TASK ORDER
REQUEST FOR PROPOSAL

OPTION YEAR 2 (2015)

SMALL AREA AERIAL PHOTOGRAPHY CONTRACT STEWARDSHIP LANDS IMAGERY (SLI) SECOND DIRECT DIGITAL PILOT

Task Order Solicitation Number: SAC-TO-2-15-2
Task Order Issue Date: 7-APR-2015

U.S. DEPARTMENT OF AGRICULTURE
FARM SERVICE AGENCY
AERIAL PHOTOGRAPHY FIELD OFFICE

NOTICE TO OFFEROR
Proposals submitted in response to this RFP must be identified with the following information labeled on the outside of the mailing package:

SOL.NO: SAC-TO-2-15-2
DUE DATE: 28-APR-2015, 2:30 PM
RECEIVING OFFICE: CONTRACTING

Mail To: AERIAL PHOTOGRAPHY FIELD OFFICE
CONTRACTING OFFICER
2222 WEST 2300 SOUTH
SALT LAKE CITY UTAH 84119-2020

NOTICE TO OFFERORS:

PLEASE NOTE THE FOLLOWING SPECIAL TASK ORDER INSTRUCTIONS:

This simplified task order RFP is issued under the Second Option Year covering the 2015 performance period, under the multi-award fixed-price IDIQ contract.

There are nine (9) separate states in this task order: 1. California, 2. Idaho, 3. Kansas, 4. Maryland, 5. Nebraska, 6. North Dakota, 7. Pennsylvania, 8. South Carolina, & 9. Washington.

Proposals must be presented in two parts: a pricing volume and a technical volume (please do not secure your proposal using a "plastic comb" or spiral type bindings). Two complete copies of the proposal are required.
- The pricing volume must contain a signed and completed copy of pages 1–2 and Exhibit 6 of this RFP.
- The technical volume shall not exceed fifty 8½"x11" single-sided pages (equivalent double-sided is acceptable). Letters of commitment, resumes, camera calibration reports, and documentation to support camera approval may be provided in an attachment without page restrictions. Do not include any pricing or cost information in the technical volume.

Evaluations of this and Task Order SAC-TO-2-15-3 will determine whether the easements associated with these states will be awarded as film based or direct digital acquisitions. They will not be awarded as both. It is possible that **no** state may be awarded under this task order.

Contractor is required to provide a detailed technical description and sample image of digital camera/sensor(s) being proposed for use on this task order. (See Paragraph 3.7(b)).

Pricing for each state will be evaluated independently (See Paragraph 6.7). Task Order awards will be made based on procedures established in Section L-3.1 of the original solicitation.

This RFP is subject to the Availability of Funds Clause (FAR 52.232-18), See Paragraph 6.5.

TASK ORDER REQUEST FOR PROPOSAL

STEWARDSHIP LANDS SECOND DIGITAL PILOT
Digital High Resolution Pilot Project for Stewardship Lands Imagery in Nine States: California, Idaho, Kansas, Maryland, Nebraska, North Dakota, Pennsylvania, South Carolina, and Washington.

1.0 DIRECT DIGITAL AERIAL PHOTOGRAPHY SERVICES

Furnish ortho-rectified aerial imagery and all related services and supplies in accordance with the requirements, specifications, terms, conditions, clauses, and provisions specified herein and in the original indefinite-delivery, indefinite-quantity contract, effective for the periods stated in the schedule. The Government's proposed states, quantities, and other parameters listed in Paragraph 1.1 are subject to change through the negotiation process of selecting the "Best Value" source for task order award.

This is the second pilot project conducted to develop strategies through the use of remote sensing and GIS technologies to monitor, adaptively manage, and ensure compliance of NRCS easements enrolled in the Stewardship Lands Program (SLI).

1.1 Pricing Proposal – Stewardship Lands Second Pilot Project – Direct Digital, Ortho-rectified, Four (4) Band Imagery.

ORTHO-RECTIFIED DIRECT DIGITAL IMAGERY FOR THE STEWARDSHIP LANDS IMAGERY (SLI) PROGRAM				
COMPANY NAME:		AUTHORIZED SIGNATURE:		DATE:
PRICING PROPOSALS				
STATE	TOTAL NUMBER OF EASEMENTS	TOTAL ACREAGE OF EASEMENTS	15 CM GSD ORTHO-RECTIFIED IMAGERY (4-Band, 8 bits per Band GeoTIFFs)	TOTAL AMOUNT
CALIFORNIA	288	130,740	Price per Acre:	$
IDAHO	78	60,742	Price per Acre:	$
KANSAS	300	65,030	Price per Acre:	$
MARYLAND	79	9,809	Price per Acre:	$

STATE	TOTAL NUMBER OF EASEMENTS	TOTAL ACREAGE OF EASEMENTS	15 CM GSD ORTHO-RECTIFIED IMAGERY (4-Band, 8 bits per Band GeoTIFFs)	TOTAL AMOUNT
NEBRASKA	619	79,956	Price per Acre:	$
NORTH DAKOTA	796	130,938	Price per Acre:	$
PENNSYLVANIA	140	6,950	Price per Acre:	$
SOUTH CAROLINA	231	65,930	Price per Acre:	$
WASHINGTON	168	26,464	Price per Acre:	$
2,699 Total Easements 576,559 Total Acres				

PRICING PROPOSAL INSTRUCTIONS:

Enter your proposed unit price and total amount in the spaces provided above. Enter 'NO BID' in the 'TOTAL AMOUNT' block where no bid is being offered. Please ensure that the total amount can be calculated by multiplying the quantity times the average unit price. In case of discrepancy between a unit price (Price per Acre) and an extended price (Total Amount), the unit price will be assumed to be correct. **PLEASE NOTE: The minimum unit of offer is all SLI Easements within each state.**

2.0 TASK ORDER REQUIREMENTS

The general scope of this task order is to procure vertical, high resolution, direct digital, 4-band, 8 bit per band, orthorectified color aerial imagery to assist in establishing standards for evaluation of several Natural Resources Conservation Service (NRCS) Stewardship Lands Easement Programs.

2.1 Task Order Performance Period

The performance period for the acquisition and delivery of SLI aerial imagery is: **Date of Award (approximately May 2015) through December 31, 2015**.

2.2 Intended Use of Photography

The Stewardship Lands Imagery Program (SLI) is conducted to develop strategies to monitor, adaptively manage, and ensure compliance of NRCS easements enrolled in the Wetlands Reserve Program (WRP), Grassland Reserve Program (GRP), Healthy Forests Reserve Program (HFRP), Farm and Ranch Lands Protection Program (FRPP), and the Emergency Watershed Program-Floodplain Easements (EWPP-FPE). As part of this project, the imagery shall be evaluated to determine whether/that it will meet the requirements of the program. NRCS shall use the imagery acquired under this task order to collect and measure natural resource data by means of photo interpretation and use of Geographic Information Systems (GIS) technologies. Within each easement, data is collected on land cover and use, soil erosion, wetlands issues, and characteristics of other natural resources.

2.3 Location of Work

The Stewardship Lands Digital Pilot covers a sample of 2,699 Easements located in California, Idaho, Kansas, Maryland, Nebraska, North Dakota, Pennsylvania, South Carolina, and Washington. Please refer to Exhibit 1, 2015 Stewardship Lands Second Digital Pilot – Easement Locations.

2.4 Task Order Deliverables

The following deliverables shall be submitted by the Contractor and prepared in accordance with this Task Order and the IDIQ contract specifications including work statement (Section C), packaging and marking (Section D), inspection and acceptance (Section E), and delivery schedule (Section F). The deliverables for this task order consist of the following:

Deliverable	Data Format	Government Approval Required	Metadata Required
Project Flight Plan	Esri compatible shapefile	No – review only	No
Pre-Production Imagery Sample**	TIFF – See Paragraph 3.5	Yes	No
4-band orthorectified photos (mosaicked as needed) covering each of the easements*	4 band 8 bit per band GeoTIFF format mosaic images. See Paragraph 3.6	Yes	Yes

Deliverable	Data Format	Government Approval Required	Metadata Required
Progress Reports	E-mail	No	No
Project Geodatabase*	Esri compatible geodatabase - See Paragraph 3.6	Yes	Yes
Metadata	ASCII text	No	--

* delivered on hard drive (internal [unenclosed] hard drive)
** delivered on CD-ROM or DVD

3.0 TECHNICAL REQUIREMENTS

The specific technical requirements of this task order are summarized as follows. Please reference the IDIQ Contract and Attachments A – APFO Specification for Digital Camera Based Acquisition and B – Digital Imagery Quality Specification for other terms, conditions and technical requirements not addressed in this task order.

3.1 Size of SLI Easements:

The easements vary in size from approximately .34 acres (.00053 square mile) in Pacific County, Washington to approximately 7,464 acres (11.66 square miles) in Blaine County, Idaho. See Exhibit 2, Easement Reference Data.

3.2 Ground Sample Distance:

The ground sample distance requirement for this project is a minimum of 15 cm.

3.3 Project Flight Plan Description:

(a) Easement Flight Requirements:
(1) Flight altitudes will be chosen as necessary to acquire the 15 cm resolution required.
(2) Buffer: A minimum buffer zone of 100 meters (328 feet) is required beyond the actual easement boundary.

(b) The Contractor shall provide a proposed flight plan for each of the easements as an ESRI compatible shapefile. NOTE: The flight plan shall include the requirement for coverage of a 100 meter buffer around each easement.

3.4 Approximate Photographic Period:

(a) Photo Period: The photo period for all easements within this project is **Date of Award (Approximately May 2015) through September 30, 2015.**

(b) Refer to the Contract, Section F-5, Performance of the Work.

3.5 Photographic Conditions:

(a) Minimum Sun Angle: 30 degrees

(b) Image Acquisition: Photography shall be undertaken when skies are **clear, free from**

smoke, clouds, cloud shadows, excessive haze, and well-defined images can be resolved. The ground shall be free from snow, standing water (other than natural or man-made ponds and lakes), flood waters from streams which have overflowed their banks, and wet ground which obscures field, soil or crop lines.

3.6 Color-corrected, Orthorectified Image Files

The Contractor shall create color-corrected, orthorectified 4-band, 8-bit per band, image files, mosaicked where needed, for each easement. Multiple easements may exist on an image due to the easement size; however, there shall be a separate image provided for each easement. The orthorectified (mosaicked where needed) image, covering the entire easement and the 100 meter buffer, shall be projected in the appropriate UTM Zone using the NAD83 projection; easements that cover more than one UTM Zone may be projected in the zone where the majority of the easement lies. Where orthorectified mosaics are needed, any orthorectified mosaic which is produced shall be separated into tiles no larger than two (2) gigabytes (GB) in size. Any mosaic created to cover an easement that exceeds 2 GB may be split (N-S, E-W, etc.) to meet the 2GB size limit and shall have 100 meters of overlap between tiles.

(a) Image Quality. The Contractor shall color-correct the imagery so it radiometrically matches the ground at the time of exposure including, but not limited to, any dodging, histogram stretching, brightness adjustments, and/or color balancing. The orthoimagery shall not contain any borders, artifacts, or other non-image items. Refer to Attachment B – Digital Imagery Quality Specification.

(b) File Format. Orthorectified imagery will be delivered as follows:
(1) 4-band, 8-bit per band, georeferenced tagged image file format (GeoTIFF) with the appropriate TIFF tag values. Refer to Exhibit 4 – Required TIFF Tags.
(2) The band order shall be Red, Green, Blue, and Near Infra-red (RGBN).

(c) Files shall use the file naming specified in Exhibit 3, File Naming Convention.

(d) Raster Support File. The Contractor shall provide an AUX.XML (Esri compatible Auxilary statistic/projection file) and an OVR (Esri compatible pyramid file) for each image file. The auxiliary file shall contain the proper projection information for the file and shall match the information in the GeoTIFF header. The files shall use the same naming convention as the image files but with an ".aux.xml" and ".ovr" extension respectively.

(e) Pre-production Sample. The Contractor shall submit a single 4-band, 8-bit per band image prior to production for Government review. The sample shall be a TIFF meeting the requirements of the contract, including TIFF and GeoTIFF tags, and submitted on a standard CD or DVD. The Government will evaluate and provide an approval or disapproval letter with comments no later than five (5) business days, with a goal of three (3) business days.

(f) Horizontal Accuracy. All orthorectified digital image files shall have 95% of all well-defined points tested fall within four (4) meters of true ground location.

(g) Media Requirements. All easement imagery shall be delivered on industry standard hard drives as defined in the contract Section D-1(d)(1), Hard Drive Disks, stored by state and county under a root directory called "stnnn". See Exhibit 3, File Naming Convention and Directory Structure. Industry Standard Serial ATA Version III drives

may also be used. Maximum disk space that can be used may not exceed ninety percent (90%) of the individual hard drive capacity.

(h) Metadata. The contractor shall create a metadata file for each orthorectified image tile in accordance with the template provided by the Government, compliant with Federal Geographic Data Committee (FGDC), FGDC_STD-001-1998 specification. The file must parse cleanly through the USGS metadata parser "mp" version 2.9.23 without any errors.

3.7 Project Geodatabase

The Contractor shall produce a file Geodatabase, compatible with ESRI® ArcGIS 10.2 and newer versions, according to the template provided by the Government, projected in the native UTM. The geodatabase shall contain a feature data set that contains a polygon feature class for an Orthorectified Image Index and a line feature class for the seamlines. The project geodatabase shall be resubmitted with corrections reflecting any image corrections. The filename for the Geodatabase and all feature data sets shall use the naming convention specified in Exhibit 3, File Naming Convention

(a) Seamline Feature Class. The feature class for orthorectified tiles shall include the following attributes:

ATTRIBUTE DESCRIPTION	COLUMN NAME	DATA TYPE	EXAMPLE
Project Number	PROJNO	Char(7)	2-14-21
State	STATE	Char(2)	CO
Method of Creation*	METHD	Char(10)	Manual
Software Used to Generate Seamlines	SOFT	Char(50)	Socet_Set

* Possible values are: Manual or Automatic

(b) Orthorectified Image Index Feature Class. A single feature class for all orthorectified tiles in each state shall include the following attributes:

ATTRIBUTE DESCRIPTION	COLUMN NAME	DATA TYPE	EXAMPLE
Project Number	PROJNO	Char(7)	2-14-21
State	STATE	Char(2)	CO
Majority Date of Imagery (YYYY-MM-DD)	IDATE	Char(10)	2014-08-27
Image File Name	NAME	Char(50)	ortho_15_66453207004JX_3_090801.tif
Pixel Resolution in centimeters	RES	Double(5)	15
Color Type	BCON	Char(3)	M4B

(c) Metadata. The Contractor shall create FGDC compliant, per the FGDC-STD-001-1998 specification, metadata file for each Project Geodatabase. Metadata must parse cleanly through the USGS metadata parser "mp" version 2.9.23 without any errors. A metadata template will be provided.

3.8 Direct Digital Sensor:

The direct digital imagery acquisition requirements will be for the collection of visible (Red, Green, Blue) and color near infrared (IR) imagery. The digital sensor system shall be a tested, stable, geometrically calibrated system with appropriate documentation, suitable for use in precision photogrammetric orthoimagery applications.

(a) Digital sensor acquisitions require compliance with the technical requirements and specifications of this task order and Attachment A, APFO Specification for Digital Camera Based Acquisition which defines the essential elements in securing high quality direct digital imagery.

(b) The Contractor is required to provide a detailed technical description and sample image of the digital camera/sensor in accordance with Paragraph 4 of Attachment A before use on this task order.

(c) The digital sensor system shall have the appropriate image resolving power and field of view required to provide the required 15 cm ground sample distance (GSD).

4.0 GOVERNMENT-FURNISHED PROPERTY

Pursuant to the Government-Furnished Property (GFP) clause (see Section I-2 of the contract) the Government shall furnish the item(s) of property listed below as GFP to the Contractor.

4.1 Exposure Data – SLI Easements

The Contractor will be furnished upon award by the Government the following items:

(a) Esri compatible shapefiles for each awarded state containing the official Easement Data for that state. The shapefile contains the identification, description, location and boundaries of each of the easements for that state. These files DO NOT contain the required 100 meter (328 foot) buffer. The following is data selected from the .dbf file that is in each Esri compatible shapefile as an example:

Admin Area	County	FIPS	New Agreement Number	Calcacres	Elevation
NC	Bertie	37015	66453207004JX	485.357	3
NC	Carteret	37031	66453204004HC	1403.284	7
NC	Halifax	37083	66453205004H7	201.246	98
NC	Halifax	37083	66453200004GL	96.293	72

(b) Metadata Template: The Contractor will be furnished upon award two (2) data text files (.txt) containing the Federal Geographic Data Committee (FGDC) compliant metadata template to be used when creating the orthorectified file as required in Paragraph 3.5(g) and the project geodatabase as required in Paragraph 3.6(c).

5.0 DELIVERY SCHEDULE

5.1 Original Materials - Delivery Schedule

All delivery materials required for all original aerial photography for a project shall be shipped as soon as completed but not later than 30 calendar days after the photographic season has ended, or any season extension thereof. Prompt delivery of all materials will better assure the timely inspection and prompt payment for accepted materials.

5.2 Remake Materials - Delivery Schedule

All remake materials requested by USDA shall be shipped as soon as possible after correction is made, but no later than 15 days after receipt in the Contractor's facility of the materials or data required to make the corrections. Signed delivery receipts will be required to verify date of receipt of such data or materials by the Contractor.

6.0 ADMINISTRATIVE MATTERS

6.1 Wage Determination

Wage Determination number 1995-222, Revision 38, dated January 14, 2015 will be applicable for Contractors located nationwide. See Exhibit 7, Wage Determination.

6.2 Annual Representations and Certifications

Contractors shall have and maintain a current System for Award Management (SAM) (www.SAM.gov) record. SAM registration is free and may be completed online at: www.sam.gov. Please refer to the FAR Clause 52.204-08 - Annual Representations and Certifications (OCT 2014).

6.3 Small Business Subcontracting Plan

If applicable, all Contractors, except those certified as a small business concern, shall submit a subcontracting plan that separately addresses subcontracting with small business, veteran-owned small business, service-disabled veteran-owned small business, HUBZone small business concerns, small disadvantaged business and women owned small business concerns. The subcontracting plan shall be included and made a part of the resultant task order award and be negotiated with the Contracting Officer during the task order negotiation period. Failure to submit and negotiate the subcontracting plan shall make the offeror ineligible for award. Please refer to the Contract, Section G-6, Small Business Subcontracting Plan, FAR Clause 52.219-09.

6.4 Task Order Ombudsman

The Director of USDA-FSA-Aerial Photography Field Office shall serve as the Task Order Ombudsman and is responsible for reviewing complaints from the contractors and ensuring that all of the contractors are afforded a fair opportunity to be considered for task orders issued under this contract. The Task Order Ombudsman may be contacted at telephone (801) 844-2907, or mail to: Director, APFO, 2222 West 2300 South, Salt Lake City, UT 84119.

6.5 Availability of Funds (FAR 52.232-18, April 1984)

Funds are not presently available for this contract. The Government's obligation under this contract is contingent upon the availability of appropriated funds from which payment for contract purposes can be made. No legal liability on the part of the Government for any payment may arise until funds are made available to the Contracting Officer for this contract and until the Contractor receives notice of such availability, to be confirmed in writing by the Contracting Officer.

6.6 Non-Discrimination Statement

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its program and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of Discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW., Washington, DC 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

6.7 Project Evaluation

Each of the nine states proposed in this solicitation will be evaluated independently in terms of pricing. The offeror's technical score will be combined with the individual pricing scores to determine ranking for each of the projects. The selection will be based on the Government's determination of the best value between awarding under the film-based solicitation (SAC-TO-2-15-3) and this solicitation using a trade-off process based on the perceived benefits and merits of the proposals. Information provided in Sections 6.0, 9.0 and 10.0 of the task order solicitation (SAC-TO-2-15-3) and Exhibit 6 of this task order (SAC-TO-2-15-2) shall be part of this task order's evaluation.

LIST OF EXHIBITS AND ATTACHMENTS

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Attachment B	Digital Imagery Quality Specification	
Attachment C	USDA Digital File Format Specifications	

EXHIBIT 1

STEWARDSHIP LANDS SECOND DIGITAL PILOT - EASEMENT LOCATIONS

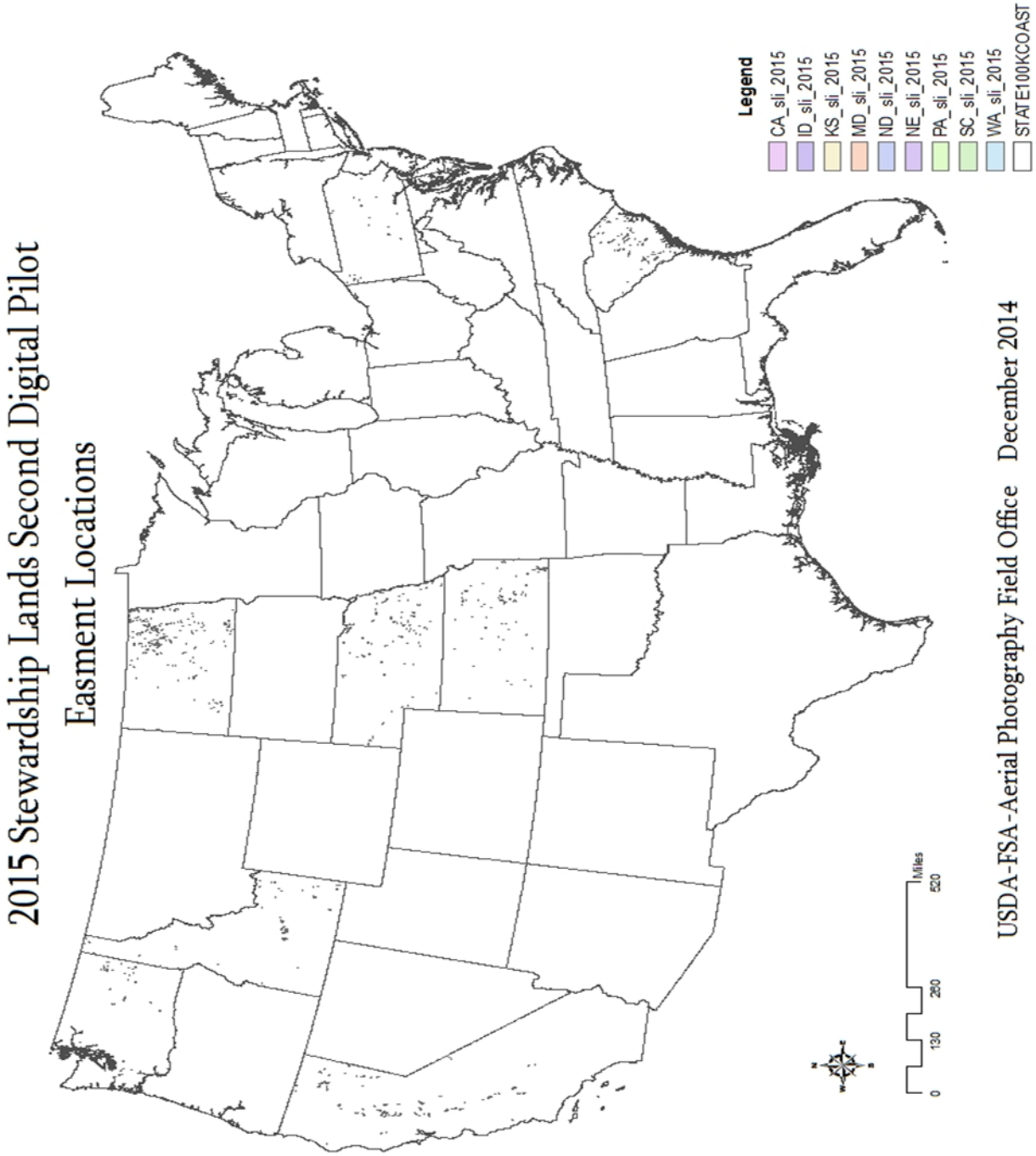

EXHIBIT 2

EASEMENT REFERENCE DATA EXAMPLE

These are selected columns from the “CA_sli_2015.dbf” file

B	C	L	M	I
Admin_Area	New_Agree_	NEST_STATE	NEST_Count	CalcAcres
CA	6691041000Y2B	California	Contra Costa , CA (06013)	648.94500000000
CA	7591040100XND	California	Tulare, CA (06107)	81.84024648000
CA	7591040000XNG	California	Tulare, CA (06107)	80.26099426000
CA	6691040500FNJ	California	Yolo, CA (06113)	471.47200000000
CA	6691040300FLQ	California	Yolo, CA (06113)	31.35600000000
CA	6691040000FJ8	California	Kings, CA (06031)	767.22679316000
CA	6691040300FL7	California	Kings, CA (06031)	194.40000000000
CA	6691049600FNX	California	Tulare, CA (06107)	831.90000000000
CA	6691049800FRM	California	Tulare, CA (06107)	111.94000000000
CA	6691040200FKV	California	Yolo, CA (06113)	2608.01000000000
CA	6691049900FSD	California	Yolo, CA (06113)	89.50353712000
CA	66910410011W1	California	Sacramento, CA (06067)	768.56865528000
CA	6691040500FN7	California	Merced, CA (06047)	76.27058849000
CA	6691049800FRV	California	Colusa, CA (06011)	314.12567202000
CA	6691049500FMT	California	San Joaquin, CA (06077)	219.97132308000
CA	6691040400FMG	California	Tehama, CA (06103)	475.85459992000
CA	6691040500FNH	California	Tehama, CA (06103)	86.26894081000
CA	6691049600FP9	California	Colusa, CA (06011)	632.06045689000

EXHIBIT 3 – 2 pages

FILE NAMING CONVENTION AND DIRECTORY STRUCTURE

Digital Image File Naming Convention:

File Name: <ortho>_<**state**>_<15>_<new_agreement_no>_<cnv>_<**yyyymmdd**>.tif
Where:
<**state**> - 2 letter postal code identifier
<15> - <spatial resolution> - ground sample distance in centimeters
<new_agreement_no> - new agreement number*
<cnv> - consecutively numbered value**
<**yyyymmdd**> - image exposure date

*new_agreement_number can be found in the government furnished property
**consecutively numbered value must reset at each location

Example: ortho_CA_15_66453207004JX_3_20150801.tif

Project Geodatahase:

File Name: Project_Geodatabase_<state>_<year>.gdb

<state> - 2 character state identification
<year> - year imagery was flown

Example: Project_Geodatabase_CA_2015.gdb

Orthorectified Image Index Feature Class:

File Name: ortho_index_<state>_<spatial resolution>_<spectral resolution>

<state> - 2 character state identification
<spatial resolution> - ground sample distance in units as dictated by the contract
<spectral resolution> - number of bands

Example: ortho_index_CA _15_4

Seamline Feature Class:

File Name: seamlines_<state>

<state> - 2 character state identification

Example: seamlines_CA

Directory Structure:

Structure Directory Contents
(root)
|--- <stnnn*>
| |-- ortho (all orthorectified images and associated auxiliary, pyramid and metadata files)
| |-- Project Geodatabase (Seamline and Ortho Index feature classes)
|--- <stnnn*>

* Where <stnnn> is the two letter postal abbreviation combined with the county three digit FIPS code.

EXHIBIT 4

REQUIRED TIFF TAGS

TAG NAME	DESCRIPTION
ImageDescription tag (270.d, 10e.h)	The ImageDescription tag shall contain the project item name. For example, under this task order the tag will read: "USDA-FSA-NRCS-Stewardship Lands Imagery-California"
PCSCitationGeoKey (3073.d, c01.h) (required)	This is a free text field for describing the projection and datum. These fields shall describe the datum and projection using <datum>/< projection> format. For example: NAD83 / UTM zone 15N
ModelPixelScaleTag (33550.d, 830e.h)	The X and Y values must be populated and be equal to the ground distance of one pixel.
ModelTiepointTag (33922.d, 8482.h)	This tag specifies the (X,Y) ground coordinates of the (0,0) image pixel, by convention in the upper left corner of the image. GeoTIFF 1.0 allows considerable flexibility in how an image is tied to the ground, but image data should be tied to the (0,0) pixel. The Z coordinate value should be set to 0. See section 2.6.1 of the GeoTIFF 1.0 standard.
GeoKeyDirectoryTag (34735.d, 87af.h) (required)	This tag references all non-ASCII GeoKeys. All projection and datum information is stored in GeoKeys. See section 2.10.2.2 of this standard and section 2.4 of the GeoTIFF 1.0 standard.
GeoAsciiParamsTag (34737.d, 87b1.h) (required)	This tag is used to store all the ASCII-valued GeoKeys. See section 2.4 of the GeoTIFF 1.0 standard.
ModelPixelScaleTag (33550.d, 830e.h)	The X and Y values must be populated and be equal to the ground distance of one pixel.
ModelTiepointTag (33922.d, 8482.h)	This tag specifies the (X,Y) ground coordinates of the (0,0) image pixel, by convention in the upper left corner of the image. GeoTIFF 1.0 allows considerable flexibility in how an image is tied to the ground, but image data should be tied to the (0,0) pixel. The Z coordinate value should be set to 0. See section 2.6.1 of the GeoTIFF 1.0 standard.
GeoKeyDirectoryTag (34735.d, 87af.h) (required)	This tag references all non-ASCII GeoKeys. All projection and datum information is stored in GeoKeys. See section 2.10.2.2 of this standard and section 2.4 of the GeoTIFF 1.0 standard.
GeoAsciiParamsTag (34737.d, 87b1.h) (required)	This tag is used to store all the ASCII-valued GeoKeys. See section 2.4 of the GeoTIFF 1.0 standard.

Refer to Attachment C – USDA Digital File Format Specification for further information.

EXHIBIT 5

U.S. DEPARTMENT OF AGRICULTURE

AERIAL PHOTOGRAPHY PROGRESS REPORT

INSTRUCTIONS

This report shall be prepared for performance that is accomplished in acquiring project photography. Reports shall be submitted to the government office E-mail address or fax number indicated below for each easement completely acquired. Reports shall be submitted in ASCII text format. On each progress report, a list of easements flown shall be indicated by their respective identification numbers. A cumulative progress record of all easements acquired shall be maintained by the Contractor.

2015 SLI DIGITAL PILOT PROGRESS REPORT
PROJECT NUMBER 2-15-??

TO:
Contracting Officer Representative
Aerial Photography Field Office
E-mail Address: bridget.barlow@slc.usda.gov
Fax Number: (801) 956-3641

FROM:
Name
Company
Telephone Number

PERFORMANCE RECORD:

Date Acquired: 06-JUL-15

Easements Acquired:

66453205004H7
66453200004GL
66453204004H8

EXHIBIT 6 – 2 Pages

REQUIRED DOCUMENTATION

1.0 AIRCRAFT TO BE USED IN COMPLETION OF ITEM(S) IN THIS ORDER

In the space provided below, list all aircraft proposed for use on this task order.

Aircraft Make/Model	Registration No. *(Tail No.)*	Operating Ceiling	Offeror Owned (check appropriate block)
			[ ] Yes [ ] No *
			[ ] Yes [ ] No *
			[ ] Yes [ ] No *

* If the aircraft is/are not offeror owned, a written statement of availability from the owner of the aircraft must be enclosed.

2.0 CAMERA(S) TO BE USED IN COMPLETION OF ITEM(S) IN THIS ORDER

In the space provided below, list all cameras proposed for use on this task order. Current certification report(s) must be enclosed or on file at the Aerial Photography Field Office.

Certification Report Number	Make/Model	Sensor ID	Offeror Owned (check appropriate block)
			[ ] Yes [ ] No *
			[ ] Yes [ ] No *
			[ ] Yes [ ] No *

* If the camera(s) is/are not offeror owned, a written statement of availability from the owner(s) of the camera(s) must be enclosed.

3.0 CAMERA CALIBRATION REPORT

Each offeror shall have on file with the Aerial Photography Field Office, or shall submit with the offer, one copy of a Report of Calibration from the U.S. Geological Survey or Manufacturer's Calibration Report for digital cameras, for each camera to be used. A camera calibration report will not be acceptable if more than three years old at the time of the scheduled date for receipt of offers. Please indicate which statement is correct:

[ ] Calibration report on file at APFO.

[ ] Calibration report submitted with offer.

4.0 KEY PERSONNEL INTENDED FOR PERFORMANCE ON THIS ORDER

List all key professional and technical personnel intended to perform on this task order. List may include project manager, pilot(s), photographer(s), and key back-up or support personnel.

Name	**Title**	**Education**	**Years of Experience**

5.0 INCOMPLETE CONTRACTS AS OF DATE OF PROPOSAL

In the space provided below, the Contractor is requested to indicate the remaining work that may coincide or conflict with the work proposed in this task order.

Indicate by Linear Miles	**Remaining Work - Winter**	**Remaining Work - Summer**
U.S. Government Contracts		
All Other Contracts		

EXHIBIT 7 (4 Pages)

Wage Determination – Pages 1 through 4

REGISTER OF WAGE DETERMINATIONS UNDER THE SERVICE CONTRACT ACT By direction of the Secretary of Labor	U.S. DEPARTMENT OF LABOR EMPLOYMENT STANDARDS ADMINISTRATION WAGE AND HOUR DIVISION WASHINGTON, D.C. 20210
Diane C. Koplewski, Director Division of Wage Determinations	Wage Determination No: 1995-0222 Revision No: 38 Date of Revision: 01/14/2015

Note: Executive Order (EO) 13658 establishes an hourly minimum wage of $10.10 for 2015 that applies to all contracts subject to the Service Contract Act for which the solicitation is issued on or after January 1, 2015. If this contract is covered by the EO, the contractor must pay all workers in any classification listed on this wage determination at least $10.10 (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract. The EO minimum wage rate will be adjusted annually.

Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.
Nationwide: Applicable in the continental U.S. Alaska, Puerto Rico, Hawaii and Virgin Islands.

Fringe Benefits Required Follow the Occupational Listing

Employed on U.S. Government contracts for aerial photographer, aerial seeding, aerial spraying, transportation of personnel and cargo, fire reconnaissance, administrative flying, fire detection, air taxi mail service, and other flying services.

OCCUPATION CODE - TITLE	FOOTNOTE	RATE
31010 - Airplane Pilot		28.36
(not set) - First Officer (Co-Pilot)		25.82
(not set) - Aerial Photographer		14.17

EXCEPT SCHEDULED AIRLINE TRANSPORTATION AND LARGE MULTI-ENGINE AIRCRAFT SUCH AS THE B-727, DC-8, AND THE DC-9.

ALL OCCUPATIONS LISTED ABOVE RECEIVE THE FOLLOWING BENEFITS:

HEALTH & WELFARE: $4.02 per hour or $160.80 per week or $696.79 per month

VACATION: 2 weeks paid vacation after 1 year of service with a contractor or successor, 3 weeks after 5 years, and 4 weeks after 15 years. Length of includes the whole span of continuous service with the present contractor or successor, wherever employed, and with the predecessor contractors in the performance of similar work at the same Federal facility. (Reg. 29 CFR 4.173)

HOLIDAYS: A minimum of ten paid holidays per year: New Year's Day, Martin Luther King Jr.'s Birthday, Washington's Birthday, Memorial Day, Independence Day, Labor Day, Columbus Day, Veterans' Day, Thanksgiving Day, and Christmas Day. (A contractor may substitute for any of the named holidays another day off with pay in accordance with a plan communicated to the employees involved.) (See 29 CFR 4.174)

VACATION (Hawaii): 2 weeks paid vacation after 1 year of service with a contractor or successor; 3 weeks after 10 years, and 4 weeks after 15 years. Length of service includes the whole span of continuous service with the present contractor or successor, wherever employed, and with the predecessor contractors in the performance of similar work at the same Federal facility. (Reg. 29 CFR 4.173)

HEALTH & WELFARE (Hawaii): $1.66 per hour, or $66.40 per week, or $297.73 per month hour for all employees on whose behalf the contractor provides health care benefits pursuant to the Hawaii prepaid Health Care Act. For those employees who are not receiving health care benefits mandated by the Hawaii prepaid Health Care Act, the new health and welfare benefit rate will be $4.02 per hour.

HAZARDOUS PAY DIFFERENTIAL: An 8 percent differential is applicable to employees employed in a position that represents a high degree of hazard when working with or in close proximity to ordnance, explosives, and incendiary materials. This includes work such as screening, blending, dying, mixing, and pressing of sensitive ordnance, explosives, and pyrotechnic compositions such as lead azide, black powder and photoflash powder. All dry-house activities involving propellants or explosives. Demilitarization, modification, renovation, demolition, and maintenance operations on sensitive ordnance, explosives and incendiary materials. All operations involving re-grading and cleaning of artillery ranges.

A 4 percent differential is applicable to employees employed in a position that represents a low degree of hazard when working with, or in close proximity to ordnance, (or employees possibly adjacent to) explosives and incendiary materials which involves potential injury such as laceration of hands, face, or arms of the employee engaged in the operation, irritation of the skin, minor burns and the like; minimal damage to immediate or adjacent work area or equipment being used. All operations involving, unloading, storage, and hauling of ordnance, explosive, and incendiary ordnance material other than small arms ammunition. These differentials are only applicable to work that has been specifically designated by the agency for ordnance, explosives, and incendiary material differential pay.

** UNIFORM ALLOWANCE **

If employees are required to wear uniforms in the performance of this contract (either by the terms of the Government contract, by the employer, by the state or local law, etc.), the cost of furnishing such uniforms and maintaining (by laundering or dry cleaning) such uniforms is an expense that may not be borne by an employee where such cost reduces the hourly rate below that required by the wage determination. The Department of Labor will accept payment in accordance with the following standards as compliance:

The contractor or subcontractor is required to furnish all employees with an adequate number of uniforms without cost or to reimburse employees for the actual cost of the uniforms. In addition, where uniform cleaning and

maintenance is made the responsibility of the employee, all contractors and subcontractors subject to this wage determination shall (in the absence of a bona fide collective bargaining agreement providing for a different amount, or the furnishing of contrary affirmative proof as to the actual cost), reimburse all employees for such cleaning and maintenance at a rate of $3.35 per week (or $.67 cents per day). However, in those instances where the uniforms furnished are made of "wash and wear" materials, may be routinely washed and dried with other personal garments, and do not require any special treatment such as dry cleaning, daily washing, or commercial laundering in order to meet the cleanliness or appearance standards set by the terms of the Government contract, by the contractor, by law, or by the nature of the work, there is no requirement that employees be reimbursed for uniform maintenance costs.

The duties of employees under job titles listed are those described in the "Service Contract Act Directory of Occupations", Fifth Edition (Revision 1), dated September 2014, unless otherwise indicated.

REQUEST FOR AUTHORIZATION OF ADDITIONAL CLASSIFICATION AND WAGE RATE
Standard Form 1444 (SF-1444)

Conformance Process:

The contracting officer shall require that any class of service employee which is not listed herein and which is to be employed under the contract (i.e., the work to be performed is not performed by any classification listed in the wage determination), be classified by the contractor so as to provide a reasonable relationship (i.e., appropriate level of skill comparison) between such unlisted classifications and the classifications listed in the wage determination. Such conformed classes of employees shall be paid the monetary wages and furnished the fringe benefits as are determined (See 29 CFR 4.6(b)(2)(i)). Such conforming procedure shall be initiated by the contractor prior to the performance of contract work by such unlisted class(es) of employees (See 29 CFR 4.6(b)(2)(ii)). The Wage and Hour Division shall make a final determination of conformed classification, wage rate, and/or fringe benefits which shall be retroactive to the commencement date of the contract (See 29 CFR 4.6(b)(2)(iv)(C)(vi)). When multiple wage determinations are included in a contract, a separate SF-1444 should be prepared for each wage determination to which a class(es) is to be conformed.

The process for preparing a conformance request is as follows:

1) When preparing the bid, the contractor identifies the need for a conformed occupation(s) and computes a proposed rate(s).

2) After contract award, the contractor prepares a written report listing in order the proposed classification title(s), a Federal grade equivalency (FGE) for each proposed classification(s), job description(s), and rationale for proposed wage rate(s), including information regarding the agreement or disagreement of the authorized representative of the employees involved, or where there is no authorized representative, the employees themselves. This report should be submitted to the contracting officer no later than 30 days after such unlisted class(es) of employees performs any contract work.

3) The contracting officer reviews the proposed action and promptly submits a report of the action, together with the agency's recommendations and pertinent information including the position of the contractor and the

employees, to the Wage and Hour Division, U.S. Department of Labor, for review (See 29 CFR 4.6(b)(2)(ii)).

4) Within 30 days of receipt, the Wage and Hour Division approves, modifies, or disapproves the action via transmittal to the agency contracting officer, or notifies the contracting officer that additional time will be required to process the request.

5) The contracting officer transmits the Wage and Hour decision to the contractor.

6) The contractor informs the affected employees.

Information required by the Regulations must be submitted on SF-1444 or bond paper.

When preparing a conformance request, the "Service Contract Act Directory of Occupations" (the Directory) should be used to compare job definitions to ensure that duties requested are not performed by a classification already listed in the wage determination. Remember, it is not the job title, but the required tasks that determine whether a class is included in an established wage determination. Conformances may not be used to artificially split, combine, or subdivide classifications listed in the wage determination.

** OCCUPATIONS NOT INCLUDED IN THE SCA DIRECTORY OF OCCUPATIONS **
Aerial Photographer
The aerial photographer must be skilled in reading flight maps, capable of assisting the pilot to adhere to flight lines, be able to level and operate a cartographic camera and its auxiliary equipment mounted in the aircraft so that the photographs that are taken will have the required forward lap and side lap for use in photogrammetric mapping equipment, and possess a working knowledge of aerial films and camera filters to insure proper exposure of the films.

First Officer (Co-Pilot)
Is second in command of commercial airplane and its crew while transporting passengers, mail, or other cargo on scheduled or nonscheduled flights. Assists or relieves an airline captain in operating the controls of an airplane; monitoring flight and engine instruments; and maintaining air-to-ground communications.

AERIAL PHOTOGRAPHY FIELD OFFICE (APFO) SPECIFICATION FOR DIGITAL CAMERA BASED ACQUISITION

(Dated February 1, 2012 – Modified for USDA/NRCS Imagery December 3, 2014)

1.0 INTRODUCTION AND BACKGROUND

The U.S. Federal Government has not established an independent government evaluation and calibration policy for digital cameras since sensor technology is still rather new. Until a policy is developed and implemented, the U.S. Department of Agriculture (USDA), Farm Service Agency (FSA) has proceeded to validate the quality and capabilities of current digital cameras by obtaining relevant information from camera manufacturers, data providers, and other government agencies and organizations. The following specifications and requirements have been developed to ensure that any digital camera proposed for use on USDA contracts meets minimum requirements to provide the highest quality digital imagery products.

2.0 DIGITAL CAMERA SPECIFICATIONS AND REQUIREMENTS

This document covers camera specifications and requirements for any direct-digital imagery acquisition under contract to APFO. Cameras for acquiring precise vertical digital imagery are required to be tested and calibrated. Cameras proposed for use must be of comparable, or better, precision and quality as traditional film-based stereoscopic mapping cameras. Imagery captured with digital cameras must also be compatible with analytical mensuration procedures used in photogrammetric surveys and in preparing accurate orthophotography. Documentation and sample imagery will be reviewed and verified by the Government before approval is granted. Only approved digital cameras shall be used on contracts administered by APFO.

3.0 GENERAL REQUIREMENTS

Digital cameras must be tested and calibrated with manufacturer certification documentation. The camera must be geometrically stable and suitable for use in precise, high-accuracy photogrammetric orthoimagery applications. All delivered imagery shall be acquired and processed in such a way as to eliminate or minimize pixel or band offset or misalignment between bands. The camera shall provide the following:

3.1 Spatial Resolution

The camera shall provide the spatial resolution and field of view necessary to meet the ground sample distance (GSD) requirement as specified in the contract.

3.2 Image Fusion

Pan sharpening will be permitted to achieve the necessary spatial resolution requirements. The multi-spectral bands may be used at a ratio no greater than 1:5 (multi-spectral to panchromatic) to achieve the required spatial resolution.

3.3 Radiometric Resolution and Accuracy

The camera's sensor shall capture and record a minimum of 12-bits of image information per color channel. If more than one lens and more than one shutter are used in the camera, the difference in radiometric values between two panchromatic or two multi-spectral sensors shall be less than ±5%. For example, a 12-bit image shall not have more than ±205 difference in gray values.

3.4 Spectral Resolution

The camera shall capture, as a minimum, natural color (approximately 440 – 850 nm) and near infrared color (approximately 780 – 850 nm) channel data simultaneously or near simultaneously using a single camera (near simultaneously is defined as less than 500 milliseconds). Additional multi-spectral bands may be collected with a secondary or auxiliary camera and/or system.

3.5 Camera Operation

The digital camera and its mount shall be checked for proper installation prior to each mission. An automatic exposure control device is permitted, but a manual override capability is required for some types of terrain to achieve proper coverage and exposure. The camera mount shall be regularly serviced and maintained and shall be insulated against aircraft vibration.

3.6 Camera Maintenance

The contractor shall perform all maintenance in accordance with the manufacturers recommended and established procedures. The contractor shall maintain a complete history of all maintenance done to the camera system and have it available for Government inspection. The contractor shall provide certification that the system has been maintained, preventive maintenance and calibration performed, to the manufacturers requirements.

3.7 System Malfunctions

The contracting officer shall be notified of all camera malfunctions within 72 hours with a written report of the malfunction. A malfunction is defined as a failure in any element or process of the camera that causes an interruption of the normal operations of the camera system (camera system is defined as the camera and any key components, such as camera mount, airborne global positioning system, and on-board data storage).

All malfunctions or failures of global positioning systems or inertial measurement unit systems shall also be reported directly to the contracting officer.

4.0 DIGITAL CAMERA APPROVAL REQUIREMENTS

All digital cameras must be approved by the Contracting Officer before acquiring imagery under any APFO contract. When requesting approval, the Contractor shall submit, or have on file with APFO, a report of calibration (see Paragraph 4.1), sample digital imagery (see Paragraph 4.2), and camera documentation (see Paragraph 4.3).

4.1 Calibration Reports

Calibration reports for each digital camera proposed for use shall be submitted to the contracting officer with the contractor's proposal and prior to project imagery acquisition if the digital camera is removed and remounted. The contractor shall follow manufacturer's specifications for appropriate calibration and recalibration. The calibration reports shall address the geometric performance of the camera, and at a minimum, include:

(a) Date of report
(b) The name of the person or company performing the calibration
(c) The methodology and procedures used for calibration
(d) Final calibration parameters, such as calibrated focal length, lens distortion values, radiometric calibration parameters, and principal point location.

NOTE: The government recognizes that individual calibration reports, procedures, and parameters may be unique to a certain manufacturer since equipment and systems vary from manufacturer to manufacturer.

4.2 Sample Imagery Requirements

The Contractor shall acquire and submit with their proposal, sample images from the digital camera proposed for use. The sample imagery shall provide the following minimum characteristics:

(a) Display the same GSD resolution required in the solicitation.
(b) Represent the type of terrain (agriculture, cropland, forest, etc.) that is similar to the proposed project area.
(c) Re-sampled and submitted as an 8-bits per band image (unless the solicitation requires only 16-bit per band image delivery, in which case the sample imagery shall be submitted as a 16-bits per band image).
(c) If ortho-rectification is required under the proposed solicitation, the sample image shall be ortho-rectified with the projection specified in the solicitation (for example, North American Datum 1983 (NAD83) and UTM Zone 12).
(d) Sample shall be produced and submitted in the footprint and file format specified in the solicitation (for example, DOQQ formatted, GeoTIFF image).

(e) The sample imagery shall fit on one standard CD or DVD. Delivered media will become part of the official Government contract file and will not be returned.

4.3 Camera Documentation Requirements

The Contractor shall provide with their proposal detailed documentation of the digital camera proposed for use. Documentation may include brochures, technical specifications, marketing material, manufacturer's user manuals, or other descriptive literature. The documentation shall contain at a minimum the following information:

(a) General overview information
(b) Product configuration description
(c) Camera component description
(d) Technical specifications
(e) Computer management and storage systems
(f) Image acquisition and processing workflow

.

AERIAL PHOTOGRAPHY FIELD OFFICE (APFO)
USDA DIGITAL IMAGERY QUALITY SPECIFICATION

(Dated February 1, 2012 – Modified for USDA/NRCS Imagery December 3, 2013)

1.0 SCOPE

This document establishes the image quality criteria to be used in the production of digital imagery products for all contracts issued by the United States Department of Agriculture's (USDA) Aerial Photography Field Office.

2.0 APPLICABLE DOCUMENTS

In the event of conflict between the contents of this specification and the documents referenced herein, the contents of this specification shall take precedence.

2.1 National Agriculture Imagery Program (NAIP) Suggested Best Practices – Final Report, dated Feb 1, 2007 (ITT Space Systems Division)

3.0 GENERAL REQUIREMENTS

USDA uses imagery for various programs including, but not limited to forest management, agriculture land use analysis, natural resource inventory, and extraction of data by means of photogrammetric interpretation. The complex nature and need for consistent imagery requires adherence to exact format and content of this specification.

3.1 Image blemishes, scratches and artifacts. Imagery shall be free of blemishes, scratches, and artifacts that obscure ground feature detail. The following table defines the maximum acceptable limits for blemishes, scratches, and artifacts. Clusters of blemishes, scratches, and artifacts that do not individually meet these criteria may be considered unacceptable.

ACCEPTABLE, IMAGE BLEMISHES, SCRATCHED, AND ARTIFACTS	
1 pixel wide	100 pixels in length
2 pixels wide	60 pixels in length
3 pixels wide	20 pixels in length
4 – 12 pixels wide	12 pixels in length

3.2 Band-to-Band Registration Accuracy. Misregistration between any color bands shall not exceed 1 pixel.

3.3 Original Image Resolution. The original image, original scan, or original capture used to create the imagery shall not be resampled from the original image resolution greater or less than the following numbers in order to meet the Ground Sample Distance (GSD) specified in the contract:

GROUND SAMPLE DISTANCE (GSD)	ORIGINAL IMAGE RESOLUTION	
	MAXIUMUM (meters)	MINIMUM (meters)
0.3-meter	0.15	0.32
0.5-meter	0.25	0.53
1-meter	0.50	1.05

4.0 UNCORRECTED IMAGERY

Uncorrected imagery is defined as imagery that has been minimally processed before exporting to a non-camera specific file format, such as a TIFF. Uncorrected imagery is the closest "match" to a traditional film negative that the direct-digital camera can provide without having the end-user employ special and/or non-standard software.

4.1 Non-image data. Imagery shall only use a pixel digital number (DN) of zero (0) for non-data values.

4.2 Image Quality. The Contractor shall not make any radiometric enhancements, such as gamma correction, histogram stretching, dodging, or other Look Up Table (LUT) adjustments, to the acquired imagery. The imagery shall not contain any borders, artifacts, or other non-image items.

5.0 COLOR CORRECTED IMAGERY

Imagery required to be color-corrected shall be adjusted so that the image matches the ground at the time of exposure. Adjustments shall include, but not limited to, any dodging, gamma correction, histogram stretching, brightness adjustments, and/or color balancing. The files shall not contain any borders, artifacts, or other non-image items.

5.1 Non-image data. Imagery shall only use a pixel digital number (DN) of zero (0) for non-data values.

5.2 Natural Color Image Quality.

(a) Clipping. Imagery shall have a tonal range that prevents the clipping of highlight or shadow detail from the image. When calculated against the luminosity histogram, the cumulative pixel count between the first and last five histogram bin

values (5 and 250 respectively for 8-bit depth) shall not be less than 98.0%, with a preferred value greater than 99%.

(b) Contrast. When calculated against the luminosity histogram, the difference between the histogram digital number (DN) value that contains 99.0% of the cumulative pixel count and the DN value that contains 1.0% shall be greater than ±59% of the bit depth, ±4% (aim point of 150, ±10 for 8-bit depth). If the cumulative pixel count percentage falls between two histogram bin values, the closest value shall be used. For example, if an 8-bit image has a luminosity DN value 222 contains 99% of the cumulative pixel count and DN value 44 contains 1% count, therefore the difference is 178.

BIT DEPTH	DN DIFFERENCE		
	TARGET	MINIMUM	MAXIUMUM
8-bit	150	140	160
16-bit	38,550	35,930	41,170

(c) Brightness. Imagery shall have a mean pixel count within ±7.5% of the middle DN value allowed for the bit depth. For example, an 8-bit depth image must have the histogram mean value between 108 and 147.

BIT DEPTH	MEAN DN	
	MINIMUM	MAXIUMUM
8-bit	108	147
16-bit	27,853	37,683

(d) Color Balance. Imagery should have a neutral tonal range without the dominance of any individual color. The difference between the minimum and maximum DN value in a RBG triplet of any nearly neutral objects within the image shall be less than 5.

5.2 Color infrared Imagery. All color infrared imagery shall have proper contrast to allow highlight and shadow detail.

5.3 Multispectral Imagery. Multispectral Imagery shall be radiometrically processed such than the natural color bands (RGB) meet the quality requirements in paragraph 5.1.

6.0 ORTHORECTIFIED IMAGERY

All orthorectified imagery shall be color-corrected in accordance with paragraph 5.0.

6.1 Geographic Extent. Imagery shall cover the entire image area, including the required minimum buffer on all four sides. Extents shall be computed by projecting the geographic corners and side midpoints to the appropriate projection, then adding the buffer on each side of the resulting minimum bounding rectangle.

6.2 Specular reflections. Specular reflections in the imagery should be minimized, especially in agriculture areas, by patching the area using "chips" from different imagery but shall be from the same type of camera and must be from the same acquisition season. Any chips used in the imagery shall not have more than ±3 pixels offset or the specified horizontal accuracy, whichever is the lesser distance, -between the chip and principal image. Any chips used shall be radiometrically balanced in accordance with paragraph 6.3(a).

6.3 Image Mosaicking. Imagery may be created using multiple image segments from the same acquisition collection to produce the final product.

(a) Radiometric Balance. When a mosaic is made from two or more image segments, the brightness and color values between the image segments will be adjusted to match that of neighboring image segments. The join lines between the overlapping image segments will be chosen to minimize tonal variations. Localized adjustment of the brightness and color values will be done to reduce radiometric differences between join areas.

6.4 Spatial. All orthoimagery shall meet the horizontal accuracy requirement of the specified project.

7.0 DEFINITIONS

Chip – Each separate piece of a mosaicked image that contributes to the final image.

Clipping – The presence of pixels exhibiting the minimum or maximum digital number in an image's dynamic range.

Digital Number – The value (0-255 for an 8-bit image) that depicts the pixel radiance for that color band.

Dodging – Manipulating the intensity of part of a photograph by selectively shading or masking.

Resample – Interpolation of pixel values based upon neighboring pixel values.

Uncorrected Imagery – Imagery that has been minimally processed, including no radiometric enhancements, such as stretching, dodging, or other Look Up Table (LUT) adjustments, to the acquired imagery.

Attachment C

USDA Digital File Format Specification

Version 1.0
01/24/2013

USDA-Farm Service Agency
Aerial Photography Field Office
2222 West 2300 South
Salt Lake City, UT 84119

Contributing Organizations

USDA

Document contributor contacts

Author	Agency	Contact Information
APFO	USDA-FSA	john.mootz@slc.usda.gov

Revision History

Date	Version	Editor	Outline Number modified	Description of Change
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1.0 PREFACE

For many years the Aerial Photography Field Office (APFO) has used the "USDA Digital Orthoimagery Quarter Quadrangle (DOQQ) Description and Specification" when contracting for Farm Service Agency's (FSA) National Agriculture Imagery Program (NAIP) imagery. However, APFO is the lead procurement office for all United States Department of Agriculture's (USDA) imagery projects greater than 100 square miles. These programs require a variety of delivery and file formats to meet the needs and diversity of various USDA's users. The previous specification was written specifically for one program, and thus was too rigid to be easily implemented for other acquisitions, resulting in continuous modifications to the specification and inefficiencies in implementation, interoperability, and data exchange. Thus, this specification has been updated to alleviate these issues. The intent is to apply this specification, as written and without modification, to all imagery contracts.

An important area of consideration for the use of imagery (raster) data is the encoding format. Various department agencies that use the APFO for procurement of imagery have valid requirements to make selected imagery data holdings available in Geographic Tagged Image File Format (GeoTIFF) in addition to other formats, including but not limited to JPEG 2000, LizardTech MrSID, and ERDAS Imagine files.

While GeoTIFF (and other formats) are widely used, they have many format options which often result in non-interoperability among disparately developed implementations. This USDA Digital File Format Specification was developed to help meet objectives for deployment of capabilities with automation and interoperability in mind. The primary rationale is to enable more timely support for delivering imagery in a format suitable for direct ingest by Geographic Information System (GIS) and/or Remote Sensing (RS) application software tools readily available to those working to support department activities.

This document specifies the requirements that shall be used for the exchange of georeferenced or ortho rectified imagery when opting to use the varied formats identified in the Appendices. The aim of this specification is to enable the interchange of rectified constraints within the design objectives of promoting interoperability for the exchange of raster information.

2.0 INTRODUCTION

This specification outlines the requirements and encoding rules that shall be used for the exchange of imagery data when opting to use the formats outlined herein. It constitutes a description of the bounds and constraints for the use of each file format within the design objectives of promoting interoperability and data exchange. It conforms with all normative documents identified in Section 5.0.

While GeoTIFF is not the only format detailed in this specification, it is a core format for encoding spatial raster data, and thus is a core component of this specification. GeoTIFF is a public domain specification which allows georeferencing information to be embedded within a TIFF file. Potential embedded information includes projections, coordinate systems, datums, and other information needed to

establish the spatial reference for the imagery or gridded data contained in the file. The GeoTIFF format augments the TIFF format, so TIFF-enabled software incapable of reading and interpreting the specialized georeferencing metadata should still be able to open a GeoTIFF file sufficiently to at least view the image data.

The main body of this specification addresses the scope of this work, conformance with other recognized industry specifications and national specifications, terms and definitions, an acronym and file extension reference, and the applicability and use of this document. The document then addresses various file format requirements and references the Appendices for the file format specifications.

3.0 SCOPE

This document establishes the file format criteria to be used in the production of digital imagery for all contracts issued by APFO. It may also be applied to all internal production activities at APFO that result in products that require archiving and public distribution.

4.0 CONFORMANCE

Any GeoTIFF data claiming conformance with this specification is claiming conformance with applicable normative documents in Section 5, and shall pass conformance requirements testing as part of the quality assurance process upon delivery of data to the USDA.

Other file formats detailed in this specification may or may not conform with normative documentation and reference information in Section 5. These file formats shall still pass testing as part of the quality assurance process upon delivery of data to USDA, to ensure requirements of this specification are met.

5.0 NORMATIVE DOCUMENTS

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies.

5.1 Industry Specifications

- The Tagged Image File Format (TIFF) – Tagged Image File Format, Revision 6.0, Adobe Systems Inc., June 1992. TIFF is a copyrighted standard of Adobe Systems, Inc. (http://partners.adobe.com/public/developer/en/tiff/TIFF6.pdf)

- GeoTIFF Format Specification, Revision 1.0, 10 November 1995; version 1.8.2 The GeoTIFF Format Specification is a public domain extension of TIFF that provides a robust and flexible method of storing georeferencing information is a TIFF file. (http://www.remotesensing.org/GeoTIFF/spec/GeoTIFFhome.html)

Supporting documents describing the scope of this document and call out requirements, and recommendations.

5.2 National Specifications

TBD

5.3 Informative References

NGA Standardization Document - Implementation Profile for Tagged Image File Format (TIFF) and Geographic Tagged Image File Format (GeoTIFF) - NGA.IP.0001_1.0, 2008-11-18

6.0 GLOSSARY

6.1 Terms and Definitions

Affine Transformation – A geometric transformation that scales, rotates, skews, and/or translates images or coordinates between any two Euclidean spaces. It is commonly used in GIS to transform maps between coordinate systems. In an affine transformation, parallel lines remain parallel, the midpoint of a line segment remains a midpoint, and all points on a straight line remain on a straight line. Source: Esri Online Dictionary

Band – A range of wavelengths of electromagnetic radiation. Also, image data gathered at this wavelength range.

Field – Refers only to the entire field, including the value, of the geokey (as defined in the TIFF Specification).

Georeference – Aligning geographic data to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. (Source: Esri® Online Dictionary)

GeoTIFF – Public domain metadata standard which allows georeferencing information to be embedded within a .TIFF file.

Image File Directory – Contains information about the image. There must be at least 1 IFD in a TIFF file and each IFD must have at least one entry.

Metadata – Description of the content, quality, condition, and other characteristics of the data.

Orthorectification - A process of removing sources of distortion from an image and correcting aerial photography to the point where measurements of a feature on the photograph approximate ground measurements of the same feature. (Source: Satellite Imaging Corporation)

Private tags – TIFF tags numbered 32,768 or higher. Private tags are not defined in the TIFF Specification.

Public tags – TIFF tags that are defined by the TIFF Specification.

Rectified Grid – A grid that has an affine transformation between the grid coordinates and the coordinates of an external coordinate reference system.

Tag – Refers only to the identifying number portion of the geokey (as defined in the TIFF Specification).

6.2 Acronyms and Abbreviations

GeoPDF – A .pdf file created by TerraGo Technologies that contains geospatial information such as layers and object data.

ERDAS – Earth Resources Data Analysis System

JPEG and JPEG 2000 – Joint Photographic Experts Group. A commonly used method of compression for digital imagery. JPEG 2000 is an updated wavelet compression of JPEG with more flexibility in the codestream.

MrSID – Multi-resolution seamless image database. Proprietary format developed by LizardTech for encoding raster graphics.

TIFF – Tagged Image File Format.

6.3 File Extensions

.ecw – Stands for enhanced compression wavelet. An ERDAS ER Mapper compressed file format specifically designed for geospatial imagery.

.ige – Stands for large raster spill file. One of two ERDAS IMAGINE files created when an image requiring more than 4GB of disk space is created. It contains the actual image data in a separate non-HFA file format (normally with the extension .ige).

.img – Stands for “image file.” An ERDAS IMAGINE file used to store raster data, including file information, ground control points, sensor information, layer information, attribute data, statistics,

map information, projection information, pyramid layers, data file values, compression, and block size. This file uses Hierarchal File Format (HFA).

.jp2 – Stands for jpeg 2000. Compressed image created using JPEG 2000 Core Coding; incorporates a wavelet compression algorithm instead of Digital Cosine Transform (DCT) compression used by standard JPEG images; can be stored using lossy and lossless compression.

.pdf – Stands for portable document format. For the purpose of this document, .pdf refers to a geopdf.

.ovr – Stands for overlay file. Similar to the .rrd file, .ovr is a file format for storing pyramid layers for a raster dataset.

.rrd – Stands for "reduced resolution dataset." A file containing pyramids created for a raster dataset.

.sid – Stands for seamless image database. A lossless compressed image file developed by LizardTech

.tif – Stands for "tagged image file." High-quality graphics format often used for storing images with many colors, such as digital photos; short for "TIFF;" includes support for layers and multiple pages. For the purpose of this document, .tif refers to a GeoTIFF.

7.0 APPLICABILITY AND USE OF THIS DOCUMENT

The primary purpose of this document is to establish guidelines and specifications for imagery developed by or for APFO. The intent is to allow for great flexibility of data structure, spatial density, quality, and format, while supporting sharing and reuse of the data.

8.0 TIFF AND GEOTIFF REQUIREMENTS

This section of this File Format Specification defines the minimum set of format options, features, and data elements necessary to promote interoperability for the exchange of Tagged Image File Format (TIFF) and GeoTIFF-formatted files. This section establishes a common frame of reference to address adequate georeferencing parameters and data value attribution needed by geospatial applications to utilize GeoTIFF-formatted images. Only uncompressed TIFF or GeoTIFF imagery that has been georeferenced or orthorectified is addressed by this section of this specification. Requirements for compression (see Sub-Section 8.2.10) and georeferenceable imagery (see Sub-Section 8.2.2) are not supported in this specification.

TIFF is an image file format used for storing and interchanging raster images. TIFF is a portable format, not specific to or favoring any particular operating systems, file systems, compilers, or processors. It is also extensible and designed to evolve as new needs arise.

GeoTIFF is a set of TIFF tags (extensions to the Baseline TIFF Format) that describe spatial information associated with TIFF imagery that originate from any digital sensor, scanned aerial photography, scanned maps, or as a result of geographic analysis or similar processes. GeoTIFF uses a small set of reserved TIFF tags to store a broad range of geo-referencing information.

This specification addresses the following fundamental topics for application and use of TIFF and GeoTIFF files:

- Required TIFF and GeoTIFF tags for standardized use of TIFF and GeoTIFF-formatted files.
- Image data or pixel structures relating to: strips, tiling, compression, precision, number of bands, etc.
- Preferred coordinate reference systems, datums.

This specifications main characteristic allows:

- All types of imagery conformant to TIFF Baseline: bi-level, grayscale, palette color image, 3-bands RGB (full color), and multi-spectral.
- Optional TIFF tiling (TIFF extension specified in section 15 of the TIFF standard) for high volume data. This option cannot be used in conjunction with TIFF striping. The use of this option may cause some interoperability problems, and must be identified as such at a different conformance level.

8.1 Data Capture

TIFF provides 2 tags for specifying the scanner or instrument manufacturer and model: Make and Model. These fields may be populated according to product specification requirements.

However the production process is usually far more complex than the simple acquisition of an image by a scanner or a camera, and the full process needs to be documented by additional metadata (i.e. process description).

Use of Make and Model tags is consequently optional: in case they are populated, the information should be consistent with additional metadata (i.e. process description).

8.2 TIFF and GeoTIFF Requirements

In general, imagery data delivered in TIFF or GeoTIFF format will conform to (not deviate from) the TIFF and GeoTIFF formats as defined in the referenced TIFF and GeoTIFF specifications. The following clauses constrain the implementation of TIFF and GeoTIFF for the purposes of this specification.

8.2.1 General File Structure and Data Value Types

The TIFF structure includes an 8-byte image file header that points to the first Image File Directory (IFD). This specification calls for a single IFD in each TIFF file and this IFD must have at least one entry. The IFD contains information about the image, as well as pointers to the actual data. All used fields are listed, and information that does not fit in the IFD is listed in other parts of the file. The IFD begins with a 2-byte count of the number of directory entries (i.e., the number of fields), followed by a sequence of 12-byte field entries, followed by a 4-byte offset of the next IFD (or 0 in the case there is no other IFD). This 4-byte (32 bit) structure of the offset allows TIFF and GeoTIFF file sizes up to 4GB (2**32 bytes). This specification only supports file sizes up to 2GB.

A GeoTIFF file is a TIFF 6.0 file, and inherits the file structure as described in the corresponding portion of the TIFF Specification. All of the GeoTIFF information is encoded in six TIFF tags, which are designed to store a broad range of georeferencing information, catering to geographic as well as projected coordinate system needs. These GeoTIFF keys will contain no private Image File Directories (IFD's), binary structures, or other private information invisible to baseline TIFF 6.0 readers.

The GeoTIFF 1.0 standard uses a MetaTag (GeoKey) approach to encode dozens of data elements into just six TIFF 6.0 tags. GeoKeys are structurally similar to TIFF 6.0 tags, but at one lower level of abstraction. GeoKeys are used within the tags to store the projection parameters and coordinate system information. All keys are referenced from one tag, the GeoKeyDirectoryTag. See Table 2.1, Appendix A for details. Not all the keys will be used when formatting GeoTIFF in conformance with this specification. This specification requires that only certain essential GeoTIFF keys be populated. Other keys may require default values.

The GeoTIFF specification requires interpret (reader) implementations to support all documented TIFF 6.0 tag data-types, and in particular requires the Institute of Electrical & Electronic Engineers (IEEE) double-precision floating point 'DOUBLE' type tag. The documented data types for use with TIFF tags are:

- BYTE = 8-bit unsigned integer
- ASCII = 8-bit byte that contains a 7-bit American Standard Code for Information Interchange (ASCII) code. The last byte of an ASCII sequence (string) must be null (binary zero)
- SHORT = 16-bit (2-byte) unsigned integer
- LONG = 32-bit (4-byte) unsigned integer
- FLOAT = Single precision (4-byte) IEEE format
- DOUBLE = Double precision (8-byte) IEEE format
- RATIONAL = Two LONGs: the first represents the numerator of a fraction; the second, the denominator
- SBYTE = 8-bit signed (twos complement) integer
- UNDEFINED = 8-bit byte containing anything, depending on the definition of the field.

- SSHORT = 16-bit (2-byte) signed (twos complement) integer
- SLONG = 32-bit (4-byte) signed (twos complement) integer
- SRATIONAL = Two SLONGs: the first represents the numerator of a fraction; the second, the denominator.

Note: Appendix A identifies which data type applies to each tag selected for use by this specification.

TIFF implicitly types all range values (data sample values) as unsigned integer values. The representation of imagery, however, requires the ability to store the range (data) values in additional representations such as signed integer and floating point. Section 19 of the TIFF standard presents a scheme for describing a variety of data sample formats. The BitsPerSample field in the TIFF Image File Directory defines the number of bits per component.

8.2.2 Rectification and Ortho-rectification

A rectified grid has an affine transformation between the grid coordinates and the coordinates of an external coordinate reference system. A rectified grid is defined by an origin in an external coordinate reference system and a set of offset vectors that specify the direction and distance between grid lines within that external coordinate reference system. If the coordinate reference system is related to the earth by a datum, the grid is a georeferenced grid. An orthorectified grid is a georeferenced grid that uses elevation data and where constant scale is maintained throughout the grid.

A referenceable grid is one that can be referenced by some other specified coordinate transform (for example, by a physical sensor geometry model or by a functional fit model of rational polynomials).

This section of this specification is concerned only with georeferenced grids and orthorectified grids. It does not address referenceable grids; for example, those associated with oblique imagery or rubber sheeting.

The GeoTIFF Format Specification describes 5 coordinate transformations 'cases' that the format is able to address:

Case 1: The model-location of a raster point (x,y) is known, but not the scale or orientations.

Case 2: The location of three non-collinear raster points are known exactly, but the linearity of the transformation is not known, and the scale is not to be defined.

Case 3: the position and scale of the data is known exactly, and no rotation or sheering of the image is needed to fit into the model space.

Case 4: (intended for equidistant- sampled data) The raster data requires rotation and/or lateral sheering to fit into the defined model space. To accomplish this, additional information is needed in the form of a transformation matrix. The ModelTransformationTag exists for the purpose of allowing this information to be provided.

Case 5: The raster data cannot fit into the model space with a simple affine transformation. Multiple tie points can be stored in GeoTIFF to allow rubber sheeting of the image in this case.

This specification requires that the scale be identified in the GeoTIFF tags (see Table 2.1 Appendix A), and therefore cases 1 and 2 are not supported. This specification requires only georectified grids and orthorectified grids, therefore case 5 is not supported.

Only cases 3 and 4 are supported by this section of this specification.

8.2.3 Coordinate Reference Systems and Datums

The GeoTIFF Configuration GeoKeys establish the general configuration of the file's coordinate system. Each of these GeoKeys is listed below with their general description followed by limitations and constraints established by this specification:

- GTModelTypeGeoKey – Tag 1024. The GTModelTypeGeoKey defines the general type of model coordinate system used – geographic or projected.
- GTRasterTypeGeoKey– Tag 1025. The GTRasterTypeGeoKey establishes if the raster pixel value (imagery or gridded data range value) is located at a point value or if the value fills the square grid cell.
- GTCitationGeoKey – Tag 1026. The GTCitationGeoKey is used to give an ASCII reference to published documentation on the overall configuration of the GeoTIFF file. This key generally shows the projection name or geographic coordinate system name and the units.

Horizontal datum – GeoTIFF has many datums to choose from in the Geodetic Datum numerical codes. This specification recommends the use of North American Datum (NAD83) as the horizontal datum, but allows for World Geodetic System 1984 (WGS84).

Coordinate systems – GeoTIFF allows many geographic latitude-longitude systems and many projected coordinate systems. There are also tags for parameters of coordinate systems or projections not available in the codes. This section of this specification limits expression of coordinate references to NAD83 latitude and longitude (decimal degrees), NAD83 UTM Grid System Northing and Easting (meters), and geographic or projected WGS84 systems.

8.2.4 Units of Measure

This section of this specification allows only the implied 'angular degree' unit for the geographic coordinate system, and the default 'meters' unit for the UTM projected coordinate system. User-defined geographic or projected coordinate systems are not allowed by this specification. In order to prevent the use of other horizontal units of measure, the use of the GeoKeys related to horizontal units of measure are prohibited (see Tables 2.x in Appendix A).

Default units are:

- Decimal degrees for longitude and latitude (geographic coordinate system)
- Meters for UTM Grid System Easting and Northing (projected / cartographic coordinate system)

8.2.5 Date and Time

There is a TIFF field called DateTime for storing the date and time of file creation. The format for the field in ASCII type is "YYYY:MM:DD HH:MM:SS" with 24 hour time used for the hours and one space character between the date and time, and one terminating NUL character. The length of the string, including the terminating NUL, is 20 bytes. All dates and times shall be expressed in Coordinated Universal Time (UTC).

Use of this tag is recommended in order to support discovery of the data, wherever possible. This information should then be consistent with additional metadata (i.e. required process description). Absence of this tag indicates this information was not available. The Date/Time stamp that will be represented in the TIFF DateTime field shall be the date/time when the image file was created.

8.2.6 Collection and Maintenance Constraints

There are several TIFF tags that can carry and address a variety of collection information. These tags should not be populated for the purpose of this section of this specification. The associated additional metadata (i.e. process description) can optionally be used to carry this type of information when needed.

8.2.7 Tiling

For low-resolution to medium-resolution images, the standard TIFF method of breaking the image into strips is adequate. However high-resolution images (grids greater than 8192 x 8192) can be accessed more efficiently if the image is broken into roughly square tiles instead of horizontally-wide but vertically-narrow strips.

TIFF extensions offer an internal TIFF tiling mechanism which should be used on large grids / images, based on the most common tiling scheme which is a rectangular grid, by specifying

additional fields for rectangular tiles (for example width and length of a tile). Tile dimensions must be a multiple of 16 (TIFF specifies TileWidth and TileLength be a multiple of 16 for performance in some graphics environments and compression schemes such as JPEG). This internal TIFF tiling extension may not always be supported by commercial or public domain software, especially older TIFF readers.

TIFF internal tiling must NOT be used in conjunction with stripping. When using internal tiles, the grid data may need to be padded to tile boundaries when the grid size is not an integer multiple of the selected tile size.

Generally, for small grids, the data should be organized as a single TIFF file with no tiling, in order to maximize interoperability.

For large grids (greater than 8192 x 8192), TIFF tiling becomes a helpful option, the recommended tile size is 1024 x 1024. Another option is external tiling, when each tile is typically stored within separate files; this option is outside the scope of this section of this specification and is therefore not supported.

8.2.8 Number of Bands

The number of bands within a GeoTIFF grid is constrained to be 1-band, 3-bands, and 4 or more bands (multi-spectral). For the case of 3 or more bands, the band interleave shall be the TIFF 'chunky' format, band interleaved by pixel (BIP). In Chunky format the component values for each pixel are stored contiguously. For example, for RGB data, the data is stored as RGBRGBRGB. The BIP data organization can handle any number of bands, and thus accommodates black and white, grayscale, true color, and multi-spectral image data.

Additional information is needed to interpret the image data, such as SamplesPerPixel, BitsPerSample, PhotometricInterpretation, and ExtraSamples:

For 1-band 8-bit Pan Sharpened imagery, the following TIFF fields are documented as follows: SamplesPerPixel = 1, BitsPerSample = 8, PhotometricInterpretation = 1 (BlackIsZero), Do not use ExtraSamples.

For 3-band 8-bit RGB imagery, the following TIFF fields are documented as follows: SamplesPerPixel = 3, BitsPerSample = 8, PhotometricInterpretation = 2 (RGB), Do not use ExtraSamples.

For 4-band 8-bit RGB imagery, the following TIFF fields are documented as follows: SamplesPerPixel = 4, BitsPerSample = 8, PhotometricInterpretation = 2 (RGB), ExtraSamples = 0 (Unspecified data).

For 8-band 16-bit multi-spectral imagery, the following TIFF fields are documented as follows: SamplesPerPixel = 8, BitsPerSample = 16, PhotometricInterpretation = 2 (RGB), ExtraSamples = 0 (Unspecified data).

8.2.9 Range Value Data Types and Precision

For imagery, the range (data) values are constrained to be unsigned integer data, 8 or 16-bits-per-band.

8.2.10 Compression

No TIFF (internal) compression shall be used.

8.2.11 Image File Implementation

This specification addresses the following cases (except explicit contrary notice): base (single) image (one single IFD). The IFD always addresses the image data.

8.2.12 Security Classification

There are no dedicated fields for storing security classification information in TIFF files. Additional metadata should be used to associate security markers and dissemination controls for content of GeoTIFF files. However, inclusion of security constraint information in the ImageDescription tag is an option proposed by this section of this specification in order to support security marking of the data. This provides a consistent place for security metadata within the TIFF structure.

It is recommended to include security constraint information in the ImageDescription field, in addition to the information provided in the additional metadata (i.e. process description) so that this information is displayed even if this metadata is ignored by an application or become separated. This security constraint information should then be consistent with dedicated additional metadata (i.e. process description).

8.2.13 Data Quality

There are neither fields nor any mechanism for storing data quality information (positional accuracy, currency, quality information etc.) in the GeoTIFF format and in this specification. This information needs to be documented by additional metadata (i.e. process description).

9.0 LIZARDTECH'S MRSID REQUIREMENTS

MrSID imagery shall be compressed and saved in Generation Three (MG3) format. When encoding the image, the following settings shall be applied:

- compression block size of 64
- both the transparency and background values set to an RGB value of 0,0,0 (black)
- use the “maximum zoom level” applicable to the input image, for example: -checking the “Use Maximum Zoom Levels for Image” button in the encoding options menu.

Compression Ratio. Compression ratio shall be determined by the project or contract specifications. All compression shall be at the same ratio and settings ("region of interest" compressed at a different ratio will not be accepted).

Header Information. The image header shall contain correct Esri® compatible projection information for the mosaic.

Required Files. All standard MrSID® MG3 files generated by the LizardTech software (i.e., .sid, .sdw, and .txt) shall be included.

Configuration File. Provide the text file created when generating the image.

Auxiliary File. Provide an “.aux” file containing Esri® projection information for each image. The auxiliary file shall contain the proper projection information for the image and shall match the information in the image header.

10.0 JPEG 2000 REQUIREMENTS

JPEG 2000 imagery shall be compressed and saved in the JPEG 2000 format with an unsigned, 8-bit depth. Compression ratio shall be determined by the project or contract specifications. When encoding the image, the following settings shall be applied:

- Tiling: None
- Code blocks: 64
- Precincts: 256 x 256
- Strip height: 12
- Progression order: rpcl
- Quality layers: 8
- Packet length markers: Yes
- Filter: 9-7
- Tile length markers: No
- Transparency: Yes
- Background: Transparent, Black, White (stated in order of preference)

All compression shall be at the same ratio and settings ("region of interest" compressed at a different ratio will not be accepted).

11.0 ERDAS IMG® REQUIREMENTS

IMG imagery shall use the standard outputs as defined in the hierarchical file structure (HFA). The .img file shall be in a tiled format with a block size of 64x64 pixels. The following statistics shall be calculated:

- Minimum and maximum data file values
- Mean of the data file values
- Median of the data file values
- Mode of the data file values
- Standard deviation of the data file values

If the file has been georeferenced, the following map information shall be stored in the raster layer:

- Upper left x, y coordinates
- Pixel size
- Map unit used for measurement (e.g., meters, inches, feet)

An .ige file shall be created for images larger than 4GB. The .ige file shall be in a non-HFA format containing only the actual image data.

12.0 ERDAS ER MAPPER ECW® REQUIREMENTS

When creating ECW files, the following input settings shall be used:

- Output file type is .ecw
- Compression type is set to correct spectral resolution (color RGB, grayscale, multiband)
- Generate NULL opacity mask channel is checked
- Compression ratio shall be determined by the project or contract specifications.
- Output resolution is set by the compressor

ERDAS ER Mapper® **must** be used when compressing imagery to the .ecw format. This ensures that all image keys and tags are correctly populated in the output image header.

APPENDIX A

TIFF/GeoTIFF Image Format Constraints

TIFF Format

The file structure for the Image File Header and Image File Directory can be found in the TIFF product specification in Part 1, Section 2: TIFF Structure. There are four Baseline TIFF image types; Bilevel Images, Grayscale Images, Palette-color Images, and RGB Full Color Images. Each type has specific field requirements which can be found in Sections 3 through 6 of the TIFF document. For the purpose of representing imagery, the grayscale and full-color image baselines are appropriate. The use of any private tags, other than those included in this appendix is prohibited for use.

TIFF Specification Document: Revision 6.0 dated June 3, 1992

Table 1.1 describes the "Baseline Fields" defined in Section 8 of the TIFF specification.
Table 1.2 describes the "CCITT Bilevel Encodings" defined in Section 11 of the TIFF specification.
Table 1.3 describes the "Document Storage and Retrieval" defined in Section 12 of the TIFF specification.
Table 1.4 describes the "Differencing Predictor" defined in Section 14 of the TIFF specification.
Table 1.5 describes the "Tiled Images" defined in Section 15 of the TIFF specification.
Table 1.6 describes the "CYMK Images" defined in Section 16 of the TIFF specification.
Table 1.7 describes the "HalftoneHints" defined in Section 17 of the TIFF specification.
Table 1.8 describes the "Associated Alpha Handling" defined in Section 12 of the TIFF specification.
Table 1.9 describes the "Data Sample Format" defined in Section 19 of the TIFF specification.
Table 1.10 describes the "RGB Image Colorimetry" defined in Section 20 of the TIFF specification.
Table 1.11 describes the "YCbCr Images" defined in Section 21 of the TIFF specification.
Table 1.12 describes the "JPEG Compression" defined in Section 22 of the TIFF specification.

<u>Legend for TIFF table</u>:

- Columns Field, Description, Tag, and Type refer to corresponding specification items of tag according to TIFF specifications.
- ROCN column specifies presence of the item:
    - R: required
    - O: optional
    - C: conditional (Condition must be specified)
    - N: Do not use
- Restricted field values: indicates (when applicable) required values for TIFF tag.

Table 1.1: TIFF 6.0 Baseline Tags

TIFF 6.0 Section 8	**Baseline Field Reference Guide**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
Artist	Person who created the image.	315	ASCII	R	Populate with the name of the organization who created the file.
BitsPerSample	Number of bits per component.	258	SHORT	R	Set to the number of bits used to represent each range (sample) value.
CellLength	The length of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file.	265	SHORT	N	Do not use this key.
CellWidth	The width of the dithering or halftoning matrix used to create a dithered or halftoned bilevel file.	264	SHORT	N	Do not use this key.
ColorMap	Defines an RGB color map for palette color images.	320	SHORT	C	Use only with palette color images.
Compression	Compression scheme used on the image data. Uncompressed CCITT 1D CCITT Group 3 CCITT Group 4 LZW JPEG Packbits (32773)	259	SHORT	R	Set to 1 (No Compression)
Copyright	Copyright notice. When access or usage restrictions (or both) exist for the dataset, populate with the applicable copyright notice of the person or organization that claims the copyright to the image. The complete copyright statement shall be listed in this field including any dates and statements of claims. If no usage restrictions exist, it shall be so stated in this field.	33432	ASCII	C	Populate only when any restrictions have been cited by the requestor.

DateTime	Date and time of image creation. The date and time that most closely reflects the currency of the data range values.	306	ASCII	R	File creation date
ExtraSamples	Description of extra components. Populate with a value of 0 only if SamplesPerPixel is greater that 3 (4-band images).	338	BYTE	C	Populate with a value of 0 only if SamplesPerPixel is greater than 3 (multi-spectral images).
FillOrder	The logical order of bits within a byte.	266	SHORT	O	Desired value is 1
FreeByteCounts	For each string of contiguous unused bytes in a TIFF file, the number of bytes in the string.	289	LONG	N	Do not use this key.
FreeOffsets	For each string of contiguous unused bytes in a TIFF file, the byte offset of the string.	288	LONG	N	Do not use this key.
GrayResponseCurve	For grayscale data, the optical density of each possible pixel value.	291	SHORT	N	Do not use this key.
GrayResponseUnit	The precision of the information contained in the GrayResponseCurve.	290	SHORT	N	Do not use this key.
HostComputer	The computer and/or operating system in use at the time of image creation.	316	ASCII	O	Optional, but not desired
ImageDescription	A string that describes the subject of the image.	270	ASCII	R	Populate with a description that identifies the acquisition Program name.
ImageHeight	The number of rows of pixels in the image.	257	SHORT or LONG	R	The number of rows of range values.
ImageWidth	The number of columns in the image, i.e., the number of pixels per row.	256	SHORT or LONG	R	The number of columns of range values.
Make	The scanner manufacturer. The manufacturer of the equipment used to generate the image.	271	ASCII	R	The manufacturer of the instrument used to obtain the range values.
MaxSampleValue	The maximum component value used.	281	SHORT	N	Do not use this key.
MinSampleValue	The minimum component value used.	280	SHORT	N	Do not use this key.

Model	The scanner model name or number.	272	ASCII	R	The model name or number of the instrument used to obtain the range values.
NewSubFileType	A general indication of the kind of data contained in this subfile.	254	LONG	N	Do not use this tag.
Orientation	The orientation of the image with respect to the rows and columns. Set this value to the default value of 1. Orientation of the grid indices to the external coordinate reference system is defined by the GeoTIFF tags.	274	SHORT	O	Default is 1
PhotometricInterpretation	The color space of the image. Note: A value for the 4-band case is not defined in the TIFF specification. In the 4-band case, use a value of 2 and populate the ExtraSamples tag with a value of 0.	262	SHORT	R	Allowed values are: 0 - WhiteIsZero 1 - BlackIsZero 2 - RGB 3 – Palette Color 4 - Transparency Mask
PlanarConfiguration	How the components of each pixel are stored. When more than one band is described by the range values, include this tag and set the value to 1. (chunky format).	284	SHORT	C	Default value is 1. Use this tag when more than one band is described by the range values and the component values are stored contiguously (ie chunky format) (Not to be used if Tiling has been used)
ResolutionUnit	The unit of measurement for XResolution and YResolution.	296	SHORT	R	Default value is 2 (inches).
RowsPerStrip	The number of rows per strip **No to be used if Tiling has been used.**	278	SHORT or LONG	C	The TIFF specification recommends selecting the value for RowsPerStrip such that each strip is about 8k bytes; it makes buffering simpler for readers.

SamplesPerPixel	The number of components per pixel.	277	SHORT	R	Allowed values are: 1 - (monochrome or transparency mask) 3 - (RGB) 4 - (4-band data).
Software	Name and version number of the software package(s) used to create the image. Populate with description of the software package(s) used to process/create the range values from the raw instrument data or other source of imagery and gridded data.	305	ASCII	N	Do not use this tag.
StripByteCounts	For each strip, the number of bytes in the strip after compression. **No to be used if Tiling has been used.**	279	LONG or SHORT	C	Populate per TIFF specification when opting to use strips. (Not to be used if Tiling has been used)
StripOffsets	For each strip, the byte offset of that strip **Not to be used if Tiling has been used.**	273	SHORT or LONG	C	Populate per TIFF specification when opting to use strips. (Not to be used if Tiling has been used)
SubFileType	A general indication of the kind of data contained in this subfile. This field is useful when there are multiple subfiles in a single TIFF file.	255	SHORT	N	Do not use this key.
Thresholding	For black and white TIFF files that represent shades of gray, the technique used to convert from gray to black and white pixels.	263	SHORT	O	Desired value is 1.
XResolution	The number of pixels per ResolutionUnit in the ImageWidth direction.	282	RATIONAL	R	Populate with intended display resolution.
YResolution	The number of pixels per ResolutionUnit in the ImageLength direction.	283	RATIONAL	R	Populate with intended display resolution.

Table 1.2: CCITT Bilevel Encodings

TIFF 6.0 Section 11	**CCITT Bilevel Encodings**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
Compression	Compression scheme used on the image data. Uncompressed CCITT 1D CCITT Group 3 CCITT Group 4 LZW JPEG Packbits (32773)	259	SHORT	R	Set to 1 (No Compression)
T4Options[2]	Options for Group 3 Fax compression	292	LONG	N	Do not use this key.
T6Options[3]	Options for Group 4 Fax compression	293	LONG	N	Do not use this key.

Table 1.3: Document Storage and Retrieval

TIFF 6.0 Section 12	**Document Storage and Retrieval**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
DocumentName	The name of the document from which this image was scanned.	269	ASCII	N	Do not use this key.
PageName	The name of the page from which this image was scanned.	285	ASCII	N	Do not use this key.
PageNumber	The page number of the page from which this image was scanned.	297	SHORT	N	Do not use this key.
XPosition	X position of the image.	286	RATIONAL	N	Do not use this key.
YPosition	Y position of the image.	287	RATIONAL	N	Do not use this key.

Table 1.4: Differencing Predictor

TIFF 6.0 Section 14	**Differencing Predictor**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
Predictor	A predictor is a mathematical operator that is applied to the image data before an encoding scheme is applied.	317	SHORT	N	Do not use this key.

Table 1.5: Tiled Images

TIFF 6.0 Section 15	**Tiled Images**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
TileWidth	The tile width in pixels. This is the number of columns in each tile.	322	SHORT or LONG	C	When tiled is allowed: Populate per TIFF specification when opting to use internal tiles.
TileLength	The tile length (Height) in pixels. This is the number of rows in each tile.	323	SHORT or LONG	C	When tiled is allowed: Populate per TIFF specification when opting to use internal tiles.
TileOffsets	For each tile, the byte offset of that tile, as compressed and stored on disk.	324	LONG	C	When tiled is allowed: Populate per TIFF specification when opting to use internal tiles.
TileByteCounts	For each tile, the number of (compessed) bytes in that tile.	325	SHORT or LONG	C	When tiled is allowed: Populate per TIFF specification when opting to use internal tiles.

Table 1.6: CYMK Images

TIFF 6.0 Section 16	**CYMK Images**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
InkSet	The set of inks used in a separated (PhotometricInterpretation=5) image.	332	SHORT	N	Do not use this key.
NumberOfInks	The number of inks. Usually equal to SamplesPerPixel, unless there are extra samples.	334	SHORT	N	Do not use this key.
InkNames	The name of each ink used in a separated (PhotometricInterpretation=5) image, written as a list of concatenated, NUL-terminated ASCII strings. The number of strings must be equal to NumberOfInks.	333	ASCII	N	Do not use this key.
DotRange	The component values that correspond to a 0% dot and 100% dot. DotRange[0] corresponds to a 0% dot, and DotRange[1] corresponds to a 100% dot.	336	BYTE or SHORT	N	Do not use this key.
TargetPrinter	A description of the printing environment for which this separation is intended.	337	ASCII	N	Do not use this key.

Table 1.7: HalftoneHints

TIFF 6.0 Section 17	**HalftoneHints**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
HalftoneHints	The purpose of the HalftoneHints field is to convey to the halftone function the range of gray levels within a colorimetrically-specified image that should retaintonal detail.	321	SHORT	N	Do not use this key.

Table 1.8: Associated Alpha Handling

TIFF 6.0 Section 18	**Associated Alpha Handling**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
ExtraSamples	Description of extra components.	338	BYTE	C	Populate with a value of 0 only if SamplesPerPixel is greater than 3 (multi-spectral images).

Table 1.9: Data Sample Format

TIFF 6.0 Section 19	**Data Sample Format**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
SampleFormat	This field specifies how to interpret each data sample in a pixel. Possible values are: 1 – unsigned integer data 2 – two's complement signed integer data. 3 – IEEE floating point data [IEEE] This field does not specify the size of data samples; the BitsPerSample field does this.	339	SHORT	R	Default value is 1. Select the value corresponding to the sample format used for representing the range (data) values.
SMinSampleValue	The minimum sample value. This tag is used in lieu of MinSampleValue when the sample type is other than integer. The minimum component value used.	340	Any	N	Do not use this key.
SMaxSampleValue	The maximum sample value. This tag is used in lieu of MaxSampleValue when the sample type is other than integer. The maximum component value used.	341	Any	N	Do not use this key.

Table 1.10: RGB Image Colorimetry

TIFF 6.0 Section 20	**RGB Image Colorimetry**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
WhitePoint	The chromaticity of the white point of the image. This is the chromaticity when each of the primaries has its ReferenceWhite value.	318	RATIONAL	N	Do not use this key.
PrimaryChromaticities	The chromaticities of the primaries of the image. This is the chromaticity for each of the primaries when it has its ReferenceWhite value and the other primaries have their ReferenceBlack values.	319	RATIONAL	N	Do not use this key.
TransferFunction[4]	Describes a transfer function for the image in tabular style. Pixel components can be gamma-compensated, companded, non-uniformly quantized, or coded in some other way. The ransferFunction maps the pixel components from a non-linear BitsPerSample (e.g. 8-bit) form into a 16-bit linear form without a perceptible loss of accuracy.	301	SHORT	N	Do not use this key.
TransferRange	Expands the range of the TransferFunction. The first value within a pair is associated with TransferBlack and the second is associated with TransferWhite. The ordering of pairs is the same as for pixel components of the PhotometricInterpretation type.	342	SHORT	N	Do not use this key.
ReferenceBlackWhite	Specifies a pair of headroom and footroom image data values (codes) for each pixel component. The first component code within a pair is associated with ReferenceBlack, and the second is associated with ReferenceWhite. The ordering of pairs is the same as those for pixel components of the PhotometricInterpretation type	532	LONG	N	Do not use this key.

Table 1.11: YCbCr Images

TIFF 6.0 Section 21	**YCbCr Images**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
PhotometricInterpretation	The color space of the image. For Specification: Allowed values are: 0 - WhiteIsZero 1 - BlackIsZero 2 - RGB 3 – Palette Color 4 - Transparency Mask Note: A value for the 4-band case is not defined in the TIFF specification. In the 4-band case, use a value of 2 and populate the ExtraSamples tag with a value of 1.	262	SHORT	N	Do not use this key.
YCbCrCoefficients	The transformation from RGB to YCbCr image data.	529	RATIONAL	N	Do not use this key.
YCbCrSubSampling	Specifies the subsampling factors used for the chrominance components of a YCbCr image.	530	SHORT	N	Do not use this key.
YCbCrPositioning	Specifies the positioning of subsampled chrominance components relative to luminance samples.	531	SHORT	N	Do not use this key.

Table 1.12: JPEG Compression

TIFF 6.0 Section 22	**JPEG Compression**				
Field	**Description**	**Tag**	**Type**	**ROCN**	**Restricted Field Values**
JPEGProc	This Field indicates the JPEG process used to produce the compressed data.	512	SHORT	N	Do not use this key.
JPEGInterchangeFormat	This Field indicates whether a JPEG interchange format bitstream is present in the TIFF file.	513	LONG	N	Do not use this key.
JPEGInterchangeFormatLength	This Field indicates the length in bytes of the JPEG interchange format bitstream.	514	LONG	N	Do not use this key.
JPEGRestartInterval	This Field indicates the length of the restart interval used in the compressed image data.	515	SHORT	N	Do not use this key.
JPEGLosslessPredictors	This Field points to a list of lossless predictor-selection values, one per component.	517	SHORT	N	Do not use this key.
JPEGPointTransforms	This Field points to a list of point transform values, one per component. This Field is relevant only for lossless processes.	518	SHORT	N	Do not use this key.
JPEGQTables	This Field points to a list of offsets to the quantization tables, one per component.	519	LONG	N	Do not use this key.
JPEGDCTTables	This Field points to a list of offsets to the DC Huffman tables or the lossless Huffman tables, one per component.	520	LONG	N	Do not use this key.
JPEGACTTables	This Field points to a list of offsets to the Huffman AC tables, one per component.	521	LONG	N	Do not use this key.

GeoTIFF Format

GeoTIFF data format
All of the GeoTIFF information is encoded in six tags, and numerous keys are available to store projection parameters and coordinate system information. Use of keys and parameters is constrained as indicated . All keys are referenced from one tag, the GeoKeyDirectoryTag. The following information is from the GeoTIFF product specification, Revision 1.0, in Section 1: Baseline GeoTIFF. Specific definitions, formats, and codes can be found in GeoTIFF Format Specification, Revision 1.0. As with baseline TIFF tags, the use of any private GeoTIFF tags, other than those included in this appendix is prohibited.

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Table 2.1 describes the "GeoTIFF Tags" defined in Sections 2.4 – 2.6 of the GeoTIFF Specifications.
Table 2.2 describes the "GeoTIFF Configuration GeoKeys" defined in Sections 2.7 – 2.7.2 of the GeoTIFF Specifications.
Table 2.3 describes the "Geographic CS Parameter Keys" defined in Sections 2.7 – 2.7.2 of the GeoTIFF Specifications.
Table 2.4 describes the "Projected CS Parameter Keys" defined in Sections 2.7 – 2.7.2 of the GeoTIFF Specifications.
Table 2.5 describes the "Vertical CS Parameter Keys" defined in Sections 2.7 – 2.7.2 of the GeoTIFF Specifications.

<u>Legend for GeoTIFF table</u>:

- Columns GeoTIFF tag/key , Description, Tag/Key Id, and Type refer to corresponding specification items of tag according to GeoTIFF specifications.
- ROCN column specifies presence of the item:
    - R: required
    - O: optional
    - C: conditional (Condition must be specified)
    - N: Do not use
- Restricted field values: indicates (when applicable) required values for GeoTIFF geokey.

Table 2.1: GeoTIFF Tags

GeoTIFF Tag	Description	Tag	Type	ROCN	Restricted Field Values
GeoKeyDirectoryTag	Stores GeoKey Directory, which defines and references the "GeoKeys." All Keys in GeoTIFF are referenced from the GeoKeyDirectoryTag All projection and datum information is stored in GeoKeys. See section 2.4 of the GeoTIFF 1.0 Standard.	34735	SHORT	R	This tag references all non-ASCII GeoKeys.
GeoDoubleParamsTag	Used to store all of the DOUBLE valued GeoKeys, referenced by the GeoKeyDirectoryTag For Profile:	34736	DOUBLE	N	Do not use this tag, it is unnecessary because as all Double type GeoKeys are prohibited by this profile.
GeoAsciiParamsTag	Used to store all of the ASCII valued GeoKeys, referenced by the GeoKeyDirectoryTag. See section 2.6.1 of the GeoTIFF 1.0 Standard.	34737	ASCII	R	This tag is used to store all the ASCII-valued GeoKeys.
ModelTiepointTag	Stores raster model tiepoint pairs in the order ModelTiepointTag = (…,I,J,K, X,Y,Z…) where (I,J,K) is the point at location (I,J) in raster space with pixel-value K, and (X,Y,Z) is a vector in model space. The Z value is an offset used in conjuction with the Z pixel scale (tag 33550) to position the data vertically.	33922	DOUBLE	R	Populate this tag with the tie point pair that correlates to the grid origin (grid coordinates 0,0) by convention in the upper left corner of the image. For imagery and typical elevation data (no offset), set Z=0
ModelPixelScaleTag	Used to specify the size of raster pixel spacing in the model space units, consists of the following three values ModelPixelScaleTag = (ScaleX, ScaleY, ScaleZ) The X and Y values must be populated and be equal to the ground distance of one pixel.	33550	DOUBLE	R	Populate per GeoTIFF specification; For imagery, set Z=0, for elevation data, set Z=1 Note: This tag must not be used if the image requires rotation.
ModelTransformationTag	Used to specify the transformation matrix between the raster space and the model space, it has the following organization: ModelTransformationTag = (a,b,c,d,e,….,m,n,o,p)	34264	DOUBLE	C	Use this tag when the image requires rotation in order to be north-oriented. For further explanation see section 2.6.2 Cookbook for Defining Transformations in the GeoTIFF Format Specification, Rev 1.0, 10 Nov 10, 1995; version 1.8.2

GeoTIFF Configuration GeoKeys

These keys are to be used to establish the general configuration of a file's coordinate system, including the types of raster coordinate systems, model coordinate systems, and citations if any.

Table 2.2: GeoTIFF Configuration GeoKeys

GeoTIFF Key	Description	Key ID	Type	ROCN	Restricted Field Values
GTModelTypeGeoKey	Defines general type of model coordinate system used, and to which the raster space will be transformed.	1024	SHORT	R	The applicable codes are: 1 – ModelTypeProjected 2 – ModelTypeGeographic
GTRasterTypeGeoKey	Establishes the raster space coordinate system – RasterPixelIsPoint, RasterPixelIsArea. a. The "PixelIsArea" raster grid space uses coordinates I and J, with (0,0) denoting the upper-left corner of the image, and increasing I to the right, increasing J down. The first pixel-value fills the square grid cell with the bounds top-left = (0,0), bottom-right = (1,1) and so on; by extension this one-by-one grid cell is also referred to as a pixel. An N by M pixel image covers an area with the mathematically defined bounds (0,0),(N,M). b. This raster space designates the upper-left corner of an image. The coordinate pair values for this location shall be “a whole number of pixels.” Each value “must be integer multiple of the resolution” of the image. For a 1-meter resolution image this pair can be odd or even whole numbers, for a 2-meter resolution image this pair needs to even whole numbers. c. The desired result is to have “Exact Pixel Registration,” meaning that pixels from multiple images line up exactly. This should not be	1025	6.3.1.2 codes	R	The applicable codes are: 1 – RasterPixellsArea (use for imagery products) 2 – RasterPixellsPoint (use for non-imagery discrete coverage data)

	confused with overlaps or gaps, but the cells have to fall on an even multiple of the cell width and height from one another, and adjacent images cannot have cells starting halfway, or partially into the cells of the original image				
GTCitationGeoKey	Provided to give an ASCII reference to published documentation on the overall configuration of this GeoTIFF file.	1026	ASCII	R	This key contains detailed product identification and is used to define the imagery file. (ie file name).

Geographic CS Parameter Keys

In general, the coordinate system used will be implied by the projected coordinate system code (Table A.2.3). However, If the model type was chosen to be Geographic (GTModelTypeGeoKey = 2), then the system must be explicitly defined with the following keys.

Table 2.3: Geographic CS Parameter Keys

GeoTIFF Key	Description	Key Id	Type	ROCN	Restricted Field Values
GeographicTypeGeoKey	This key may be used to specify the code for the geographic coordinate system used to map lat-long to a specific ellipsoid over the earth.	2048	SHORT (Code from Section 6.3.2.1)	C	Use when GTModelTypeGeoKey = 2 and ProjectedCSTypeGeoKey is absent. Example: 4326 (ie GCS_WGS84)
GeogCitationGeoKey	This key provides a general citation and reference for all Geographic CS parameters.	2049	ASCII	C	Use when GeographicTypeGeoKey is present. Example: WGS84
GeogGeodeticDatumGeoKey	This key may be used to specify the horizontal datum, defining the size, position and orientation of the reference ellipsoid used in userdefined geographic coordinate systems.	2050	SHORT (code from Section 6.3.2.2)	N	Do not use this key.
GeogPrimeMeridianGeoKey	This key allows specification of the location of the Prime meridian for user-defined Geographic coordinate systems. The default standard is Greenwich, England.	2051	SHORT (Code from Section 6.3.2.4)	N	Do not use this key.
GeogLinearUnitsGeoKey	This key allows the definition of geocentric CS linear units for user-defined GCS.	2052	DOUBLE Code from Section 6.3.1.3)	N	Do not use this key.
GeogLinearUnitSizeGeoKey	Allows the definition of user-defined linear geocentric units, as measured in meters.	2053	DOUBLE	N	Do not use this key.

GeogAngularUnitsGeoKey	This key Allows the definition of geocentric CS Linear units for user-defined GCS and for ellipsoids	2054	SHORT (Code from Section 6.3.1.4)	N	Do not use this key.
GeogAngularUnitSizeGeoKey	Allows the definition of user-defined angular geographic units, as measured in radians.	2055	DOUBLE	N	Do not use this key.
GeogEllipsoidGeoKey	This key may be used to specify the coded ellipsoid used in the geodetic datum of the Geographic Coordinate System.	2056	SHORT (Code from Section 6.3.2.3)	N	Do not use this key.
GeogSemiMajorAxisGeoKey	This key allows the specification of user-defined Ellipsoid Semi-Major Axis (a).	2057	DOUBLE	N	Do not use this key.
GeogSemiMinorAxisGeoKey	This key allows the specification of user-defined Ellipsoid Semi-Minor Axis (b).	2058	DOUBLE	N	Do not use this key.
GeogInvFlatteningGeoKey	This key Allows the specification of the inverse of user-defined Ellipsoid's flattening parameter (f).	2059	DOUBLE	N	Do not use this key.
GeogAzimuthUnitsGeoKey	This key This key may be used to specify the angular units of measurement used to defining azimuths, in geographic coordinate systems. These may be used for defining azimuthal parameters for some projection algorithms, and may not necessarily be the same angular units used for lat-long.	2060	SHORT (Codes from Section 6.3.1.4)	N	Do not use this key.
GeogPrimeMeridianLongGeoKey	This key allows definition of user-defined Prime Meridians, the location of which is defined by its longitude relative to Greenwich.	2061	DOUBLE	N	Do not use this key.

Projected CS Parameter Keys

Table 2.4: Projected CS Parameter Keys

GeoTIFF Key	Description	Key Id	Type	ROCN	Restricted Field Values
ProjectedCSTypeGeoKey	This key contains a coded value for the projection, datum, and possibly plane coordinate zone. Legal values for this key are listed in section 6.3.3.1 of the GeoTIFF 1.0 standard. This code is provided to specify the projected coordinate system. 326zz – UTM Northern Hemisphere 327zz – UTM Southern Hemisphere Where zz is the UTM zone number.	3072	SHORT (Code from Section 6.3.3.1)	C	Use when GTModelTypeGeoKey = 1. Example: 326zz – UTM Northern Hemisphere 327zz – UTM Southern Hemisphere Where zz is the UTM zone number.
PCSCitationGeoKey	This key is provided to give an ASCII reference to published documentation on the Projected Coordinate System. Free text field for describing the projection and datum.	3073	ASCII	C	Use when ProjectedCSTypeGeoKey is present. Citation of Projected Coordinate System. For example: UTM zzN/UTM Where zz is the UTM zone number.
ProjectionGeoKey	This key allows specification of the coordinate transformation method and projection zone parameters.	3074	SHORT (Code from Section 6.3.3.2)	N	Do not use this key.
ProjCoordTransGeoKey	This key allows specification of the coordinate transformation method used.	3075	SHORT (Code from Section 6.3.3.3)	N	Do not use this key.

ProjLinearUnitsGeoKey	This key defines the linear units used by the projection	3076	SHORT (Code from Section 6.3.1.3)	N	Do not use this key.
ProjLinearUnitSizeGeoKey	This key defined the size of user-defined linear units in meters.	3077	DOUBLE	N	Do not use this key.
ProjStdParallel1GeoKey	This key specifies the latitude of the primary standard parallel.	3078	DOUBLE	N	Do not use this key.
ProjStdParallel2GeoKey	This key specifies the latitude of the second standard parallel.	3079	DOUBLE	N	Do not use this key.
ProjNatOriginLongGeoKey	This key defines the longitude of the map projection natural origin.	3080	DOUBLE	N	Do not use this key.
ProjNatOriginLatGeoKey	This key defines the latitude of the map projection natural origin.	3081	DOUBLE	N	Do not use this key.
ProjFalseEastingGeoKey	This key provides the easting coordinate of the map projection natural origin.	3082	DOUBLE	N	Do not use this key.
ProjFalseNorthingGeoKey	This key provides the northing coordinate of the map projection natural origin.	3083	DOUBLE	N	Do not use this key.
ProjFalseOriginLongGeoKey	This key provides the longitude of the false origin.	3084	DOUBLE	N	Do not use this key.
ProjFalseOriginLatGeoKey	This key provides the latitude of the false origin	3085	DOUBLE	N	Do not use this key.
ProjFalseOriginEastingGeoKey	This key provides the easting coordinate of the false origin.	3086	DOUBLE	N	Do not use this key.
ProjFalseOriginNorthingGeoKey	This key provides the northing coordinate of the false origin.	3087	DOUBLE	N	Do not use this key.
ProjCenterLongGeoKey	This key provides the longitude of the center of the projection (not necessarily the origin).	3088	DOUBLE	N	Do not use this key.
ProjCenterLatGeoKey	This key provides the latitude of the center of the projection (not necessarily the origin).	3089	DOUBLE	N	Do not use this key.

ProjCenterEastingGeoKey	This key provides the easting coordinate of the center.	3090	DOUBLE	N	Do not use this key.
ProjCenterNorthingGeoKey	This key provides the northing coordinate of the center.	3091	DOUBLE	N	Do not use this key.
ProjScaleAtNatOriginGeoKey	This key provides the scale at the origin. This is a ratio, so no units are required.	3092	DOUBLE	N	Do not use this key.
ProjScaleAtCenterGeoKey	This key provides the scale at the projection center as a ratio.	3093	DOUBLE	N	Do not use this key.
ProjAzimuthAngleGeoKey	This key provides the azimuth angle east of true north of the central line passing through the projection center.	3094	DOUBLE	N	Do not use this key.
ProjStraightVertPoleLongGeoKey	This key provides the longitude at the straight vertical pole for Polar Stereographic projections.	3095	DOUBLE	N	Do not use this key.

Vertical CS Parameter Keys

Table 2.5: Vertical CS Parameter Keys

GeoTIFF Key	Description	Key Id	Type	ROCN	Restricted Field Values
VerticalCSTypeGeoKey	This key may be used to specify the vertical coordinate system. Note: The 'user defined' code shall be used for the EGM 2008 geoid case, or when using a hydrographic datum. The VerticalCitationGeoKey shall be used to identify the coordinate system/datum for the user defined case.	4096	SHORT (Code from Section 6.3.4.1)	N	Do not use this key.
VerticalCitationGeoKey	This key may be used to document the vertical coordinate system used, and its parameters.	4097	ASCII	N	Do not use this key.
VerticalDatumGeoKey	This key may be used to specify the vertical datum for the vertical coordinate system.	4098	SHORT (Codes from Section 6.3.4.2)	N	Do not use this key.
VerticalUnitsGeoKey	This key may be used to specify the vertical units of measurement used in the geographic coordinate system, in cases where geographic CS's needs to reference the vertical coordinate. This, together with the Citation key, comprises the only fully implemented keys in this section, at present.	4099	SHORT (Code from Section 6.3.1.3)	N	Do not use this key.