GPS receiver	GPSSpeed	13	D	RATIONAL	1
Reference for direction of movement	GPSTrackRef	14	E	ASCII	2
Direction of movement	GPSTrack	15	F	RATIONAL	1
Reference for direction of image	GPSImgDirectionRef	16	10	ASCII	2
Direction of image	GPSImgDirection	17	11	RATIONAL	1
Geodetic survey data used	GPSMapDatum	18	12	ASCII	Any
Reference for latitude of destination	GPSDestLatitudeRef	19	13	ASCII	2
Latitude of destination	GPSDestLatitude	20	14	RATIONAL	3
Reference for longitude of destination	GPSDestLongitudeRef	21	15	ASCII	2
Longitude of destination	GPSDestLongitude	22	16	RATIONAL	3
Reference for bearing of destination	GPSDestBearingRef	23	17	ASCII	2
Bearing of destination	GPSDestBearing	24	18	RATIONAL	1
Reference for distance to destination	GPSDestDistanceRef	25	19	ASCII	2
Distance to destination	GPSDestDistance	26	1A	RATIONAL	1
Name of GPS processing method	GPSProcessingMethod	27	1B	UNDEFINED	Any
Name of GPS area	GPSAreaInformation	28	1C	UNDEFINED	Any
GPS date	GPSDateStamp	29	1D	ASCII	11
GPS differential correction	GPSDifferential	30	1E	SHORT	1

A. Tags Relating to GPS

GPSVersionID

Indicates the version of *GPSInfoIFD*. The version is given as 2.2.0.0. This tag is mandatory when *GPSInfo* tag is present. Note that the *GPSVersionID* tag is written as a different byte than the Exif Version tag.

- Tag = 0 (0.H)
- Type = BYTE
- Count = 4
- Default = 2.2.0.0
- 2.2.0.0 = Version 2.2
- Other = reserved

GPSLatitudeRef

Indicates whether the latitude is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

- Tag = 1 (1.H)

Type = ASCII
 Count = 2
 Default = none
 'N' = North latitude
 'S' = South latitude
 Other = reserved

GPSPLatitude

Indicates the latitude. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If latitude is expressed as degrees, minutes and seconds, a typical format would be dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be dd/1,mmmm/100,0/1.

Tag = 2 (2.H)
 Type = RATIONAL
 Count = 3
 Default = none

GPSLongitudeRef

Indicates whether the longitude is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west longitude.

Tag = 3 (3.H)
 Type = ASCII
 Count = 2
 Default = none
 'E' = East longitude
 'W' = West longitude
 Other = reserved

GPSLongitude

Indicates the longitude. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If longitude is expressed as degrees, minutes and seconds, a typical format would be ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be ddd/1,mmmm/100,0/1.

Tag = 4 (4.H)
 Type = RATIONAL
 Count = 3
 Default = none

GPSAltitudeRef

Indicates the altitude used as the reference altitude. If the reference is sea level and the altitude is above sea level, 0 is given. If the altitude is below sea level, a value of 1 is given and the altitude is indicated as an absolute value in the GPSAltitude tag. The reference unit is meters. Note that this tag is BYTE type, unlike other reference tags.

Tag = 5 (5.H)
 Type = BYTE
 Count = 1
 Default = 0

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0	=	Sea level
1	=	Sea level reference (negative value)
Other	=	reserved

GPSAltitude

Indicates the altitude based on the reference in *GPSAltitudeRef*. Altitude is expressed as one RATIONAL value. The reference unit is meters.

Tag	=	6 (6.H)
Type	=	RATIONAL
Count	=	1
Default	=	none

GPSTimeStamp

Indicates the time as UTC (Coordinated Universal Time). TimeStamp is expressed as three RATIONAL values giving the hour, minute, and second.

Tag	=	7 (7.H)
Type	=	RATIONAL
Count	=	3
Default	=	none

GPSSatellites

Indicates the GPS satellites used for measurements. This tag can be used to describe the number of satellites, their ID number, angle of elevation, azimuth, SNR and other information in ASCII notation. The format is not specified. If the GPS receiver is incapable of taking measurements, value of the tag shall be set to NULL.

Tag	=	8 (8.H)
Type	=	ASCII
Count	=	Any
Default	=	none

GPSStatus

Indicates the status of the GPS receiver when the image is recorded. 'A' means measurement is in progress, and 'V' means the measurement is Interoperability.

Tag	=	9 (9.H)
Type	=	ASCII
Count	=	2
Default	=	none
'A'	=	Measurement in progress
'V'	=	Measurement Interoperability
Other	=	reserved

GPSMeasureMode

Indicates the GPS measurement mode. '2' means two-dimensional measurement and '3' means three-dimensional measurement is in progress.

Tag	=	10 (A.H)
Type	=	ASCII
Count	=	2

Default = none
 '2' = 2-dimensional measurement
 '3' = 3-dimensional measurement
 Other = reserved

GPSDOP

Indicates the GPS DOP (data degree of precision). An HDOP value is written during two-dimensional measurement, and PDOP during three-dimensional measurement.

Tag = 11 (B.H)
 Type = RATIONAL
 Count = 1
 Default = none

GPSSpeedRef

Indicates the unit used to express the GPS receiver speed of movement. 'K' 'M' and 'N' represents kilometers per hour, miles per hour, and knots.

Tag = 12 (C.H)
 Type = ASCII
 Count = 2
 Default = 'K'
 'K' = Kilometers per hour
 'M' = Miles per hour
 'N' = Knots
 Other = reserved

GPSSpeed

Indicates the speed of GPS receiver movement.

Tag = 13 (D.H)
 Type = RATIONAL
 Count = 1
 Default = none

GPSTrackRef

Indicates the reference for giving the direction of GPS receiver movement. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 14 (E.H)
 Type = ASCII
 Count = 2
 Default = 'T'
 'T' = True direction
 'M' = Magnetic direction
 Other = reserved

GPSTrack

Indicates the direction of GPS receiver movement. The range of values is from 0.00 to 359.99.

Tag = 15 (F.H)

JEITA CP-3451

Type = RATIONAL
 Count = 1
 Default = none

GPSImgDirectionRef

Indicates the reference for giving the direction of the image when it is captured. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 16 (10.H)
 Type = ASCII
 Count = 2
 Default = 'T'
 'T' = True direction
 'M' = Magnetic direction
 Other = reserved

GPSImgDirection

Indicates the direction of the image when it was captured. The range of values is from 0.00 to 359.99.

Tag = 17 (11.H)
 Type = RATIONAL
 Count = 1
 Default = none

GPSMapDatum

Indicates the geodetic survey data used by the GPS receiver. If the survey data is restricted to Japan, the value of this tag is 'TOKYO' or 'WGS-84'. If a *GPS Info* tag is recorded, it is strongly recommended that this tag be recorded.

Tag = 18 (12.H)
 Type = ASCII
 Count = Any
 Default = none

GPSDestLatitudeRef

Indicates whether the latitude of the destination point is north or south latitude. The ASCII value 'N' indicates north latitude, and 'S' is south latitude.

Tag = 19 (13.H)
 Type = ASCII
 Count = 2
 Default = none
 'N' = North latitude
 'S' = South latitude
 Other = reserved

GPSDestLatitude

Indicates the latitude of the destination point. The latitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If latitude is expressed as degrees, minutes and seconds, a typical format would be dd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be dd/1,mmmm/100,0/1.

Tag = 20 (14.H)
 Type = RATIONAL
 Count = 3
 Default = none

GPSDestLongitudeRef

Indicates whether the longitude of the destination point is east or west longitude. ASCII 'E' indicates east longitude, and 'W' is west longitude.

Tag = 21 (15.H)
 Type = ASCII
 Count = 2
 Default = none
 'E' = East longitude
 'W' = West longitude
 Other = reserved

GPSDestLongitude

Indicates the longitude of the destination point. The longitude is expressed as three RATIONAL values giving the degrees, minutes, and seconds, respectively. If longitude is expressed as degrees, minutes and seconds, a typical format would be ddd/1,mm/1,ss/1. When degrees and minutes are used and, for example, fractions of minutes are given up to two decimal places, the format would be ddd/1,mmmm/100,0/1.

Tag = 22 (16.H)
 Type = RATIONAL
 Count = 3
 Default = none

GPSDestBearingRef

Indicates the reference used for giving the bearing to the destination point. 'T' denotes true direction and 'M' is magnetic direction.

Tag = 23 (17.H)
 Type = ASCII
 Count = 2
 Default = 'T'
 'T' = True direction
 'M' = Magnetic direction
 Other = reserved

GPSDestBearing

Indicates the bearing to the destination point. The range of values is from 0.00 to 359.99.

Tag = 24 (18.H)
 Type = RATIONAL
 Count = 1
 Default = none

GPSDestDistanceRef

Indicates the unit used to express the distance to the destination point. 'K', 'M' and 'N' represent kilometers, miles and knots.

JEITA CP-3451

Tag	=	25 (19.H)
Type	=	ASCII
Count	=	2
Default	=	'K'
'K'	=	Kilometers
'M'	=	Miles
'N'	=	Knots
Other	=	reserved

GPSTDestDistance

Indicates the distance to the destination point.

Tag	=	26 (1A.H)
Type	=	RATIONAL
Count	=	1
Default	=	none

GPSProcessingMethod

A character string recording the name of the method used for location finding. The first byte indicates the character code used (Table 6, Table 7), and this is followed by the name of the method. Since the Type is not ASCII, NULL termination is not necessary.

Tag	=	27 (1B.H)
Type	=	UNDEFINED
Count	=	Any
Default	=	none

GPSAreaInformation

A character string recording the name of the GPS area. The first byte indicates the character code used (Table 6, Table 7), and this is followed by the name of the GPS area. Since the Type is not ASCII, NULL termination is not necessary.

Tag	=	28 (1C.H)
Type	=	UNDEFINED
Count	=	Any
Default	=	none

GPSTDateStamp

A character string recording date and time information relative to UTC (Coordinated Universal Time). The format is "YYYY:MM:DD." The length of the string is 11 bytes including NULL.

Tag	=	29 (1D.H)
Type	=	ASCII
Count	=	11
Default	=	none

GPSTDifferential

Indicates whether differential correction is applied to the GPS receiver.

Tag	=	30 (1E.H)
Type	=	SHORT

Count = 1
 Default = none
 0 = Measurement without differential correction
 1 = Differential correction applied
 Other = reserved

Note—When the tag Type is ASCII, it shall be terminated with NULL.

It shall be noted carefully that since the value count includes the terminator NULL, the total count is the number of data+1. For example, *GPSLatitudeRef* cannot have any values other than Type ASCII 'N' or 'S'; but because the terminator NULL is added, the value of N is 2.

4.6.7 Interoperability IFD Attribute Information

The attached information(field name, code) stored in Interoperability IFD is listed in and the meaning will be explained also.

Table 13 Interoperability IFD Attribute Information

Tag Name	Field Name	Tag ID		Type	Count	
		Dec	Hex			
A. Attached Information Related to Interoperability						
	Interoperability Identification	InteroperabilityIndex	1	1	ASCII	Any

A. Tags Relating to Interoperability

The rules for Exif image files defines the description of the following tag. Other tags stored in Interoperability IFD may be defined dependently to each Interoperability rule.

InteroperabilityIndex

Indicates the identification of the Interoperability rule. The following rules are defined. Four bytes used including the termination code (NULL).

Tag = 1 (1.H)
 Type = ASCII
 Count = Any
 Default = none
 "R98" = Indicates a file conforming to R98 file specification of Recommended Exif Interoperability Rules (ExifR98) or to DCF basic file stipulated by Design Rule for Camera File System.
 "THM" = Indicates a file conforming to DCF thumbnail file stipulated by Design rule for Camera File System.

JEITA CP-3451

4.6.8 Tag Support Levels

The tags and their support levels are given here.

A. Primary Image (0th IFD) Support Levels

The support levels of primary image (0th IFD) tags are given in Table 14, Table 15, Table 16 and Table 17.

Table 14 Tag Support Levels (1) - 0th IFD TIFF Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Image width	ImageWidth	256	100	M	M	M	J
Image height	ImageLength	257	101	M	M	M	J
Number of bits per component	BitsPerSample	258	102	M	M	M	J
Compression scheme	Compression	259	103	M	M	M	J
Pixel composition	PhotometricInterpretation	262	106	M	M	M	N
Image title	ImageDescription	270	10E	R	R	R	R
Manufacturer of image input equipment	Make	271	10F	R	R	R	R
Model of image input equipment	Model	272	110	R	R	R	R
Image data location	StripOffsets	273	111	M	M	M	N
Orientation of image	Orientation	274	112	R	R	R	R
Number of components	SamplesPerPixel	277	115	M	M	M	J
Number of rows per strip	RowsPerStrip	278	116	M	M	M	N
Bytes per compressed strip	StripByteCounts	279	117	M	M	M	N
Image resolution in width direction	XResolution	282	11A	M	M	M	M
Image resolution in height direction	YResolution	283	11B	M	M	M	M
Image data arrangement	PlanarConfiguration	284	11C	O	M	O	J
Unit of X and Y resolution	ResolutionUnit	296	128	M	M	M	M
Transfer function	TransferFunction	301	12D	R	R	R	R
Software used	Software	305	131	O	O	O	O
File change date and time	DateTime	306	132	R	R	R	R
Person who created the image	Artist	315	13B	O	O	O	O
White point chromaticity	WhitePoint	318	13E	O	O	O	O
Chromaticities of primaries	PrimaryChromaticities	319	13F	O	O	O	O
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	N	N	N	N
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	N	N	N	N
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	N	N	O	O
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	N	N	M	J
Y and C positioning	YCbCrPositioning	531	213	N	N	M	M
Pair of black and white reference values	ReferenceBlackWhite	532	214	O	O	O	O
Copyright holder	Copyright	33432	8298	O	O	O	O
Exif tag	Exif IFD Pointer	34665	8769	M	M	M	M
GPS tag	GPSInfo IFD Pointer	34853	8825	O	O	O	O

Notation
M : Mandatory (shall be recorded)
R : Recommended
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

Table 15 Tag Support Levels (2) - 0th IFD Exif Private Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Exposure time	ExposureTime	33434	829A	R	R	R	R
F number	FNumber	33437	829D	O	O	O	O
Exposure program	ExposureProgram	34850	8822	O	O	O	O
Spectral sensitivity	SpectralSensitivity	34852	8824	O	O	O	O
ISO speed ratings	ISOSpeedRatings	34855	8827	O	O	O	O
Optoelectric coefficient	OECF	34856	8828	O	O	O	O
Exif Version	ExifVersion	36864	9000	M	M	M	M
Date and time original image was generated	DateTimeOriginal	36867	9003	O	O	O	O
Date and time image was made digital data	DateTimeDigitized	36868	9004	O	O	O	O
Meaning of each component	ComponentsConfiguration	37121	9101	N	N	N	M
Image compression mode	CompressedBitsPerPixel	37122	9102	N	N	N	O
Shutter speed	ShutterSpeedValue	37377	9201	O	O	O	O
Aperture	ApertureValue	37378	9202	O	O	O	O
Brightness	BrightnessValue	37379	9203	O	O	O	O
Exposure bias	ExposureBiasValue	37380	9204	O	O	O	O
Maximum lens aperture	MaxApertureValue	37381	9205	O	O	O	O
Subject distance	SubjectDistance	37382	9206	O	O	O	O
Metering mode	MeteringMode	37383	9207	O	O	O	O
Light source	LightSource	37384	9208	O	O	O	O
Flash	Flash	37385	9209	R	R	R	R
Lens focal length	FocalLength	37386	920A	O	O	O	O
Subject area	SubjectArea	37396	9214	O	O	O	O
Manufacturer notes	MakerNote	37500	927C	O	O	O	O
User comments	UserComment	37510	9286	O	O	O	O
DateTime subseconds	SubSecTime	37520	9290	O	O	O	O
DateTimeOriginal subseconds	SubSecTimeOriginal	37521	9291	O	O	O	O
DateTimeDigitized subseconds	SubSecTimeDigitized	37522	9292	O	O	O	O
Supported Flashpix version	FlashpixVersion	40960	A000	M	M	M	M
Color space information	ColorSpace	40961	A001	M	M	M	M
Valid image width	PixelXDimension	40962	A002	N	N	N	M
Valid image height	PixelYDimension	40963	A003	N	N	N	M
Related audio file	RelatedSoundFile	40964	A004	O	O	O	O
Interoperability tag	Interoperability IFD Pointer	40965	A005	N	N	N	O
Flash energy	FlashEnergy	41483	A20B	O	O	O	O
Spatial frequency response	SpatialFrequencyResponse	41484	A20C	O	O	O	O
Focal plane X resolution	FocalPlaneXResolution	41486	A20E	O	O	O	O
Focal plane Y resolution	FocalPlaneYResolution	41487	A20F	O	O	O	O
Focal plane resolution unit	FocalPlaneResolutionUnit	41488	A210	O	O	O	O
Subject location	SubjectLocation	41492	A214	O	O	O	O
Exposure index	ExposureIndex	41493	A215	O	O	O	O
Sensing method	SensingMethod	41495	A217	O	O	O	O
File source	FileSource	41728	A300	O	O	O	O
Scene type	SceneType	41729	A301	O	O	O	O
CFA pattern	CFAPattern	41730	A302	O	O	O	O
Custom image processing	CustomRendered	41985	A401	O	O	O	O
Exposure mode	ExposureMode	41986	A402	R	R	R	R
White balance	WhiteBalance	41987	A403	R	R	R	R
Digital zoom ratio	DigitalZoomRatio	41988	A404	O	O	O	O
Focal length in 35 mm film	FocalLengthIn35mmFilm	41989	A405	O	O	O	O
Scene capture type	SceneCaptureType	41990	A406	R	R	R	R
Gain control	GainControl	41991	A407	O	O	O	O
Contrast	Contrast	41992	A408	O	O	O	O
Saturation	Saturation	41993	A409	O	O	O	O
Sharpness	Sharpness	41994	A40A	O	O	O	O
Device settings description	DeviceSettingDescription	41995	A40B	O	O	O	O
Subject distance range	SubjectDistanceRange	41996	A40C	O	O	O	O
Unique image ID	ImageUniqueID	42016	A420	O	O	O	O

Notation
M : Mandatory (shall be recorded)
R : Recommended
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

JEITA CP-3451

Table 16 Tag Support Levels (3) - 0th IFD GPS Info Tags -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
GPS tag version	GPSVersionID	0	0	O	O	O	O
North or South Latitude	GPSLatitudeRef	1	1	O	O	O	O
Latitude	GPSLatitude	2	2	O	O	O	O
East or West Longitude	GPSLongitudeRef	3	3	O	O	O	O
Longitude	GPSLongitude	4	4	O	O	O	O
Altitude reference	GPSAltitudeRef	5	5	O	O	O	O
Altitude	GPSAltitude	6	6	O	O	O	O
GPS time (atomic clock)	GPSTimeStamp	7	7	O	O	O	O
GPS satellites used for measurement	GPSStatus	8	8	O	O	O	O
GPS receiver status	GPSSpeed	9	9	O	O	O	O
GPS measurement mode	GPSMeasureMode	10	A	O	O	O	O
Measurement precision	GPSDOP	11	B	O	O	O	O
Speed unit	GPSSpeedRef	12	C	O	O	O	O
Speed of GPS receiver	GPSSpeed	13	D	O	O	O	O
Reference for direction of movement	GPSTrackRef	14	E	O	O	O	O
Direction of movement	GPSTrack	15	F	O	O	O	O
Reference for direction of image	GPSTrackRef	16	10	O	O	O	O
Direction of image	GPSTrack	17	11	O	O	O	O
Geodetic survey data used	GPSTrack	18	12	O	O	O	O
Reference for latitude of destination	GPSDestLatitudeRef	19	13	O	O	O	O
Latitude of destination	GPSDestLatitude	20	14	O	O	O	O
Reference for longitude of destination	GPSDestLongitudeRef	21	15	O	O	O	O
Longitude of destination	GPSDestLongitude	22	16	O	O	O	O
Reference for bearing of destination	GPSDestBearingRef	23	17	O	O	O	O
Bearing of destination	GPSDestBearing	24	18	O	O	O	O
Reference for distance to destination	GPSDestDistanceRef	25	19	O	O	O	O
Distance to destination	GPSDestDistance	26	1A	O	O	O	O
Name of GPS processing method	GPSProcessingMethod	27	1B	O	O	O	O
Name of GPS area	GPSAreaInformation	28	1C	O	O	O	O
GPS date	GPSDateStamp	29	1D	O	O	O	O
GPS differential correction	GPSDifferential	30	1E	O	O	O	O

Table 17 Tag Support Levels (4) - 0th IFD Interoperability Tag -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Interoperability Identification	InteroperabilityIndex	1	1	N	N	N	O

Notation
M : Mandatory (shall be recorded)
R : Recommended
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded

B. Thumbnail (1st IFD) Support Levels

The support levels of thumbnail (1st IFD) tags are shown in Table 18.

Table 18 Tag Support Levels (5) - 1st IFD TIFF Tag -

Tag Name	Field Name	Tag ID		Uncompressed			Compressed
		Dec	Hex	Chunky	Planar	YCC	
Image width	ImageWidth	256	100	M	M	M	J
Image height	ImageLength	257	101	M	M	M	J
Number of bits per component	BitsPerSample	258	102	M	M	M	J
Compression scheme	Compression	259	103	M	M	M	M
Pixel composition	PhotometricInterpretation	262	106	M	M	M	J
Image title	ImageDescription	270	10E	O	O	O	O
Manufacturer of image input equipment	Make	271	10F	O	O	O	O
Model of image input equipment	Model	272	110	O	O	O	O
Image data location	StripOffsets	273	111	M	M	M	N
Orientation of image	Orientation	274	112	O	O	O	O
Number of components	SamplesPerPixel	277	115	M	M	M	J
Number of rows per strip	RowsPerStrip	278	116	M	M	M	N
Bytes per compressed strip	StripByteCounts	279	117	M	M	M	N
Image resolution in width direction	XResolution	282	11A	M	M	M	M
Image resolution in height direction	YResolution	283	11B	M	M	M	M
Image data arrangement	PlanarConfiguration	284	11C	O	M	O	J
Unit of X and Y resolution	ResolutionUnit	296	128	M	M	M	M
Transfer function	TransferFunction	301	12D	O	O	O	O
Software used	Software	305	131	O	O	O	O
File change date and time	DateTime	306	132	O	O	O	O
Person who created the image	Artist	315	13B	O	O	O	O
White point chromaticity	WhitePoint	318	13E	O	O	O	O
Chromaticities of primaries	PrimaryChromaticities	319	13F	O	O	O	O
Offset to JPEG SOI	JPEGInterchangeFormat	513	201	N	N	N	M
Bytes of JPEG data	JPEGInterchangeFormatLength	514	202	N	N	N	M
Color space transformation matrix coefficients	YCbCrCoefficients	529	211	N	N	O	O
Subsampling ratio of Y to C	YCbCrSubSampling	530	212	N	N	M	J
Y and C positioning	YCbCrPositioning	531	213	N	N	O	O
Pair of black and white reference values	ReferenceBlackWhite	532	214	O	O	O	O
Copyright holder	Copyright	33432	8298	O	O	O	O
Exif tag	Exif IFD Pointer	34665	8769	O	O	O	O
GPS tag	GPSInfo IFD Pointer	34853	8825	O	O	O	O

Notation
M : Mandatory (must be recorded)
R : Recommended
O : Optional
N : Not recorded
J : Included in JPEG marker and so not recorded