PURCHASE AGREEMENT
FOR
PHOTOGRAMMETRIC PRODUCTS & SERVICES

THIS AGREEMENT dated the 30th day of December 2014 is made between Boone County, Missouri, a political subdivision of the State of Missouri through the Boone County Commission, herein "County" and **Surdex Corporation,** herein "Vendor."

IN CONSIDERATION of the parties performance of the respective obligations contained herein, the parties agree as follows:

1. ***Contract Documents*** - This agreement shall consist of this Purchase Agreement for Photogrammetric Products & Services, Request for Proposal number **48-17OCT14,** State of Missouri Contract C213036001-4, any applicable addenda, the Vendor's proposal response dated October 17, 2014 and response to Best And Final Offer #1 dated November 4, 2014 all executed by **Tim Donze** on behalf of the Vendor. All such documents shall constitute the contract documents which are incorporated herein by reference. Service or product data, specification and literature submitted with proposal response may be permanently maintained in the County Purchasing Office contract file for this proposal if not attached. In the event of conflict between any of the foregoing documents this Purchase Agreement, the Request for Proposal and any applicable addenda shall prevail and control over the Vendor's proposal response.

2. ***Purchase* - The County of Boone agrees to purchase from the Vendor** and the Vendor agrees to supply the County with Photogrammetric Products and Services as follows:

	Unit Price
Item I-A. Option 1 – Orthophotography	$ 60,919.25
Item I-A. Option 1 Optional Deliverable A – Color-IR Deliverable	$ 500.00
Item I-A. Option 1 Optional Deliverable B – Ground Control Targets	$ 0.00
Item I-A. Option 1 Optional Deliverable C – Digital file format MrSID Photomosaic Deliverable (cost list per County party to PAQ)	$ 500.00
Item II – Boone County LiDAR A. Option 1	$122,375.00
Total	**$184,294.25**

Regional Entity Products & Services Availability – Additional Photogrammetric Products and Services available to those regional entities participating in the original Project Assessment Quote (PAQ) Request and other regional entities as approved by the Vendor are as specified in the Vendor Response Pricing provided herein.

3. ***Delivery*** – Vendor agrees to deliver products and/or services no later than six (6) months after imagery collection and as specified in the Vendor's response to Section 6.1.5. *Delivery Dates* of the RFP Response Pricing Page. Delivery shall be to the Boone County GIS Department, Attn: Jason Warzinik, 801 E. Walnut, Rm. 220, Columbia, MO 65201.

4. ***Billing and Payment*** - All billing shall be invoiced to the Boone County GIS Department and billings may only include the prices listed in the vendor's proposal response. No additional fees for labor or taxes shall be included as additional charges in excess of the charges in the Vendor's proposal response to the specifications. The County agrees to pay all invoices within thirty days of receipt. In the event of a billing dispute, the County reserves the right to withhold payment on the disputed amount; in the event the billing dispute is resolved in favor of the Vendor, the County agrees to pay interest at a rate of 9% per annum on disputed amounts withheld commencing from the last date that payment was due.

5. ***Binding Effect*** - This agreement shall be binding upon the parties hereto and their successors and assigns for so long as this agreement remains in full force and effect.

6. ***Entire Agreement*** - This agreement constitutes the entire agreement between the parties and supersedes any prior negotiations, written or verbal, and any other bid or bid specification or contractual agreement. This agreement may only be amended by a signed writing executed with the same formality as this agreement.

7. ***Termination*** - This agreement may be terminated by the County upon thirty days advance written notice for any of the following reasons or under any of the following circumstances:

a. County may terminate this agreement due to material breach of any term or condition of this agreement, or
b. County may terminate this agreement if in the opinion of the Boone County Commission if delivery of products are delayed or products delivered are not in conformity with bidding specifications or variances authorized by County, or
c. If appropriations are not made available and budgeted for any calendar year.

IN WITNESS WHEREOF the parties through their duly authorized representatives have executed this agreement on the day and year first above written.

SURDEX CORPORATION

by R C Hoffmann

title PRESIDENT

BOONE COUNTY, MISSOURI

by: Boone County Commission

Daniel K. Atwill, Presiding Commissioner

APPROVED AS TO FORM:

C.J. Dykhouse

C.J. Dykhouse, County Counselor

ATTEST:

Wendy S. Noren my

Wendy S. Noren, County Clerk

In accordance with RSMo 50.660, I hereby certify that a sufficient unencumbered appropriation balance exists and is available to satisfy the obligation(s) arising from this contract. (Note: Certification of this contract is not required if the terms of this contract do not create a measurable county obligation at this time.)

June E. Pitchford by cy

Signature

12/19/14

Date

2010-71101 - $184,294.25

Appropriation Account

STANDARD TERMS AND CONDITIONS - BOONE COUNTY, MISSOURI

1. Contractor shall comply with all applicable federal, state, and local laws and failure to do so, in County's sole discretion, shall give County the right to terminate this Contract.

2. Responses shall include all charges for packing, delivery, installation, etc., (unless otherwise specified) to the Boone County Department identified in the Request for Bid and/or Proposal.

3. The Boone County Commission has the right to accept or reject any part or parts of all bids, to waive technicalities, and to accept the offer the County Commission considers the most advantageous to the County. Boone County reserves the right to award this bid on an item-by-item basis, or an "all or none" basis, whichever is in the best interest of the County.

4. Bidders must use the bid forms provided for the purpose of submitting bids, must return the bid and bid sheets comprised in this bid, give the unit price, extended totals, and sign the bid. The Purchasing Director reserves the right, when only one bid has been received by the bid closing date, to delay the opening of bids to another date and time in order to revise specifications and/or establish further competition for the commodity or service required. The one (1) bid received will be retained unopened until the new Closing date, or at request of bidder, returned unopened for re-submittal at the new date and time of bid closing.

5. When products or materials of any particular producer or manufacturer are mentioned in our specifications, such products or materials are intended to be descriptive of type or quality and not restricted to those mentioned.

6. Do not include Federal Excise Tax or Sales and Use Taxes in bid process, as law exempts the County from them.

7. The delivery date shall be stated in definite terms, as it will be taken into consideration in awarding the bid.

8. The County Commission reserves the right to cancel all or any part of orders if delivery is not made or work is not started as guaranteed. In case of delay, the Contractor must notify the Purchasing Department.

9. In case of default by the Contractor, the County of Boone will procure the articles or services from other sources and hold the Bidder responsible for any excess cost occasioned thereby.

10. Failure to deliver as guaranteed may disqualify Bidder from future bidding.

11. Prices must be as stated in units of quantity specified, and must be firm. Bids qualified by escalator clauses may not be considered unless specified in the bid specifications.

12. No bid transmitted by fax machine or e-mail will be accepted.

13. The County of Boone, Missouri expressly denies responsibility for, or ownership of any item purchased until same is delivered to the County and is accepted by the County.

14. The County reserves the right to award to one or multiple respondents. The County also reserves the right to not award any item or group of items if the services can be obtained from a state or other governmental entities contract under more favorable terms.

15. The County, from time to time, uses federal grant funds for the procurement of goods and services. Accordingly, the provider of goods and/or services shall comply with federal laws, rules and regulations applicable to the funds used by the County for said procurement, and contract clauses required by the federal government in such circumstances are incorporated herein by reference. These clauses can generally be found in the Federal Transit Administration's Best Practices Procurement Manual – Appendix A. Any questions regarding the applicability of federal clauses to a particular bid should be directed to the Purchasing Department prior to bid opening.

16. In the event of a discrepancy between a unit price and an extended line item price, the unit price shall govern.

17. Should an audit of Contractor's invoices during the term of the Agreement, and any renewals thereof, indicate that the County has remitted payment on invoices that constitute an over-charging to the County above the pricing terms agreed to herein, the Contractor shall issue a refund check to the County for any over-charges within 30-days of being notified of the same.

18. **For all titled vehicles and equipment the dealer must use the actual delivery date to the County on all transfer documents** including the Certificate of Origin (COO,) Manufacturer's Statement of Origin (MSO,) Bill of Sale (BOS,) and Application for Title.

19. **Equipment and serial and model numbers -** The contractor is strongly encouraged to include equipment serial and model numbers for all amounts invoiced to the County. If equipment serial and model numbers are not provided on the face of the invoice, such information may be required by the County before issuing payment.

#48-17OCT14 – PROJECT ASSESSMENT QUOTATION (PAQ) REQUEST
VENDOR RESPONSE PRICING

Item I – Orthophotography (See Attachment A) (referencing PAQ response dated 10/17/14)

A. OPTION 1 – Orthophoto Regional Flight

1.	Cost for 4.8 sqmi - 3" Color Orthophotography		$ 5,984
2.	Cost for 1,340 sqmi - 6" Color Orthophotography		$ 109,426
3.	Cost for 2,287 sqmi - 12" Color Orthophotography		$ 44,795
		Total	$160,205

Item I – A. OPTION 1 County-Level Orthophoto Regional Flight Cost Detail

Boone	$60,919.25
Callaway	$24,769.99
Cole	$34,706.01
Cooper	$12,911.90
Howard	$10,669.07
Moniteau	$10,244.79
University of Missouri	$5,984.00
	$160,205.00

Color-IR (cost list by County party to PAQ)

$500/county

Ground control targets (cost list by County party to PAQ)

Included in Orthophoto Pricing

Optional digital file format MrSID photomosaic (cost list per County party to PAQ)

$500/county

Alternate Bids

B. OPTION 2 – Alternate Pricing Per Square Mile Matrix

Square Miles	**3"**	**6"**	**12"**
30 to 100	$400	$150	$50
101 to 800	$300	$100	$35
801 to 2000	$255	$85	$29
2001 to 4000	$240	$80	$27
4001+	$225	$75	$25

Item II – Boone County LiDAR (referencing PAQ response dated 10/17/14)

Commission Order # ______________

A. OPTION 1 – Classifying Bare-Earth LiDAR: County-wide Flight and Processing (See Attachment B)

1a.	Cost for 432 sqmi- 0.7m County LiDAR (bare earth and hydro flatten to USGS spec)	$ 72,835
1b.	Cost for 264 sqmi- 0.7m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 49,540
1c.	Other Additional Costs	$0
	Total	$ 122,375

Item III – Topographics / Planimetrics (referencing BAFO #1 dated 10/31/14)

A. Topographics Deliverables: Orthophotography & LiDAR Based

Option 1 (See Attachment C)

1. Cost for 264 sqmi - Metro Area New 2' Contours (Level 3) $24,010

Total $24,010

B. Planimetrics Deliverables: Orthophotography & LiDAR Based
Option 3 (See Attachment D)

1. Cost for 19 sqmi – New Planimetrics $ 100,590
2. Cost for 5.5 sqmi – Updated Planimetrics $ 9,420

Total $ 110,010

Option 6 Topographics / Planimetrics Price Matrix

NOTE FROM SURDEX:

We have provided two charts below. The first Chart A is provided as requested to make sure we comply with your format and request fully.

Chart B is showing the format we initially provided. We believe the Urban, Suburban, Rural planimetric pricing is a better reflection of how we typically price planimetric work and believe it best represents the cost of this type work.

We have provided a plan density map (Exhibit A-Plan Density Map) and shapefiles of metro Columbia that delineates Urban, Suburban, and Rural areas. This should aid the city in estimating what their cost would be to map specific areas.

Chart A

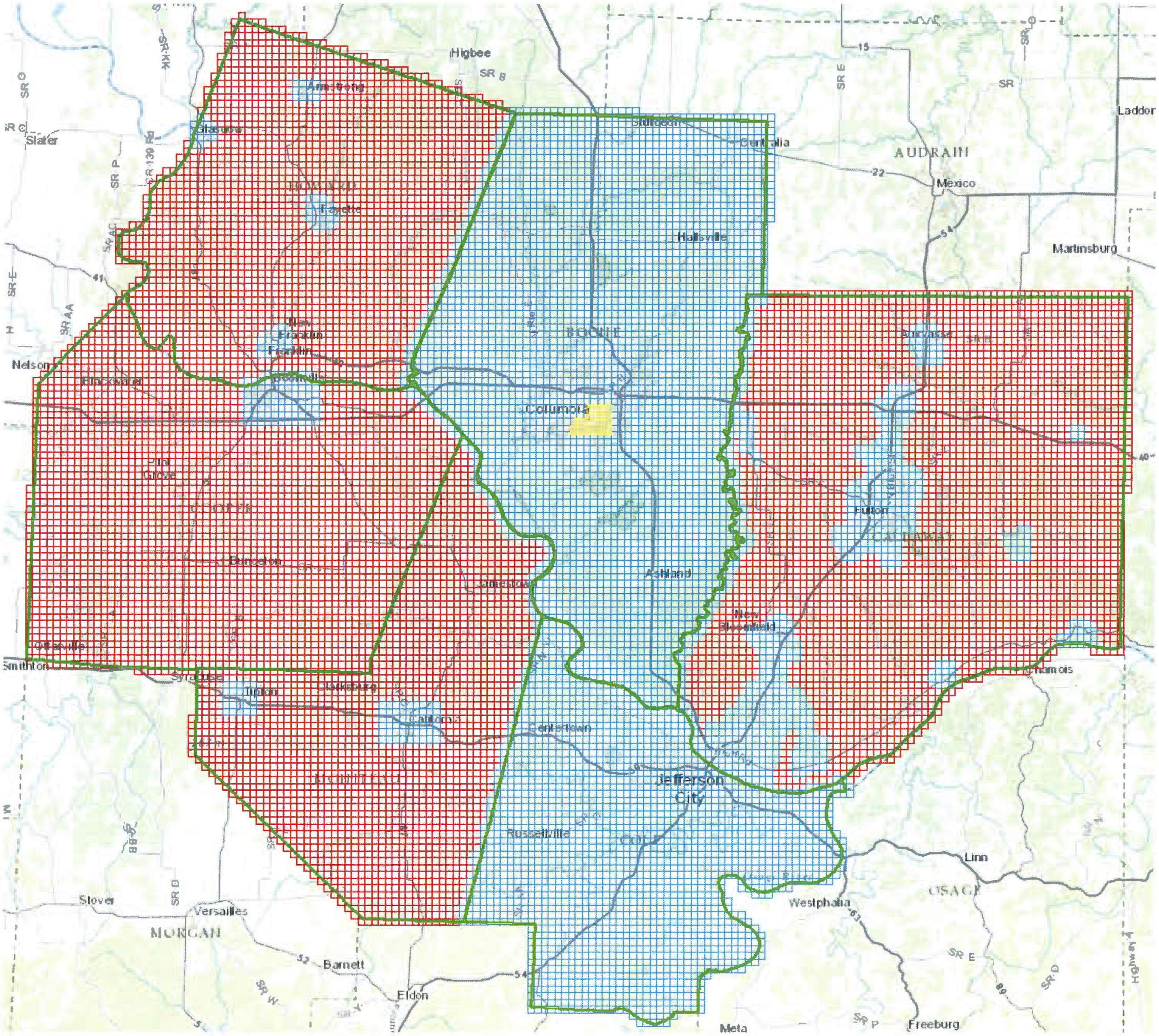
Cost Per Sq. Mile	New Planimetrics	Updated Planimetrics	New 2' Contours	Impervious Surface
1 to 30	$7,325	$5,130	$91	$6,595
31 to 100	$5,110	$3,830	$91	$4,565
100 to 300	$2,815	$2,175	$91	$2,470

Chart B

Cost Per Sq. Mile	New Planimetrics	Updated Planimetrics	New 2' Contours	Impervious Surface
Urban	$7,325	$5,130	$91	$6,595
Suburban	$2,880	$2,530	$91	$2,530
Rural	$1,290	$1,075	$91	$1,075

Attachment A:

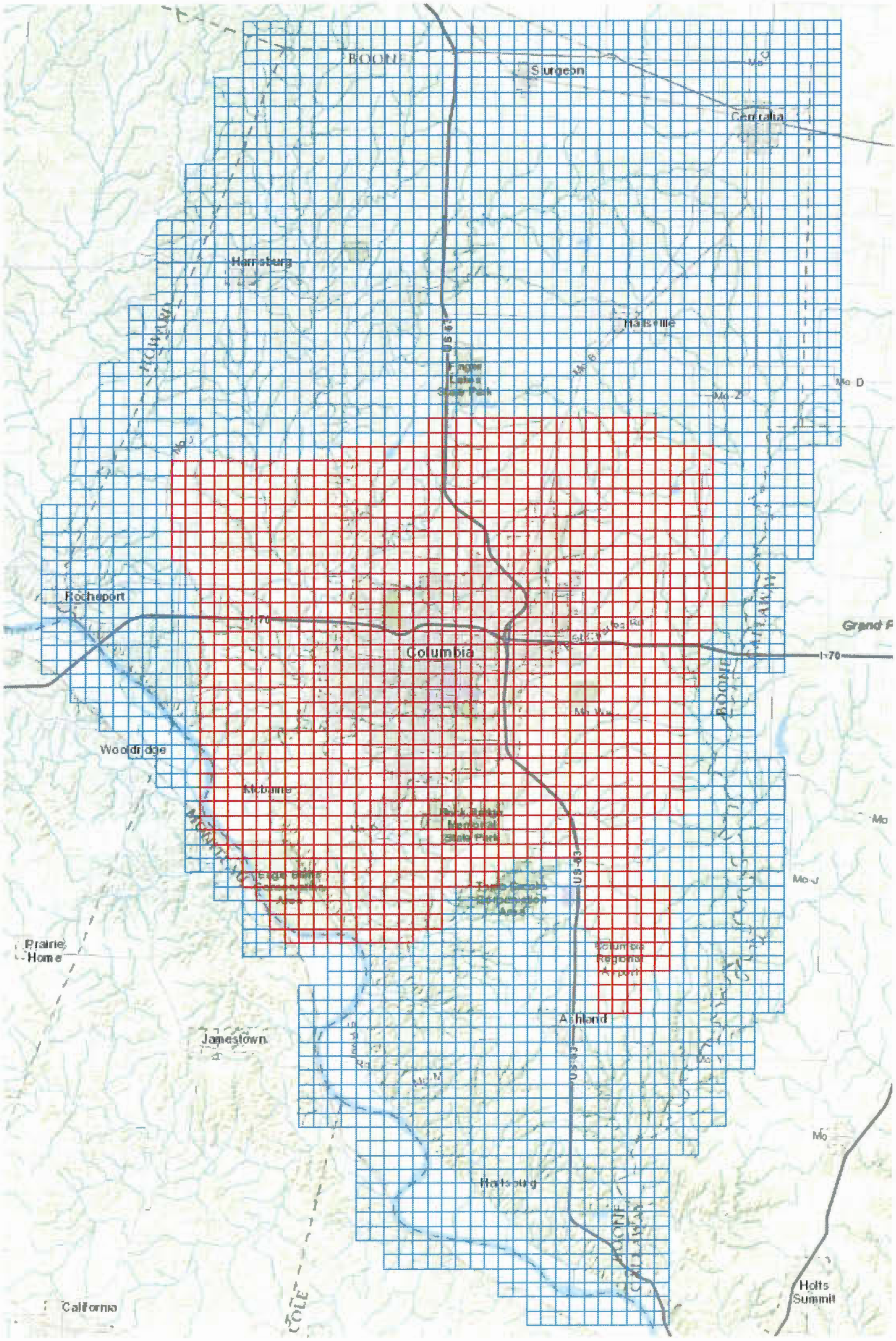
Orthophoto Regional Flight – Option 1



Resolution		
(yellow)	3	4.8
(blue)	6	1,340.0
(red)	12	2,287.0
	Total	3,631.8

Attachment B:

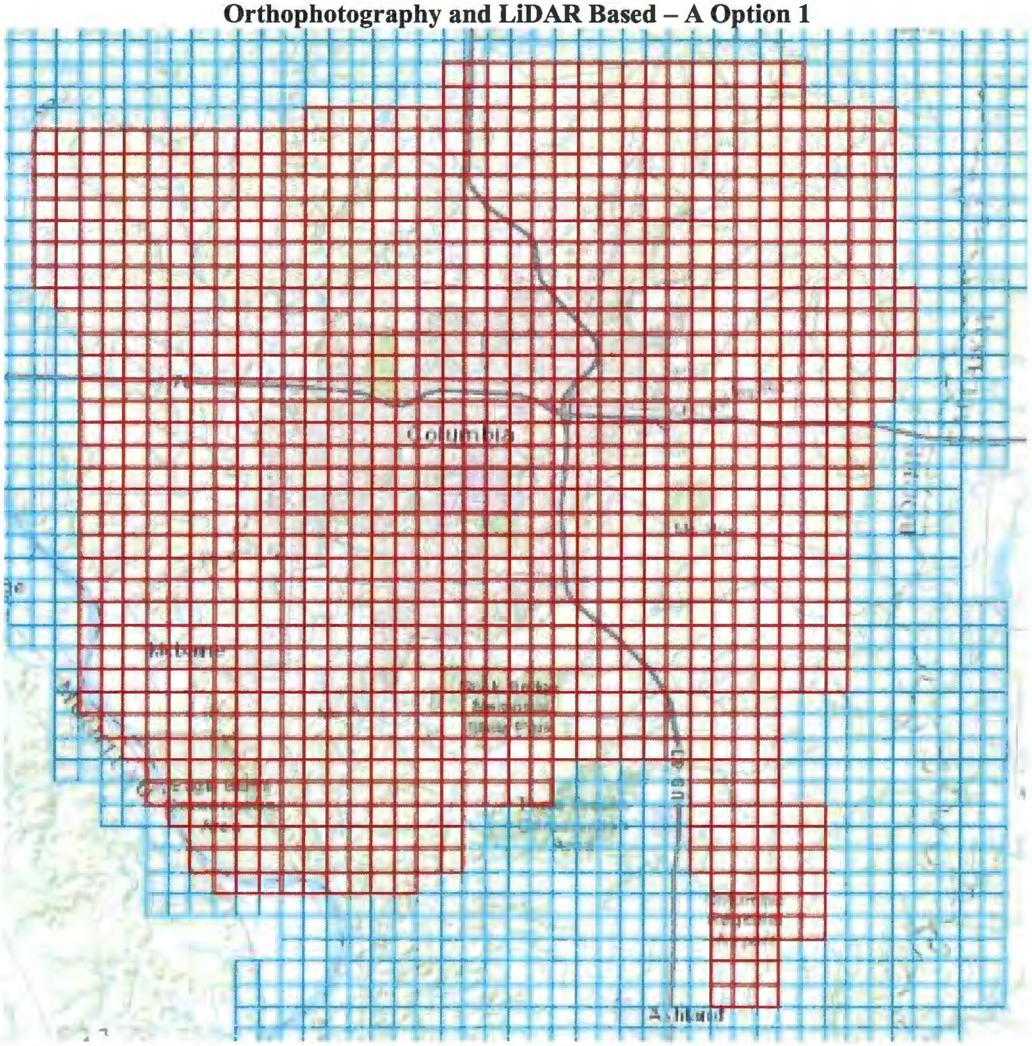
LiDAR Flight Areas



County-wide LiDAR flight area: 691 square miles.
City of Columbia metro area (shown in red): 264 square miles.

Attachment C:

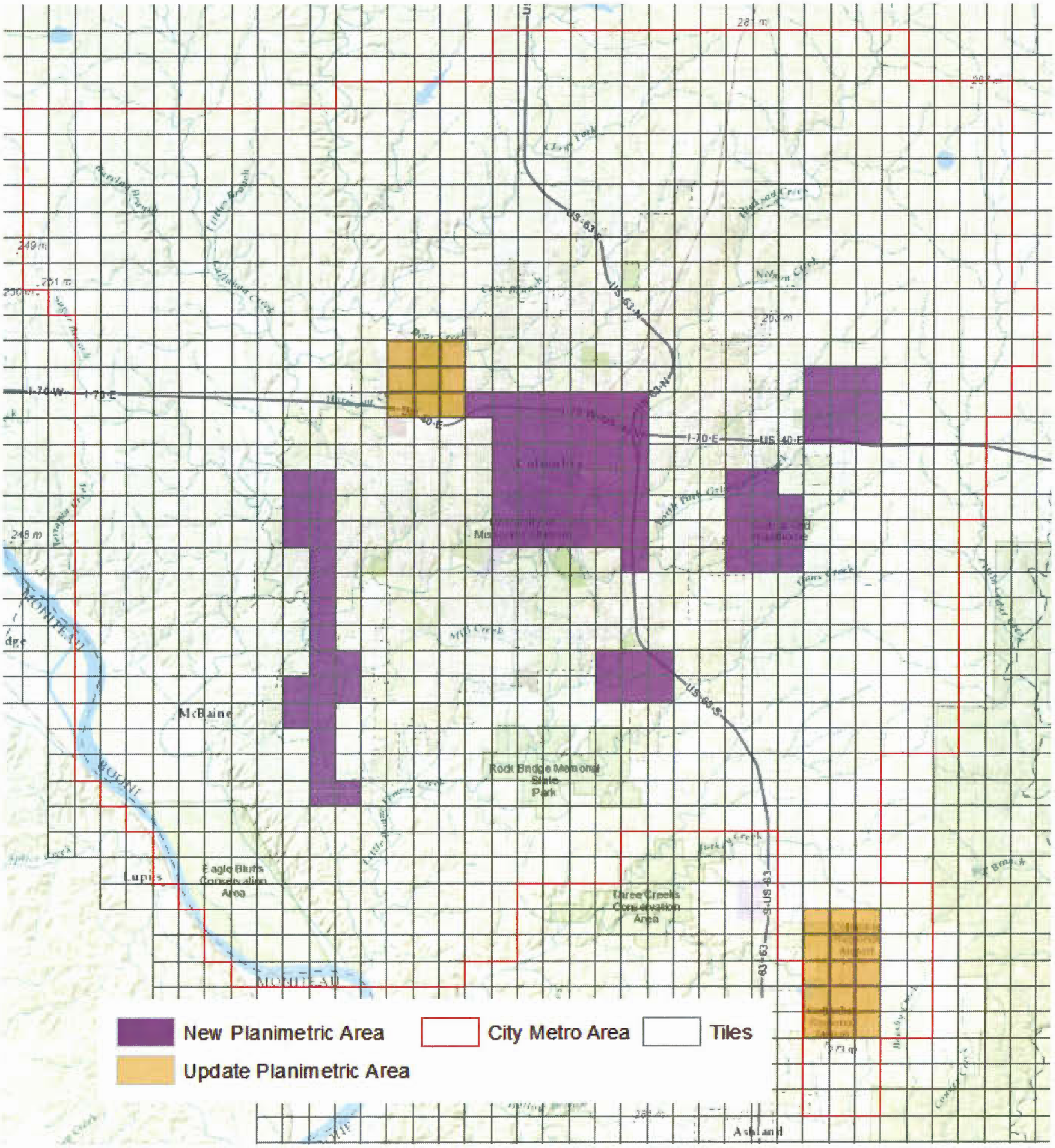
City of Columbia Topographics Deliverable:
Orthophotography and LiDAR Based – A Option 1



City of Columbia metro area new 2' contours area (shown in red): 264 square miles.

Attachment D:

City of Columbia Planimetrics Deliverable: Orthophotography and LiDAR Based – B Option 3



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 19 square miles. Updated planimetric area (shown in orange): 5.5 square miles.

BAFO #1 – Surdex Corporation

November 5, 2014

Amy Robbins
Senior Buyer
613 E. Ash Street, Room 110
Columbia, Mo 65201

Email: arobbins@boonecountymo.org

RE: Surdex Clarification and Best & Final Offer #48-17OCT14-PAQ - Request for Photogrammetric Products and Services

Dear Ms. Robbins:

We appreciate your interest and the interest of the City of Columbia in providing us this Best & Final Offer opportunity.

Many of the options for the planimetric mapping were revised from the initial request and we have adjusted for this.

The most notable change in the options listed was the removal of impervious surface line item in many of the options. Keep in mind that impervious surface and planimetric tasks are tied very closely together and overlap in many ways.

When the impervious surface and planimetric tasks were included together, much of the work to create planimetrics was incorporated in the impervious surface task and the cost listed in our response.

This said, since the impervious surface options have been eliminated, much of the effort that had been accounted for in the impervious surface work will not be accounted for in the planimetric tasks.

If further clarifications are needed on this topic, I'd be glad to discuss them with you and/or your project partners.

If you have any questions or comments, do not hesitate to contact me directly at any point in the evaluation process.

Sincerely,
SURDEX CORORATION

Tim Doyle

Vice President Business Development, Midwest Region
Direct Tel: 314-422-7616
Email: TimD@surdex.com

Surdex Corporation's Response / Pricing Page
BAFO #1 for
48-17OCT14 – PAQ Request for Photogrammetric Products & Services

Topographics / Planimetrics

The City of Columbia has topographic and planimetrics of the requested area from 2007 and 2002. It is left to the discretion of the Offeror to base the cost on updating the City's current information or recreating the planimetrics from the new flight information. Each Offeror will be provided with a sample of several of the panels to help with their determination. Delivery extent layers available for download at http://maps.showmeboone.com/downloads/files/2015_MidMO_PAQ_TopoPlan_Shapefiles_BAFO.zip

A. Topographics Deliverables: Orthophotography & LiDAR Based

Option 1 (See Attachment A)

1. Cost for 264 sqmi - Metro Area New 2' Contours (Level 3)		$ 24,010
	Total	$ 24,010

B. Planimetrics Deliverables: Orthophotography & LiDAR Based

Option 1 (See Attachment B)

1. Cost for 8.5 sqmi – New Planimetrics		$ 58,200
2. Cost for 6 sqmi – Updated Planimetrics		$ 11,880
	Total	$ 70,080

Option 2 (See Attachment C)

1. Cost for 14.5 sqmi – New Planimetrics		$ 75,090
2. Cost for 5 sqmi – Updated Planimetrics		$ 17,860
	Total	$ 92,950

Option 3 (See Attachment D)

1. Cost for 19 sqmi – New Planimetrics		$ 100,590
2. Cost for 5.5 sqmi – Updated Planimetrics		$ 9,420
	Total	$ 110,010

Option 4 (See Attachment E)

1. Cost for 25 sqmi – New Planimetrics		$ 136,150
2. Cost for 5.5 sqmi – Updated Planimetrics		$ 9,420
	Total	$ 145,570

Option 5 (See Attachment F)

1. Cost for 32.0 sqmi – New Planimetrics		$ 166,760
2. Cost for 5.5 sqmi – Updated Planimetrics		$ 9,420
	Total	$ 176,180

Option 6 Topographics / Planimetrics Price Matrix

NOTE FROM SURDEX:

We have provided two charts below. The first Chart A is provided as requested to make sure we comply with your format and request fully.

Chart B is showing the format we initially provided. We believe the Urban, Suburban, Rural planimetric pricing is a better reflection of how we typically price planimetric work and believe it best represents the cost of this type work.

We have provided a plan density map (Exhibit A-Plan Density Map) and shapefiles of metro Columbia that delineates Urban, Suburban, and Rural areas. This should aid the city in estimating what their cost would be to map specific areas.

Chart A

Cost Per Sq. Mile	New Planimetrics	Updated Planimetrics	New 2' Contours	Impervious Surface
1 to 30	$7,325	$5,130	$91	$6,595
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100 to 300	$2,815	$2,175	$91	$2,470

Chart B

Cost Per Sq. Mile	New Planimetrics	Updated Planimetrics	New 2' Contours	Impervious Surface
Urban	$7,325	$5,130	$91	$6,595
Suburban	$2,880	$2,530	$91	$2,530
Rural	$1,290	$1,075	$91	$1,075

C. Additional Charges / Alternate Deliverables (if any)

List any additional charges below – Attach supporting documentation, if necessary and note if charges a specific cost per certain county/entity or a standard rate for the regional flight area.

N/A

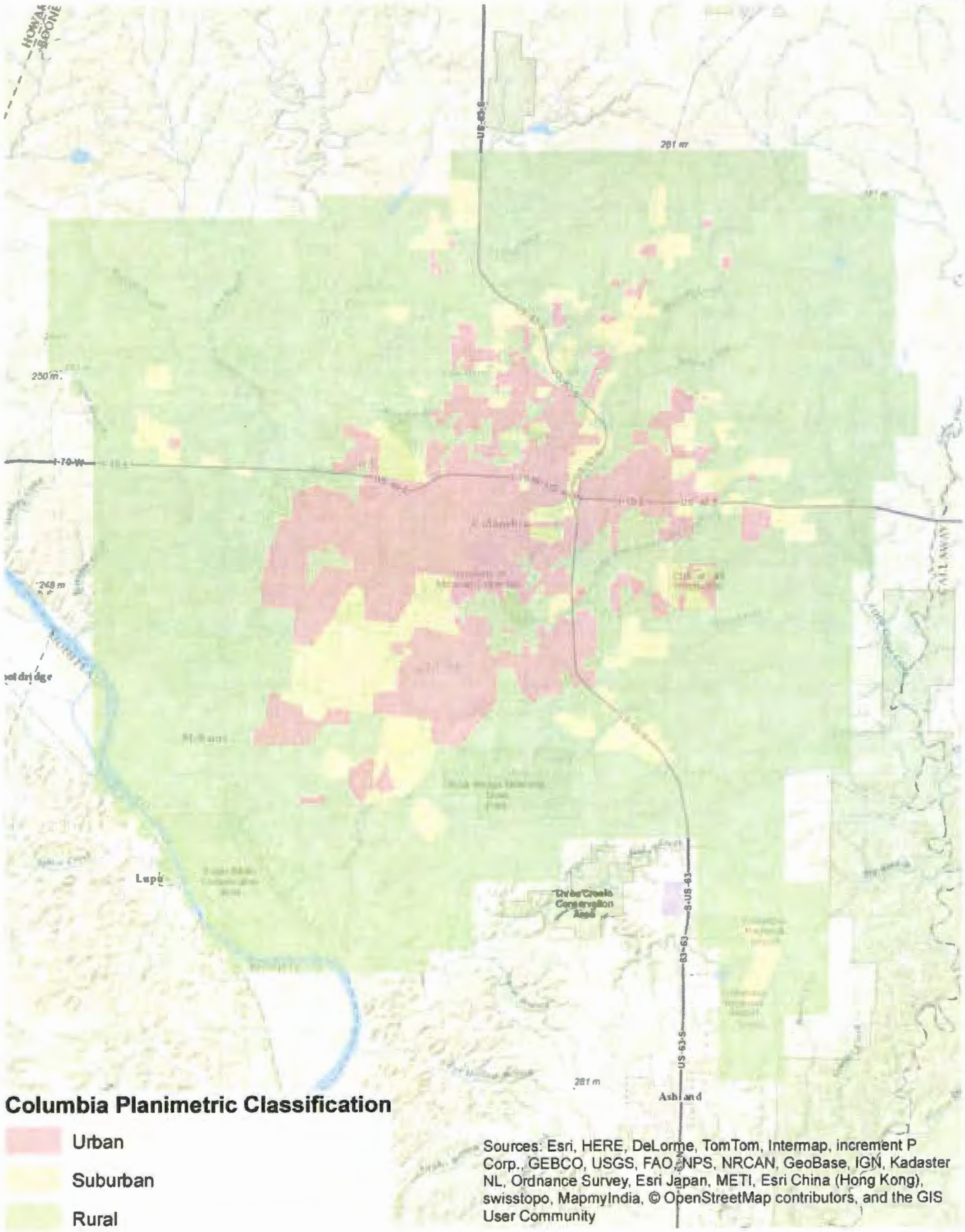
______________________________ $ __________

______________________________ $ __________

______________________________ $ __________

Total $ __________

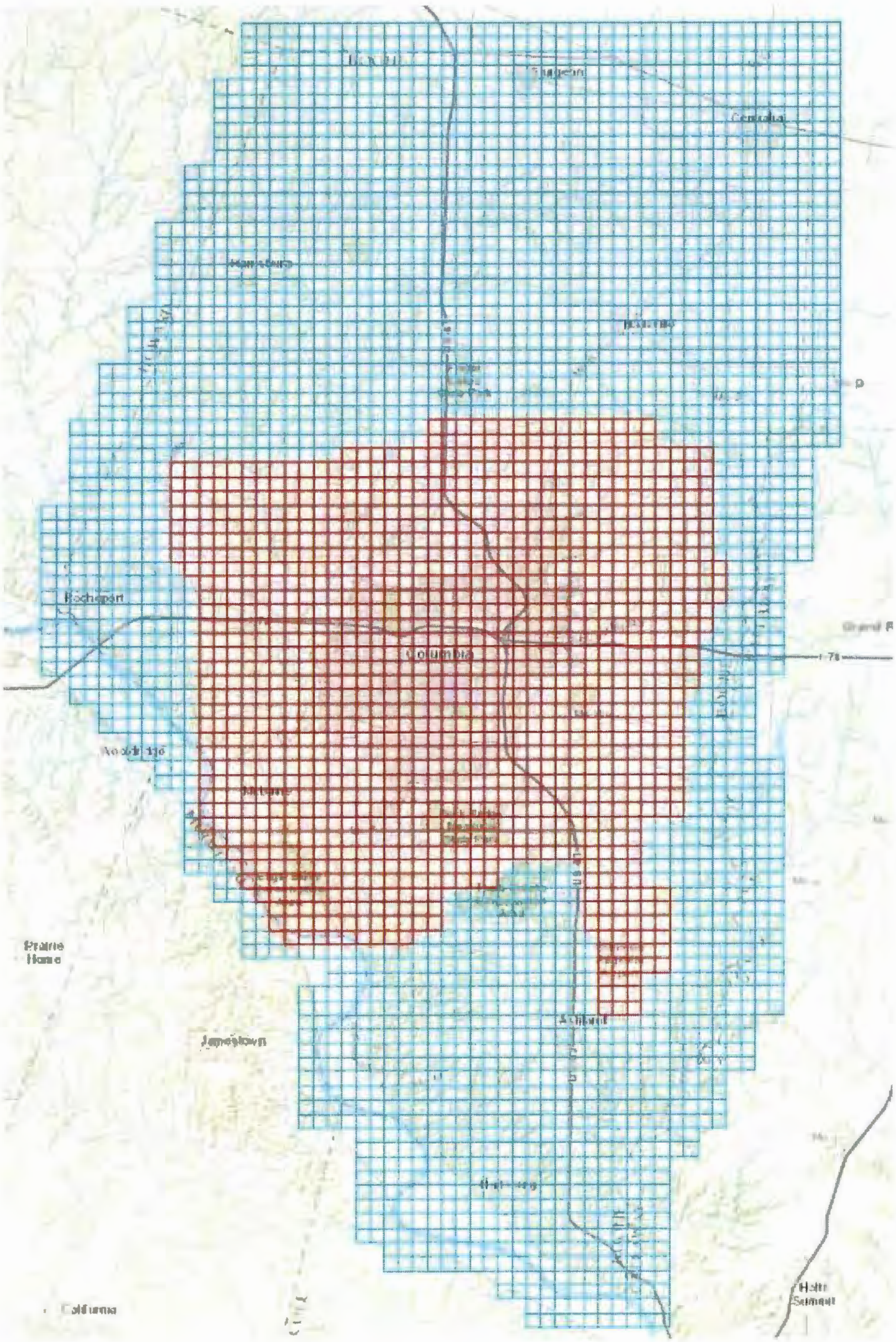
Exhibit A -Plan Density



CAUTION: This diagram is for estimating purposes only. Final positions may vary.

Attachment A:

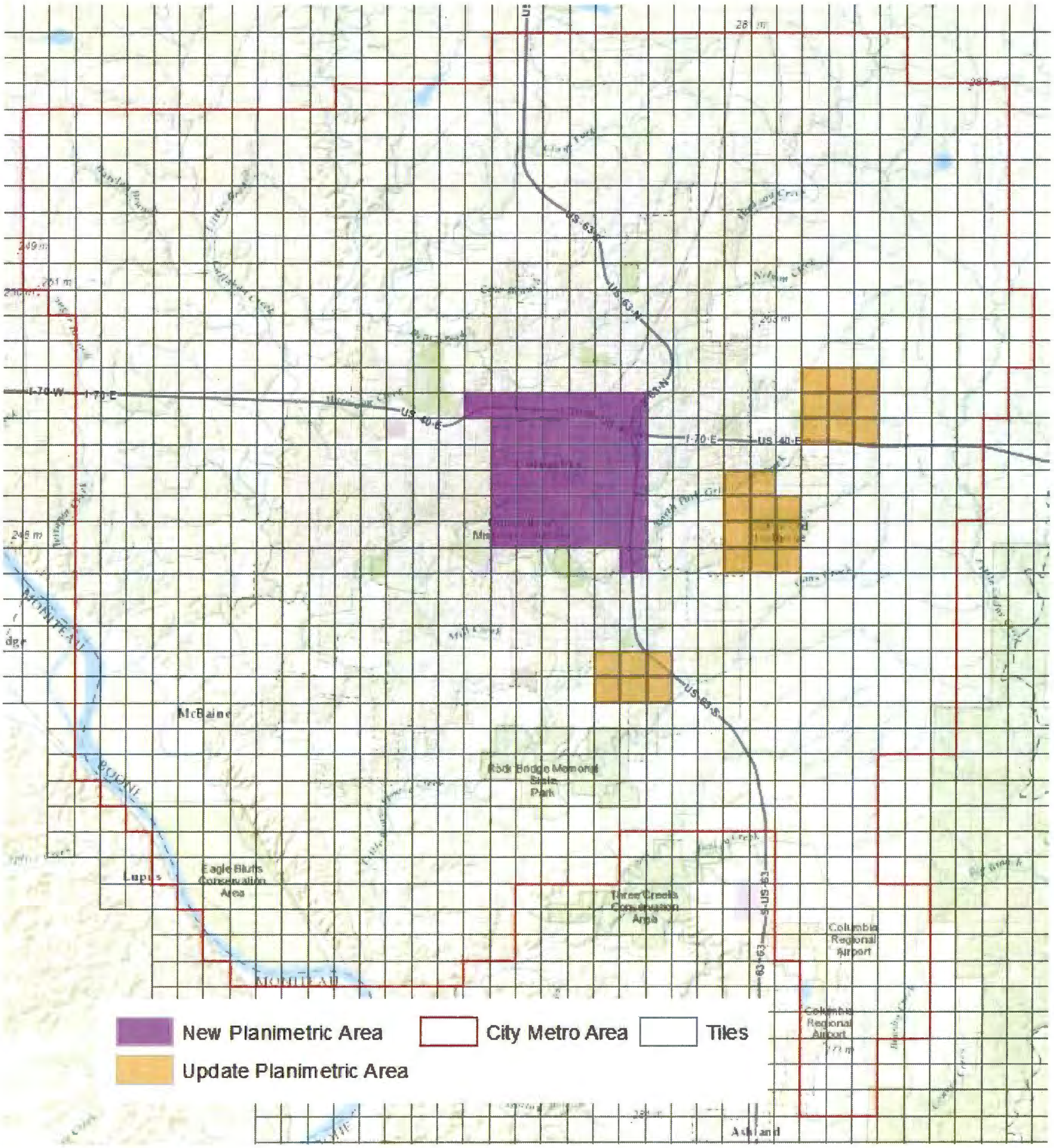
City of Columbia Topographics Deliverable: Orthophotography and LiDAR Based – A Option 1



City of Columbia metro area new 2' contours area (shown in red): 264 square miles.

Attachment B:

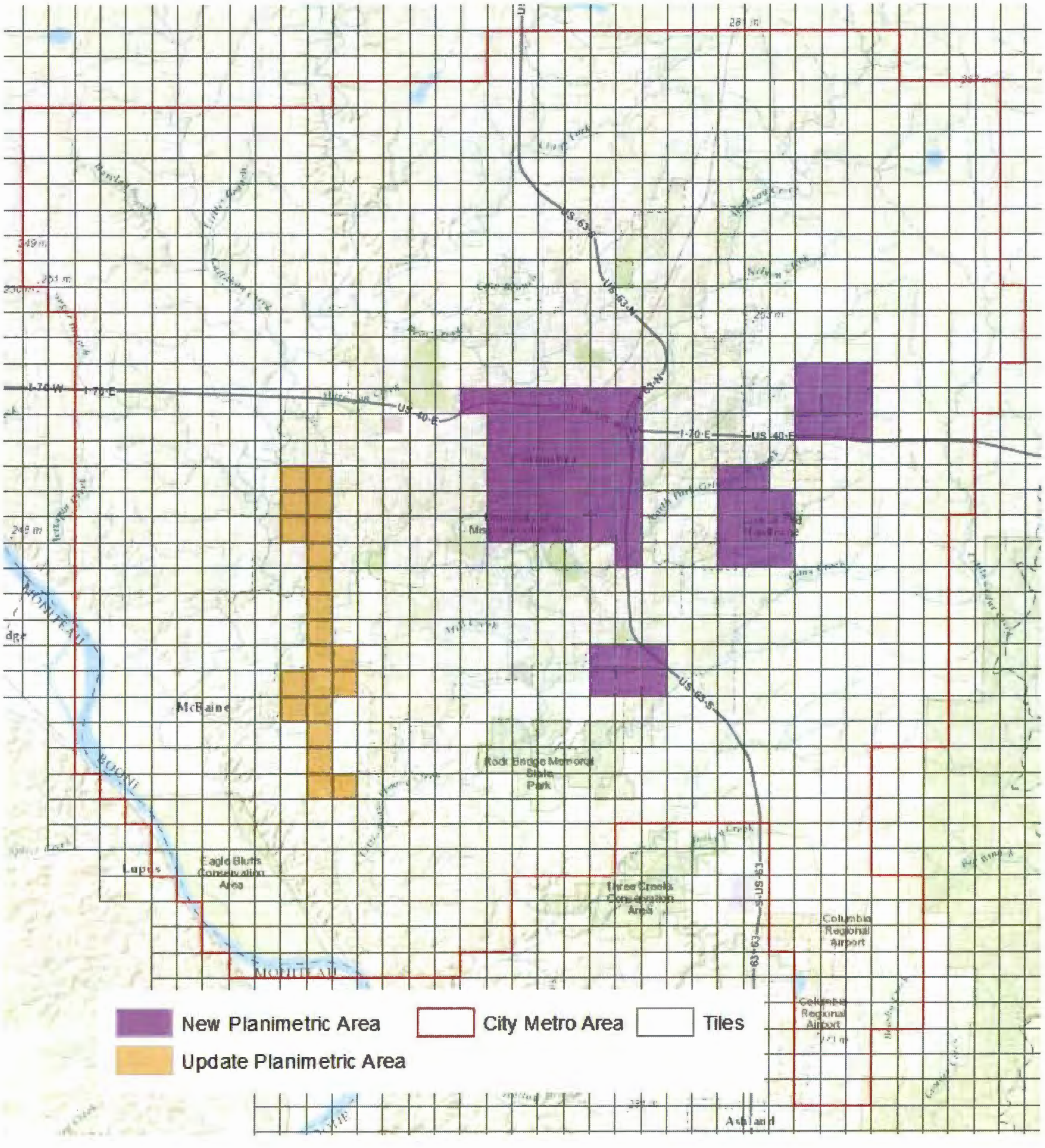
City of Columbia Planimetrics Deliverable: Orthophotography and LiDAR Based – B Option 1



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 8.5 square miles. Updated planimetric area (shown in orange): 6 square miles.

Attachment C:

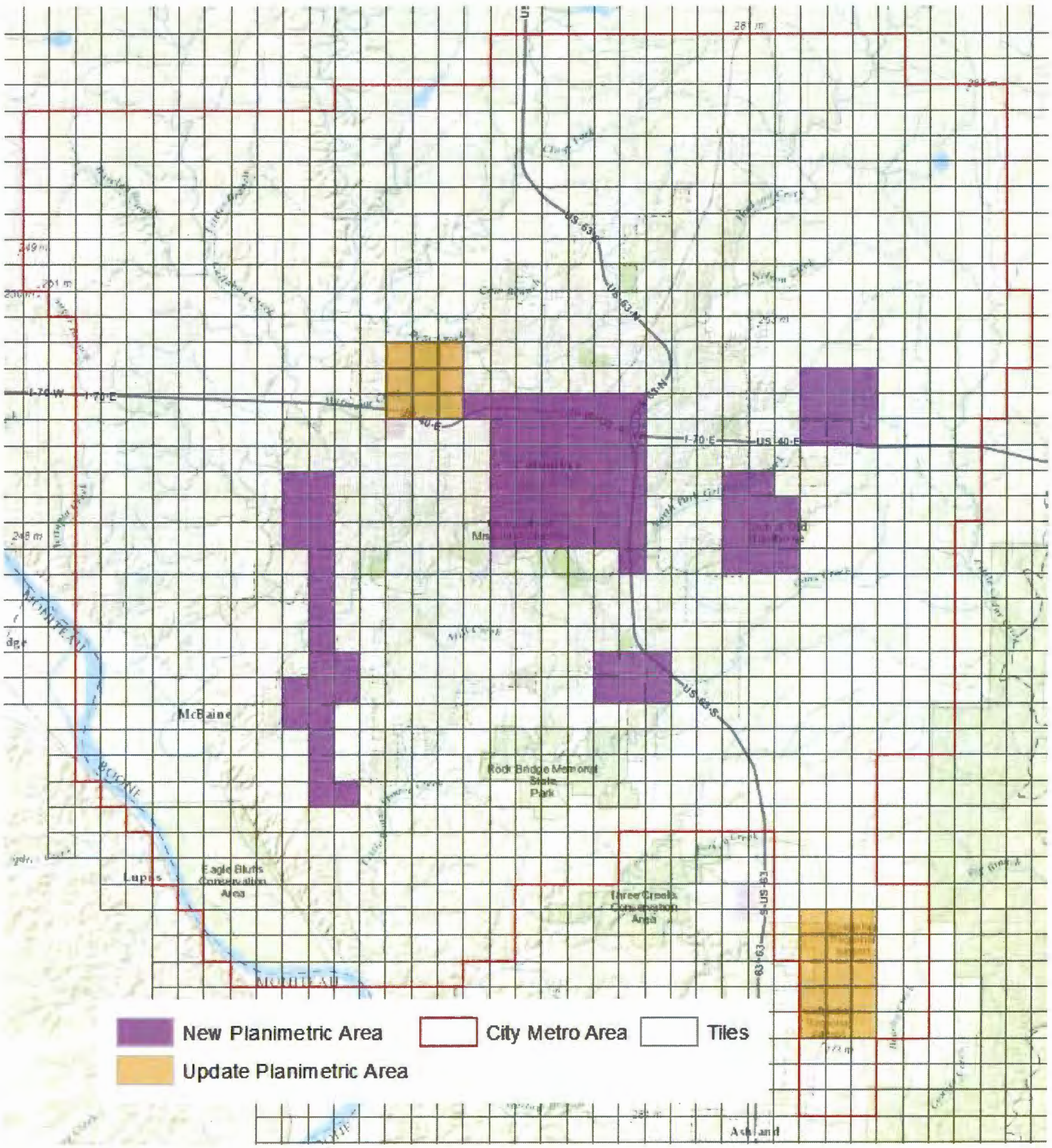
City of Columbia Planimetrics Deliverable:
Orthophotography and LiDAR Based – B Option 2



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 14.5 square miles. Updated planimetric area (shown in orange): 5 square miles.

Attachment D:

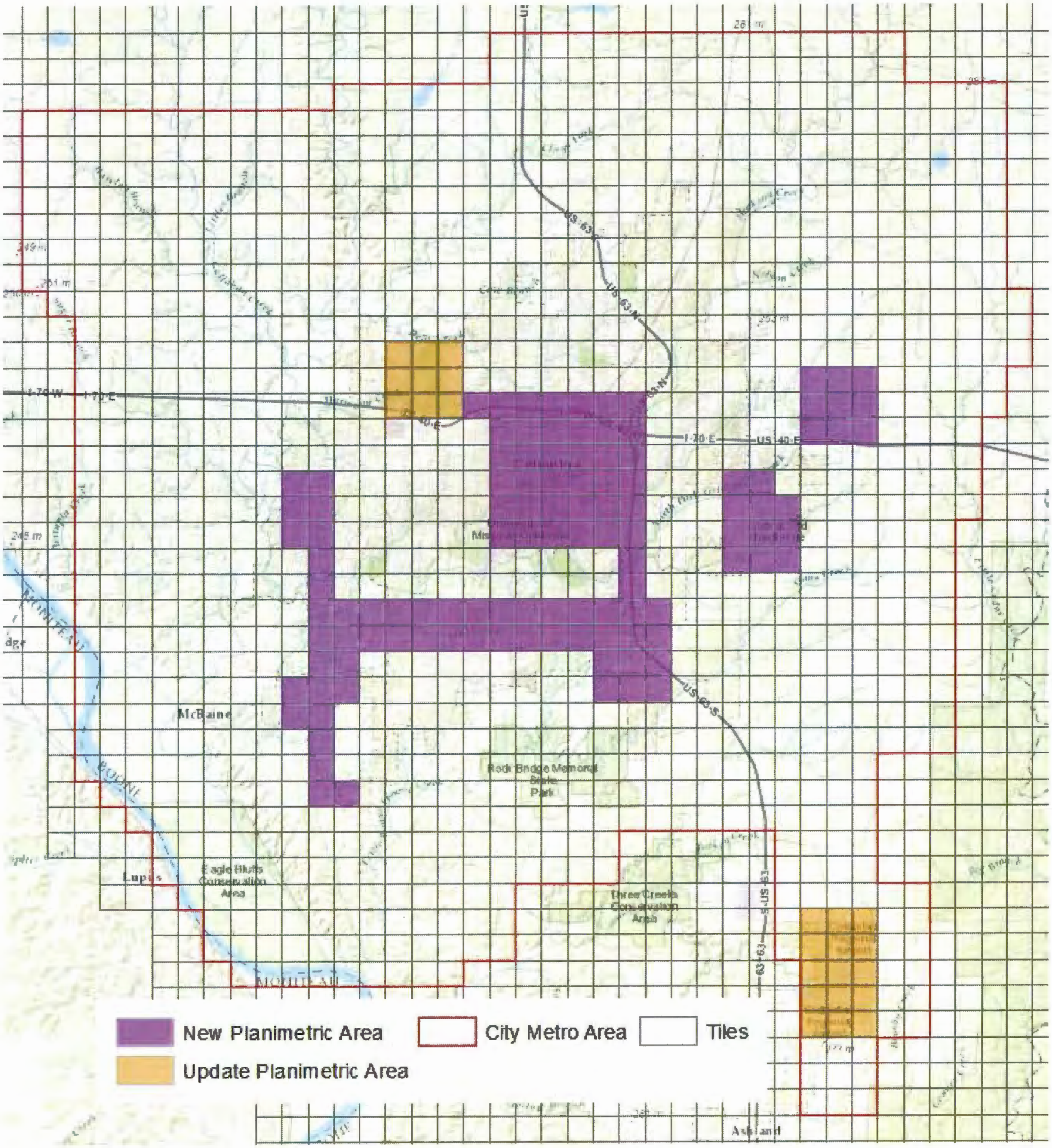
City of Columbia Planimetrics Deliverable: Orthophotography and LiDAR Based – B Option 3



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 89 square miles. Updated planimetric area (shown in orange): 5.5 square miles.

Attachment E:

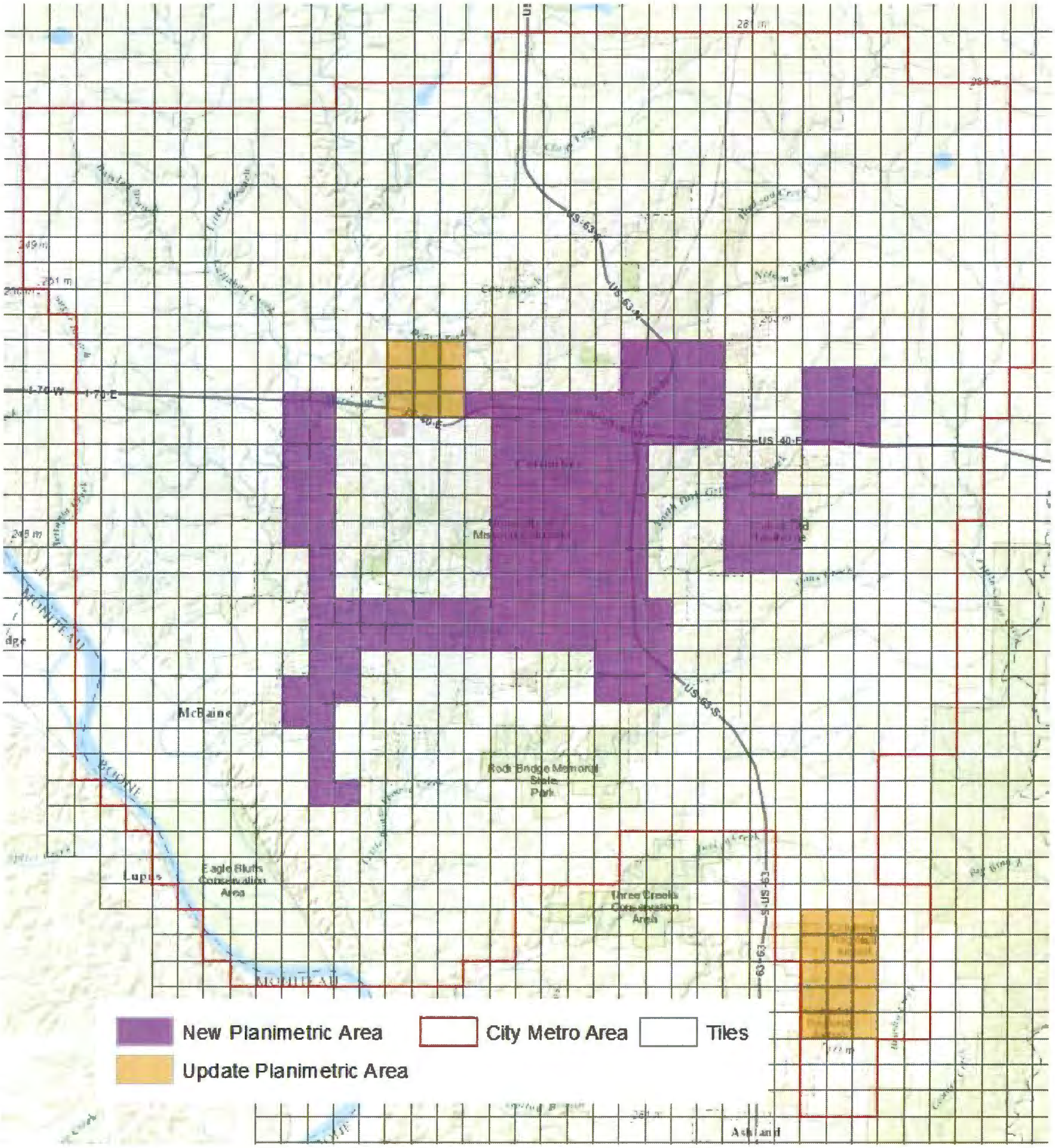
City of Columbia Planimetrics Deliverable: Orthophotography and LiDAR Based – B Option 4



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 95 square miles. Updated planimetric area (shown in orange): 5.5 square miles.

Attachment F:

City of Columbia Planimetrics Deliverable: Orthophotography and LiDAR Based – B Option 5



City of Columbia metro area new 2' contours area (shown in red): 264 square miles. New planimetric area (shown in purple): 32.0 square miles. Updated planimetric area (shown in orange): 5.5 square miles.

PROPOSAL FOR

DIGITAL ORTHOIMAGERY ACQUISITION

DUE DATE: OCTOBER 17, 2014, 1:30 P.M.

Amy Robbins
Senior Buyer
613 E. Ash Street, Room 109
Columbia, Missouri 65201
Phone: (573) 886-4392
E-mail: arobbins@boonecountymo.org

Surdex Corporation
520 Spirit of St. Louis Blvd.
Chesterfield, MO 63005-1002 United States

Tim Donze, Vice President Business Development, Midwest Region
Email: TimD@surdex.com
Direct: 636-368-4424
Mobile: 314-422-7616

www.surdex.com

Cover Letter

October 17, 2014

Amy Robbins
Senior Buyer
Boone County Purchasing Department 613 E. Ash Street, Room 109
Columbia, Missouri 65201-4460

Dear Ms. Robbins:

On behalf of our Team, Surdex is pleased to provide this fully-compliant response to the Project Assessment Quotation "#48-17OCT14, County of Boone, Missouri" under the State of Missouri Contract C213036001-4, Photogrammetric Products and Services.

Surdex brings numerous advantages to this project:

- Our Chesterfield, Missouri headquarters is less than 100 miles from the project area, providing quick response for field and aerial acquisition operations, as well as availability to our staff and facilities at any point during the project.
- Only US Labor will be used on this project. Nearly all of the acquisition and processing will be performed with Missouri labor, bolstering the State's employment and tax base.
- We have performed numerous projects in the State of Missouri at the State, Federal, and Local government level and are familiar with weather conditions and ground cover.
- Our state-of-the-art Leica ADS100 digital pushbroom cameras are ideally suited for orthoimagery projects as well as planimetric and topographic mapping. Surdex's four (4) ADS100 systems represent the largest installation of this technology in the United States.
- We have provided LiDAR acquisition and processing for large areas of the State of Missouri over the last several years and bring the necessary expertise to perform on this project.
- We bring more than sufficient resource capacity to acquire and process the orthoimagery, LiDAR, planimetric, and topographic products for this project.
- We have a wealth of experience in "doing the job right" and have a strong reputation for delivering successful projects on time and providing superior customer service in the process.
- We treat our clients as partners, allowing us to overcome unexpected challenges by keeping our clients in the loop at all times to ensure issues are resolved in an efficient and wise manner.
- Our Team includes David Mason & Associates of St. Louis (MoDOT Certified DBE) to assist with the ground survey operations.

Since acquiring the first two ADS100 systems in the summer of 2013 – the first such installation in the United States – Surdex-lead teams have acquired, processed, and delivered over 1,000 hours of acquisition with these sensors.

Surdex-lead teams have acquired and processed over 20,000 square miles of LiDAR data in the State of Missouri and surrounding areas over the last few years.

Surdex provides a high level of technical detail in our proposal responses so that our clients are able to assess our design and technical approach. In the case of this response, some portions of our proposal are general in nature due to a variety of options that can be selected by the FlyMidMo partners.

- The orthoimagery portion of this project is well defined and thus our design and approach are discussed thoroughly and in detail.
- The LiDAR portion of the project has several options in terms of area and product scope and our response is thorough.
- Topographic contours are less defined and dependent upon the options selected by FlyMidMo. For example, contours can be done from new LiDAR acquisition if this option is selected, but would have to be done photogrammetriclly if the LiDAR option is not selected.
- Planimetric extraction and impervious surface scopes are still to be determined to some degree and our treatment of these is general in nature.

Once the final project scope is more defined and the options known, Surdex would be glad to provide more detail in our methodology. Similarly regarding delivery dates, we have given our best estimate on realistic delivery dates. The options selected for the final scope of work will likely effect the delivery dates. For instance, if LiDAR is selected, we will want to delay ortho production for the LiDAR areas to produce the new DEM before producing orthos. We will work with the partners during final scoping of the project to optimize the delivery schedule. We will do our best to work with your needs and priorities to make this a successful endeavor for everyone.

We acknowledge and support the plan to have individual contracts written for each partner of your consortium. Surdex often has regional projects executed in this manner with more than a dozen potential partners. We also will continue to help identify and support additional potential partners joining your consortium.

We have placed a number of sample 6" and 1' GSD orthoimages on our ftp site for use by the reviewers of this submission. The details for the login are below. Please note that the login and password are case-sensitive.

ftp:	ftp://ftp.surdex.com/flymidmo_samples/
Login:	sdxguest
Password:	Sdx2012

If you have any questions or comments, do not hesitate to contact me directly at any point in the evaluation process.

Sincerely,

SURDEX CORORATION

Tim Donze

Tim Donze
Vice President Business Development, Midwest Region

Direct Tel: 314-422-7616
Email: TimD@surdex.com

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COVER LETTER 2

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Section 1: Proposal Forms

1.1 STATEMENT OF RESPONDENT'S QUALIFICATIONS

(File with Response Form)

1. **Number of years in business: 60 If not under present firm name, list previous firm names and types of organizations.**

   None

2. **Contracts on hand: (Complete the following schedule)**

Item	Purchaser	Amount of Percent Contract Completed
NAIP	USDA	90%
One-foot imagery, state of KS	State of KS	90%
Wisconsin digital orthophotos	Northeast Wisconsin Consortium	55%
Mo LIDAR	US Army Corps of Engineers	70%
ILGS LiDAR	University of Illinois	76%
NM LiDAR	US Army Corps of Engineers	5%
Municipal mapping update	City of Maryland Heights, MO	10%
Fall foliage contract	MN DNR	85%
Fall foliage contract	WI DNR	20%
Iowa LIDAR	Iowa DOT/Iowa DNR	80%
2014 Piedmont Mtn orthophotos	State of NC	98%
NC LiDAR	ESP Associates	95%

3. **General type of product sold and manufactured:**

   Photogrammetric Mapping Services

4. **There has been no default in any contract completed or un-completed except as noted below:**

   (a) **Number of contracts on which default was made:** None
   (b) **Description of defaulted contracts and reason therefore:**

5. **List banking references:**

   Jefferson Bank & Trust, Mr. Darryl Dickerhoff, Vice President (314) 624-0100

   2301 Market Street, St. Louis MO 63103

6. **Upon request will you within 3 (three) days file a detailed confidential financial statement?**

Yes ____X____ **NO** ________

Dated at 520 Spirit of St. Louis Blvd., Chesterfield, MO 63005

This 16 **day of** October, **20** 2014.

Surdex Corporation
Name of Organization(s)

By RC Hoffmann
(Signature)

President
(Title of person signing)

WORK AUTHORIZATION CERTIFICATION

PURSUANT TO 285.530 RSMo

(FOR ALL BIDS IN EXCESS OF $5,000.00)

County of St. Louis)

)SS.

State of Missouri)

My name is Robert Berger. I am an authorized agent of Surdex Corporation (Bidder). This business is enrolled and participates in a federal work authorization program for all employees working in connection with services provided to the Agency. This business does not knowingly employ any person that is an unauthorized alien in connection with the services being provided. Documentation of participation in a federal work authorization program is attached hereto.

Furthermore, all subcontractors working on this contract shall affirmatively state in writing in their contracts that they are not in violation of Section 285.530.1 and shall not thereafter be in violation. Alternatively, a subcontractor may submit a sworn affidavit under penalty of perjury that all employees are lawfully present in the United States.

Robert H. Berger 10/17/2014

Affiant Date

ROBERT H. BERGER

Printed Name

Subscribed and sworn to before me this ~~16~~ 17th day of October, 2014.

Notary Public

Attach to this form the first and last page of the *E-Verify Memorandum of Understanding* that you completed when enrolling for proof of enrollment.

RETTA MORCOM
Notary Public - Notary Seal
STATE OF MISSOURI
St. Louis County
My Commission Expires Aug. 09, 2018
Commission #14442469

1.2.1 Last page of the E-Verify Memorandum of Understanding

E-Verify

Company ID Number: 163675

To be accepted as a participant in E-Verify, you should only sign the Employer's Section of the signature page. If you have any questions, contact E-Verify at 888-464-4218.

Employer Surdex Corporation

Robert Berger	
Name (Please Type or Print)	Title
Electronically Signed	01/23/2009
Signature	Date

Department of Homeland Security – Verification Division

USCIS Verification Division	
Name (Please Type or Print)	Title
Electronically Signed	01/23/2009
Signature	Date

Page 11 of 13 E-Verify MOU for Employer Revision Date 10/29/09 www.dhs.gov/E-Verify

Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion Lower Tier Covered Transactions

This certification is required by the regulations implementing Executive Order 12549, Debarment and Suspension, 29 CFR Part 98 Section 98.510, Participants' responsibilities. The regulations were published as Part VII of the May 26, 1988, Federal Register (pages 19160-19211).

(BEFORE COMPLETING CERTIFICATION, READ INSTRUCTIONS FOR CERTIFICATION)

(1) The prospective recipient of Federal assistance funds certifies, by submission of this quotation, that neither it nor its principals are presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from participation in this transaction by any Federal department or agency.

(2) Where the prospective recipient of Federal assistance funds is unable to certify to any of the statements in this certification, such prospective participant shall attach an explanation to this quotation.

Ronald C. Hoffmann, President

Name and Title of Authorized Representative

RC Hoffmann

Signature

October 16, 2014

Date

Section 2: References

2.1 Summaries of Similar Projects

Surdex is providing several projects that are relevant to this project. The following table summarizes these, with the details for each following.

Relevance of Similar Projects				
Project	**Year**	**Resolution**	**Sensor**	**Project Manager**
A. City of Roswell, GA	2014	6" GSD	DMC	Cornell Rowan
B. Collier County, FL	2014	6" GSD 2' GSD	ADS100	Wade Williams
C. City of Raleigh, NC	2014	6" GSD	DMC	Cornell Rowan
D. East-West Gateway	2012	6" GSD	DMC	Dan Martin
E. Missouri LiDAR Partners USACE – St. Louis District	2013		Leica ALS50-II Leica ALS70	Wade Williams
F. Adams County, IL	2012	6" GSD	DMC	Cornell Rowan

A. CITY OF ROSWELL, GEORGIA

Surdex performed a mapping project for a collection of five Georgia communities in the Roswell, Georgia area: established control survey and collected 4-band color aerial photography, color digital orthophotography, and LiDAR data for the cities of Alpharetta, Dunwoody, Roswell, Sandy Springs and Brookhaven, Georgia. The imagery was acquired at 4800' AGL to produce 0.5' GSD orthophotography with a mapping scale of 1"=100'. In addition, the LiDAR data was used to for planimetric and topographic mapping for several participating communities.

<table>
<tr><td colspan="2" rowspan="4">Five Cities in Georgia
(Alpharetta, Dunwoody, Roswell, Sandy Springs and Brookhaven)</td><th>Point of Contact</th><th>Surdex Project Manager</th></tr>
<tr><td rowspan="3">Scott Huffman
City of Roswell, Georgia
Tel: 770-594-6270
SHuffman@roswellgov.com
38 Hill Street
Roswell, GA 30075</td><td>Cornell Rowan</td></tr>
<tr><th>Contract Value</th></tr>
<tr><td>$154,304</td></tr>
<tr><th>Approximate Square Miles</th><th>AGL</th><th colspan="2">Notes</th></tr>
<tr><td>132</td><td>4,800</td><td colspan="2">Natural color orthoimagery
4-band orthoimagery</td></tr>
<tr><td colspan="2">Project Deliverables</td><td colspan="2">• 0.5' natural color and 4-band orthoimagery
• LiDAR for five cities in GA
• 1"=100' planimetric mapping for City of Dunwoody
• Planimetric mapping and 2' contours for the City of Brookhaven</td></tr>
<tr><td colspan="2">Scheduled / Actual Completion</td><td colspan="2">• 1/2013 – 1/2014</td></tr>
</table>

B. COLLIER COUNTY, FLORIDA

Surdex has flown this project annually since 2006. The purpose of the project was to collect multiple scales of DMC imagery over the entire county and create digital orthophotos at 2' and 6" resolution. A complete planimetric update is also done at 1" = 100' in the urban areas.

In 2006, we generated the datasets in color from color aerial film. In 2007 the datasets were produced from the Digital Mapping Camera. The data sets consisted of 400-scale color digital orthophotos with a 2-foot pixel resolution covering 2,850 square miles and 100-scale color digital orthophotos with a 0.5-foot pixel resolution covering 630 square miles. In addition, 100-scale and 400-scale planimetric features were updated for the appropriate areas of the County. The same data was produced and delivered in May of 2008.

In 2009 we provided the 100-scale planimetric features and in 2010 we are providing a full update. For the 2013 project (concluded in 2014) we again provided the annual digital orthophoto updates at the same resolution and 100'/400' planimetric updates.

<table>
<tr><td colspan="2" rowspan="4">Digital Orthophotography, Collier County, Florida</td><th>Point of Contact</th><th>Surdex Project Manager</th></tr>
<tr><td rowspan="3">Vickie Downs, GIS Director
Tel: 239-774-8147
vdowns@collierappraiser.com
Collier County
39S0 Radio Road
Naples, FL 34104</td><td>Wade Williams</td></tr>
<tr><th>Contract Value</th></tr>
<tr><td>$521,000</td></tr>
<tr><th>Approximate Square Miles</th><th>Camera</th><th colspan="2">Notes</th></tr>
<tr><td>2,850 at 2' GPR
630 at 6" GPR</td><td>DMC
ADS100</td><td colspan="2">Surdex has updated this project every year for 19 years.</td></tr>
<tr><td colspan="2">Project Deliverables</td><td colspan="2">• 6" GPR color digital orthophotography
• 2' GPR color digital orthophotography
• 1"=100' scale planimetric mapping in urban areas
• 1"=400' scale planimetric mapping</td></tr>
<tr><td colspan="2">Scheduled / Actual Completion</td><td colspan="2">• 2014</td></tr>
</table>

C. CITY OF RALEIGH, NORTH CAROLINA

Surdex has updated digital orthoimagery for the City of Raleigh every year since 2002. We are currently in the first year of another five-year contract to update 100% of the City's orthoimagery and 205 of the mapping annually. We used the DMC digital mapping camera to acquire color digital orthophotos at 1"=100' with 0.5' ground pixel resolution. Fully analytical aerial triangulation met all requirements to produce 1"=100' mapping. Surdex updated the 2' DTM and contours, and produced 1,037 tiles of digital orthophotography. Surdex provided a project-wide map that denoted the areas of change as compared to the previous project. Surdex also updated 2' contours and DTM. All photogrammetric mapping products met NMAS for 1"=100' mapping and 2' contours. Originally acquired using film, beginning in 2008 the imagery was acquired digitally. This project required ground control, aerial photography, fully analytical aerial triangulation, change detection, planimetric updates, topographic updates, digital orthophotography.

<table>
<tr><td colspan="2" rowspan="4">Annual Orthophotography and Planimetric Mapping Update for the City of Raleigh, NC</td><th>Point of Contact</th><th>Surdex Project Manager</th></tr>
<tr><td rowspan="3">James Alberque
GIS Manager
City of Raleigh
Information Services Dep't
#1 Exchange Plaza, Suite 807
Raleigh, NC 27602
Tel.: (919) 996-2520
james.alberque@raleighnc.gov</td><td>Wade Williams</td></tr>
<tr><th>Contract Value</th></tr>
<tr><td>$321,000 (2014-2017)</td></tr>
<tr><th>Approximate Square Miles</th><th>Camera</th><th colspan="2">Notes</th></tr>
<tr><td>2,032 orthos annually
40 miles mapping annually</td><td>DMC</td><td colspan="2">100% of city has orthoimagery updated annually
20% of city has planimetric update annually</td></tr>
<tr><td colspan="2">Project Deliverables</td><td colspan="2">• Ground control
• Aerial photography
• Planimetric updates
• 2' Topographic updates
• 6" GPR color digital orthophotography</td></tr>
<tr><td colspan="2">Scheduled / Actual Completion</td><td colspan="2">• 2014</td></tr>
</table>

D. EAST-WEST GATEWAY

This project was for the East-West Gateway and the St. Louis Area Regional Response System (STARRS). Surdex provided 2012 (leaf-off) color digital orthorectified aerial photography of the St. Louis Urban Area at a resolution of 6" and a specified altitude above ground not to exceed 4,800'. This project encompasses approximately 4,503 square miles.

The East-West Gateway and the St. Louis Area Regional Response System (STARRS)intent and objective of this project was develop and implement a regional map for the Enhanced 911 systems in seven counties located in the St. Louis Urban Area plus the City of St. Louis. In addition, the data was shared with a variety of other end users. Surdex has developed a scope of work and services designed specifically to meet the needs of the Council's project.

<table>
<tr><td colspan="4" rowspan="4">East-West Gateway Coordinating Council
7 county base mapping</td><td>Point of Contact</td><td>Surdex Project Manager</td></tr>
<tr><td rowspan="3">Jenny Reiman
GIS Manager
(314) 421-4220
jennifer.reiman@ewgateway.org</td><td>Dan Martin</td></tr>
<tr><td>Contract Value</td></tr>
<tr><td>$600K</td></tr>
<tr><td>Year</td><td>Sensor</td><td>GSD</td><td>Approximate Square Miles</td><td>Acquisition Conditions</td><td>Notes</td></tr>
<tr><td>2012</td><td>DMC-1</td><td>6-inch</td><td>4,503</td><td>Leaf-off (spring 2012)</td><td>Natural color orthoimagery</td></tr>
<tr><td colspan="4">Project Deliverables</td><td colspan="2">• 6" GPR color digital orthophotos at a map scale of 1"=100'
• Use existing LiDAR Digital Elevation Model (DEM)
• Generation of new Digital Elevation Model (DEM) suitable for orthomosaics in areas without LiDAR</td></tr>
<tr><td colspan="4">Subcontractors and Roles</td><td colspan="2">• David Mason & Associates, survey</td></tr>
<tr><td colspan="4">Challenges</td><td colspan="2">• Small amount of reflight due to motion
• Minor delay due to weather; all imagery captured leaf-off</td></tr>
<tr><td colspan="4">Scheduled / Actual Completion</td><td colspan="2">• October 2012 / October 2012</td></tr>
</table>

Note: East-West Gateway is finalizing a similar project for 2015 and the technical committee has recommended to their board that Surdex perform this project as well.

E. MISSOURI LIDAR PARTNERS USACE – ST. LOUIS DISTRICT

Surdex Corporation was contracted through the Corps of Engineers-St. Louis District to provided LiDAR data. This project consisted of LiDAR data collected for 29,000+ sq. miles across Missouri meeting the USGS Specification and the NDEP Guidelines for Digital Elevation data. The project required deliverables that were tested for and met vertical and horizontal accuracy that would support 2' contours. The digital terrain data was hydro-enforced using photographic methods and included breaklines. Partners include: MO NRCS, USGS, MO DNR and others.

Missouri LiDAR Partners USACE – St. Louis District			Point of Contact	Surdex Project Manager
			Ted Stanton, **Tel: 314-331-8389** **U.S. Army Corps of Engineers—St. Louis District** **1222 Spruce Street** **St. Louis, MO 6310**	**Wade Williams** Contract Value **$4.0M**
Year	Sensor	Approximate Square Miles	Acquisition Conditions Notes	
2011 2014	Leica ALS50-II Leica ALS70	29,000+	Vertical Accuracy 18.5 cm (2011 & 2012) 15 cm (2014)	
Project Deliverables			• 6" GPR color digital orthophotos at a map scale of 1"=100' • Use existing LiDAR Digital Elevation Model (DEM) • Collected with 0.7, 1.0 meter average ground point density • Hydrographic data, breaklines were added to the bare-earth LiDAR surface • Bare-earth LiDAR elevation data was provided in LAS & ESRI Grid DEMs	
Scheduled / Actual Completion			• 2011 and 2014	

F. ADAMS COUNTY, IL

Surdex Corporation developed 2' contours from existing LiDAR Data. Surdex flew new imagery this last season and produced 6" ortho imagery county-wide.

Adams County, Orthophotography Project	Point of Contact	Surdex Project Manager
	Joye Baker **Tel: (217) 223-0614** **Email: adamsgis@adams.net** **Adams County, IL** **101 N 54th Street** **Quincy, IL 62301**	**Cornell Rowan** Contract Value **$71,245**

Year	Sensor	GSD	Approximate Square Miles	Acquisition Conditions	Notes
2012	Vexcel	6-inch	5,692.2	Leaf-off (spring 2012)	Natural color orthoimagery

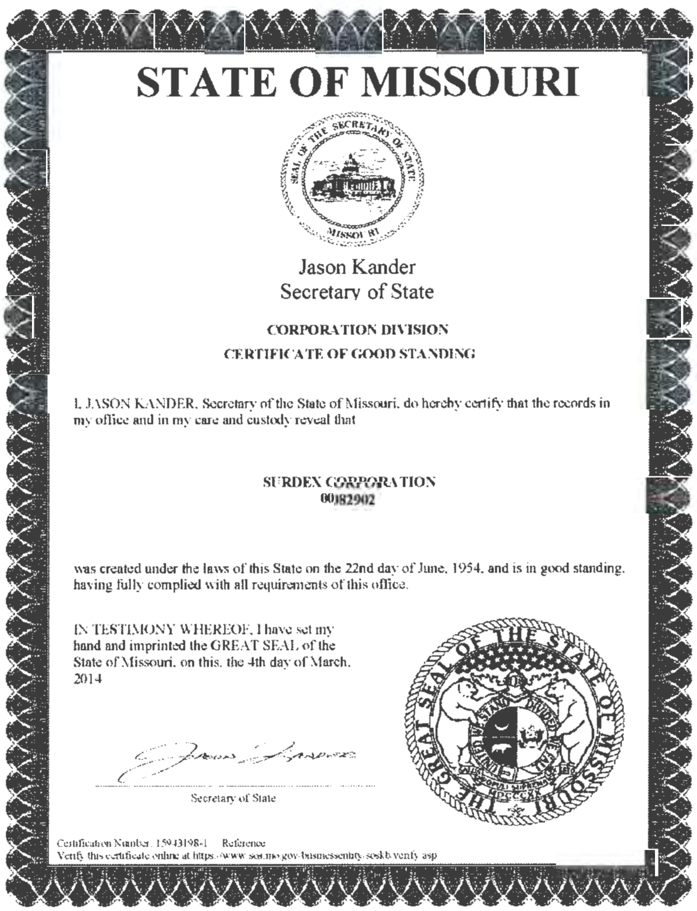
Project Deliverables	• County wide project for all deliverables • 6" GPR color digital orthophotos at a map scale of 1"=100' • Use existing LiDAR Digital Elevation Model (DEM) • Generation of 2' contours from existing LiDAR Data
Challenges	• Flooding issues were overcoming during the flight season
Scheduled / Actual Completion	• October 2012 / September 2013

Section 3: Licenses, Certifications, Accreditation, and/or Permits

Name of Firm	Surdex Corporation
Business Address	520 Spirit of St. Louis Blvd. Chesterfield, MO 63005-1002 United States
Contact	Ron Hoffman, President

3.1 CERTIFICATE OF GOOD STANDING

Missouri Incorporation No.	0082902
Type Ownership	S-Corporation
FEIN	43-0690641
Year Established	Est. 1954, Missouri



STATE OF MISSOURI

Jason Kander
Secretary of State

CORPORATION DIVISION
CERTIFICATE OF GOOD STANDING

I, JASON KANDER, Secretary of the State of Missouri, do hereby certify that the records in my office and in my care and custody reveal that

SURDEX CORPORATION
00082902

was created under the laws of this State on the 22nd day of June, 1954, and is in good standing, having fully complied with all requirements of this office.

IN TESTIMONY WHEREOF, I have set my hand and imprinted the GREAT SEAL of the State of Missouri, on this, the 4th day of March, 2014

Secretary of State

Certification Number: 15943198-1 Reference:
Verify this certificate online at https://www.sos.mo.gov/businessentity/soskb/verify.asp

Section 4: Staffing

Surdex believes that there is no substitute for experience; workers' experience on previous projects, resolving difficulties and streamlining processes, will enable them to apply their knowledge on the project, thereby saving time, avoiding potential problems, and improving quality. We have assigned key technical staff to this project, with an average of 22 years of experience.

Project Staff Experience

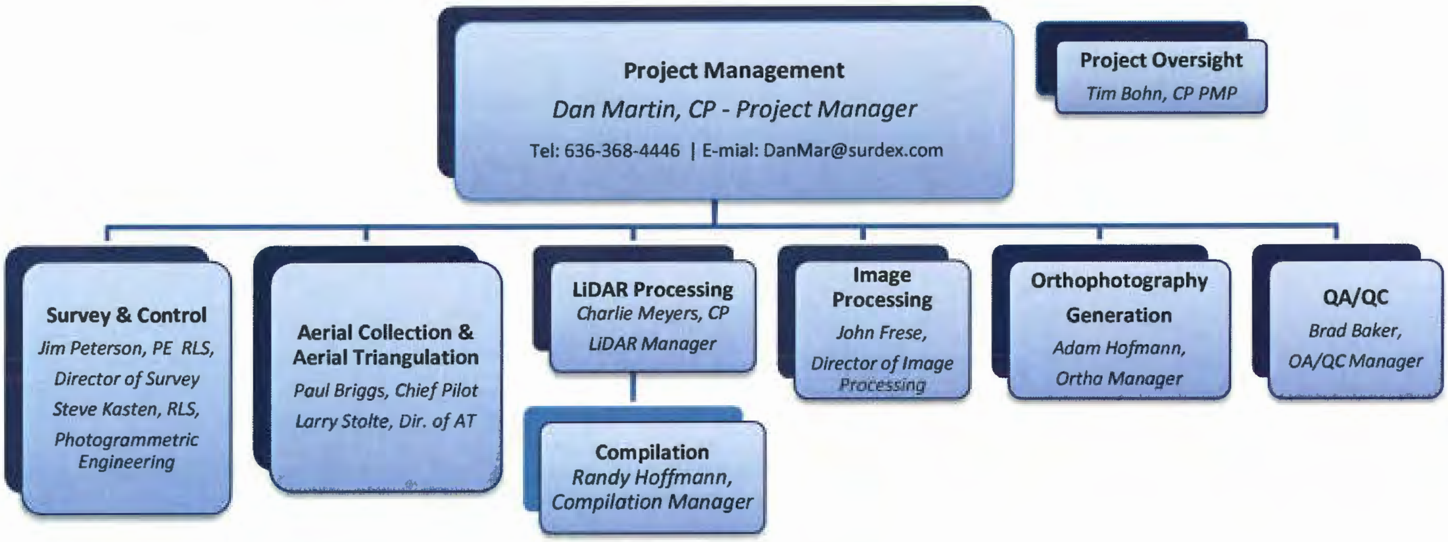
Name	Years Exp.	Role
Dan Martin, CP	14	Project Manager
Jim Peterson, PE, PLS	25	Director of Survey
Steve Kasten, CP, PLS	27	Photogrammetric Control
John Boeding, CP, RLS	27	Senior VP, Operations
Charlie Meyer, CP	18	LiDAR Manager
John Frese	12	Director of Image Processing
Paul Briggs	27	Chief Pilot
Larry Stolte	29	Director of Aerial Triangulation
Brad Barker	15	QA/QC Manager
Adam Hoffmann	8	Digital Orthophotography Manager
Randy Hoffmann	40	Compilation Manager

In addition, Surdex has 10 photogrammetrists certified with the American Society of Photogrammetry and Remote Sensing. The following is a synopsis of these individuals and their certification numbers.

ASPRS Certified Photogrammetrists

Name	Years Experience	Certification/ Registration	Name	Years Experience	Certification/ Registration
Dave Beattie	15	2009, #1417	Scott Merritt	18	2010, #1444
John Boeding, PLS	27	1997, #1043	Charles Meyers	18	2007, #1329
Tim Bohn	19	2002, #1207	Karl North	17	1998, #1122
Steve Kasten, PLS	27	1997, #1040	Cornell Rowan	25	1997, #1055
Dan Martin	14	2012, #1530	Wade Williams	18	2006, #1290

4.1 ORGANIZATION CHART



4.2 RESUMES

Surdex has provided the resumes for the key staff that will work directly on your project.

DAN MARTIN, CP

PROJECT MANAGER

Project Management, Assigned Project Manager

Experience

- **Experience: Professional: 16 years, Company: 4 years**
- **ASPRS Certified Photogrammetrist #1530 (2012)**
- **BS, Cartography and GIS, Salem State College, Massachusetts**
- **Lean Steering Committee Leader**
- **AAIM Supervisory Certification**
- **Project Management Development Training Program**

Cornell oversees assigned projects and manages the scopes of work for various clients. He is responsible for managing As a Project Manager; Dan oversees projects and manages the scopes of work for various clients. He is responsible for managing in-house communications regarding all aspects of project execution including client communication, project planning, surveying, aerial photography acquisition, scanning, aerial triangulation, LiDAR processing, planimetric/topographic feature collection and digital ortho-imagery production. Dan has vast experience with the oversight and management of many various sized digital imagery projects. He has worked as the operations manager on projects outside of the United States. Working on the Lean Steering Committee, Dan works as part of a geospatial solutions team, and has been instrumental in the reengineering of production workflows for efficiency and productivity gains.

JOHN BOEDING, CP

SENIOR VICE PRESIDENT, PRODUCTION AND OPERATIONS

Operations/Production

Experience

- **Experience: Professional: 27 years, Company: 27 years**
- **BS, Cartography/Mapping Technology, Southwest Missouri State University**
- **Professional Photogrammetric Land Surveyor: South Carolina, North Carolina, Virginia, Oregon**
- **ASPRS Certified Photogrammetrist #1043 (1997)**
- **American Society for Photogrammetry and Remote Sensing**
- **Society of American Military Engineers**
- **American Society of Quality**
- **Adoption of ISO 9000 Quality Assurance Standards**

As senior vice president of production and operations for Surdex Corporation, John directly supervises and coordinates all phases of production of every project. He is responsible for survey; aerial photography; fully analytical aerial triangulation (FAAT); stereo mapping; digital imaging; systems management; GIS and GIS data conversion; estimating; and R&D. John also is responsible for resource allocation and scheduling. He uses Microsoft Project software to track resources and progress of each project, including equipment, personnel and cost. John personally reviews quality control reports after each phase of a project, including flight, survey, triangulation, photo lab, digital mapping, digital imaging and GIS development. John has been instrumental in Surdex's adaptation of ISO 9000 Quality Assurance Standards. He builds the corporate environment for quality, maintains the procedures manual and evaluates suggestions for continuous improvement. He provides a single point of contact for all departments and is an information hub for crews in the field. He works closely with the project manager to assure clients' needs are met for every project.

PAUL BRIGGS

CHIEF PILOT

Flight Operations

Experience

- **Experience: Professional: 27 years, Company 1 year**
- **Bachelor of University Studies, Aviation, Broadcasting and Music, 1987, Minot State University North Dakota**
- **FAA ATP Airline Transport Pilot – AMEL**
- **FAA Commercial Pilot, Instrument Pilot – ASEL**
- **FAA Class 1 Medical**
- **FCC Radio Telephone Operators Permit**
- **F27 Type Rating**

As Chief Pilot, Paul is responsible managing pilots and working closely with our aerial photographers as well as the safe operation of the firms aircraft on each aerial capture mission. Paul is engaged in the pre-flight planning preparations that include monitoring the weather conditions, review of aerial flight plans for LiDAR and photography capture, adherence to overall project specifications, proper equipment and material handling procedures, pre- and post-flight status reporting, and all FAA notices and air space designations along with any notices to airmen.

JIM PETERSON II, PE, PLS

DIRECTOR OF SURVEY

Director of Survey / UAS Technologies

Experience:

- **Experience: Professional: 25 years, Company 1 year**
- **ASPRS Certified Photogrammetrist, able to sit**
- **Professional Engineer (PE): IL #50712; MO #27630; AR #49438**
- **Professional Land Surveyor (PLS): MO #2732; IL: #035-003397; AZ: #50505**
- **BS, Civil Engineering, University of Missouri Rolla**
- **MS, Civil Engineering, Southern Illinois University Edwardsville**
- **PhD., GeoSpatial: Geological Engineering, University of Missouri Rolla**

James has over 25 years' experience in engineering, construction, mining, materials, surveying, mapping, GIS, and geospatial. Professional Engineer and Land Surveyor in Illinois, Missouri and Arizona. He recently completed his Ph.D. dissertation from Missouri University of Science and Technology.

Professional Organizations

- Engineers Club of St. Louis
- Illinois Society of Professional Engineers
- American Society for Photogrammetry and Remote Sensing
- Illinois Professional Land Surveyors Association
- Missouri Society of Professional Land Surveyors

STEVE KASTEN, PLS, CP

VICE PRESIDENT, SURVEY AND PHOTOGRAMMETRIC ENGINEERING

Project Design

Experience:

- **Experience: Professional: 27 years, Company: 10 years**
- **BS, Earth Science and Cartography, Purdue University**
- **MS, Civil Engineering & Photogrammetry, Southern University Edwardsville, Illinois**
- **ASPRS Certified Photogrammetrist #1040 (1997)**
- **Missouri Society of Professional Land Surveyors**
- **The Society of American Engineers**
- **Professional Photogrammetric Land Surveyor: South Carolina, North Carolina, Virginia, Oregon**
- **Florida Professional Surveyor and Mapper**

Steve has over two decades of experience in the fields of photogrammetric engineering application development, photogrammetric mapping, geodesy, cartography and surveying. While at Surdex, Steve has performed disparate duties that include the management of photogrammetric projects, airborne GPS survey data and triangulation. In addition to his extensive project management experience, Steve has experience providing direct photogrammetric engineering support services. He is skilled in developing algorithms for sensor modeling, post processing of GPS data, error propagation, photogrammetric data reduction, and implementing algorithms into engineering programs such as C and FORTRAN on Unix or DOS platforms. In addition, he has developed an aerial SAR sensor mathematical model, engineering triangulation software and performed the geopositioning performance assessment of aerial SAR sensor systems.

CHARLIE MEYERS, CP

LIDAR MANAGER / LIDAR PROCESSING

LiDAR Processing and Production

Experience:

- **Experience: Professional: 18 years, Company: 18 years**
- **BS, Geography and Geology, Southwest Missouri State**
- **ASPRS Certified Photogrammetrist, 2007 #1329**
- **AAIM Supervisory Certification Training**
- **NovAtel on GrafNav and GrafNet processing**
- **Leica on IPAS Pro and IPAS-TC processing**
- **Tazmoe on LiDAR line to line calibration processing**
- **MS, Resource Planning, Southwest Missouri State**

Applicable Experience: As LiDAR Data Manager, Charlie is responsible for all phases of LiDAR processing and ancillary production. He has intimate knowledge of the entire LiDAR project life cycle which includes planning, acquisition, ABGPS/IMU processing, initial LiDAR processing, classification and edit. Charlie is well versed with the TerraSolid Suite of LiDAR processing software and GeoCue's data management system. In addition to traditional processing and classification, Charlie's responsibilities include processing and production of Digital Elevation Models (DEM), Digital Surface Models (DSM). Charlie is also experienced with MicroStation, software packages from his previous photogrammetric mapping responsibilities.

LARRY STOLTE

DIRECTOR OF AERIAL TRIANGULATION

Aerial Triangulation

Experience

- **Experience: Professional: 29 years, Company: 29 years**
- **U.S. Army Electronic School**

Larry has over 14 years of direct experience performing Fully Analytical Aerial Triangulation (FAAT) and photogrammetric services. Larry has a unique blend of experience that allows him to accurately and adequately evaluate and process each FAAT challenge. He is a highly qualified and experienced stereocompiler. He has compiled using first and second order analog and analytical instruments. Larry lends his expertise to the stereo compilation department by performing quality assurance verification checks, inspections, and troubleshooting model setup problems. As Manager of Fully Analytical Aerial Triangulation, he retains complete knowledge of the interrelationships between flight parameters, survey layout and field crew coordination, as well as a thorough knowledge of the challenges associated with each specialty. Larry personally evaluates each FAAT solution, producing the final reports for QC verification and approval. His unique experience in compiling, surveying, film processing and diapositive inspection supplement his ability to precisely determine the cause of FAAT anomalies and eliminate them from future occurrences where possible.

JOHN FRESE

DIRECTOR OF IMAGE PROCESSING

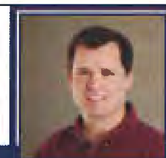
Image Processing

Experience

- **Experience Professional: 20 years, Company: 12 years**
- **Bachelor of Arts, Northwestern University, Illinois**

John manages the Image Processing department. His team handles all image scanning and processing as well as inspection of digital imagery. John has been overseeing the production of digital imagery for some of the company's largest and most challenging projects for the past nine years.

ADAM HOFFMANN



DIGITAL ORTHOPHOTOGRAPHY MANAGER

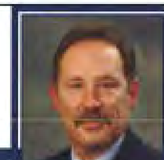
Digital Orthophotography

Experience

- **Experience: Professional: 18 years, Company: 8 years**
- **BFA, Graphic Design, Maryville University in St. Louis**

Adam has four years of experience as the Digital Ortho Manager. He is responsible for the department's activities involved in the production of high-end digital ortho imagery. These activities include orthorectification, radiometric balancing, cutline placement, Quality Control and final preparation and packaging of digital orthoimage data products.

RANDY HOFFMANN



STEREO COMPILATION MANAGER

Stereo Compilation (DEM)

Experience

- **Experience: Professional: 40 years, Company: 40 years**
- **BS, Forestry, Photogrammetry and Remote Sensing, University of Missouri**

Randy has experience in all phases of photogrammetry, giving him an exceptional ability to coordinate and lead the stereo department. He has served as an aerial photographer, operating a variety of precision aerial cameras. Randy has been the stereo compilation manager for over 10 years. He oversees all shifts of stereo compilers, and he meticulously reviews each project for accuracy, completeness and adherence to the digital specifications. Randy has a wealth of experience managing all types of projects ranging in scope from detailed engineering-scale topographic maps to planning-scale DEM modeling for orthophotography. He has directly supervised and assured the successful completion of hundreds of projects. His experience includes DTM production and verification including modifying existing DEMs to produce quality orthoimagery.

BRAD BARKER

QA/QC MANAGER

Project Quality Assurance and Control

Experience

- **Experience: Professional: 15 years, Company: 15 years**
- **BS, Cartography and Map Technology, Southwest Missouri State University**

Brad's primary responsibilities include cartographic finishing and design of geographic information system database conversion applications to support CAD/GIS database generation. Brad is also responsible for digital orthophoto and CAD production including data input, editing and plotting. Brad has expertise in CAD/GIS programs including the full ESRI suite of software products that include ArcGIS and ArcIMS. He also has expertise with MicroStation and ImageStation (orthophoto software).

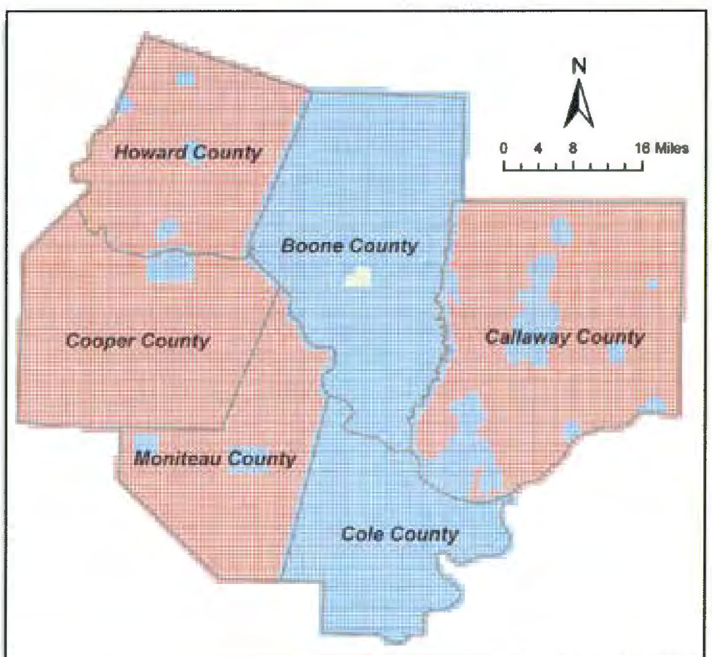
Section 5: Methodology of Performance

5.1 ITEM I – ORTHOPHOTOGRAPHY

5.1.1 PROJECT UNDERSTANDING

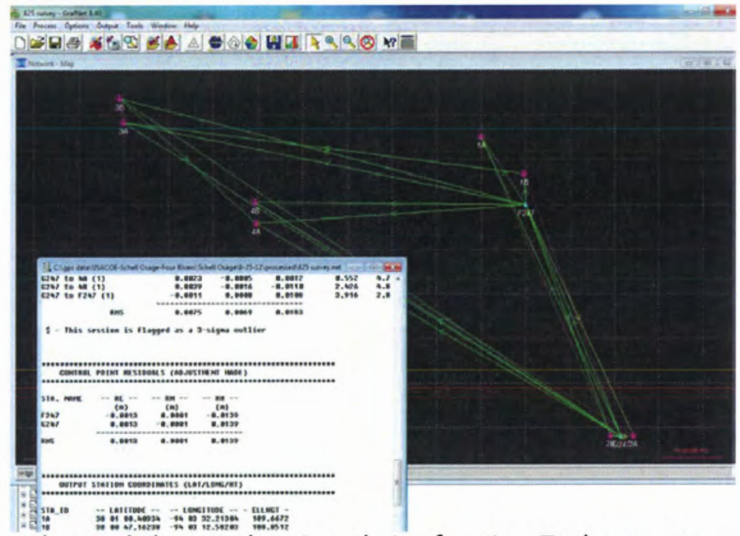
The following graphic and table presents our understanding of the orthophotography portions of the project. For the most part, each county will be flown at the dominant resolution with higher/lower resolution sub areas flown separately.

Summary of Orthophotography Requirements		
Resolution	Areas	Approximate Area
3" GSD	University of Missouri, Columbia	4.8 sq mi
6" GSD	Boone County	1,340 sq mi
	Cole County	
	Howard County (partial)	
	Callaway County (partial)	
	Cooper County (partial)	
	Moniteau County (partial)	
12" GSD	Howard County	2,287 sq mi
	Cooper County	
	Moniteau County	
	Callaway County	



5.1.2 GROUND SURVEY OPERATIONS

GPS data reduction using GrafNet Software.



All Survey operations will be conducted under the supervision of a Registered Land Surveyor in the State of Missouri.

Post processing of the GPS data will be performed with the GrafNet software from Waypoint Consulting. This software allows for the input of the raw GPS data and ground control points. The survey technicians will perform a free-net adjustment on a daily basis to assure the accuracy and consistency of the field data. This process controls the GPS data on one control point. Once all the data has been run through the free-net adjustment, a constrained adjustment will be performed. Analysis will be performed to assess the accuracy of the field data and its consistency with the control. Outliers will be removed from the solution. The resultant coordinates and their control values will be output and passed along to the triangulation function. To document the survey process a ground control survey report will be generated and provided.

Our Team will employ both photo-identifiable points as well as paneled targets for this project. We will work with the participating entities to coordinate the placement and number of ground control points. All datasets will be provided in Missouri State Plane Central Zone Coordinate System, NAD83, US Feet.

Ground survey operations.

All ground survey operations for the project will be furnished by Surdex and David Mason & Associates. In brief summary:

- All adjustments will be made in the project reference frames.
- A control diagram will be furnished for all survey points utilized on this effort. This will include point positions and observed baselines designating beginning and ending points.
- A least squares adjustment will be performed for all control points. Output to be furnished will include results of the constrained and unconstrained adjustment. This will include fixed coordinates and adjusted coordinates in U.S. Feet, error ellipse values in Meters, relative baseline error ellipses in Meters, precision of the observed baselines in ppm, and redundancy expressed as degrees of freedom. All information will be referenced to field notebooks.

- All field notes and observation logs will be neatly kept and indexed. This includes notes pertaining to the establishment and/or extension of control. For recovered points, information on the condition of each point will be provided in the notes. The observation logs for each point will include all information pertinent to the recovery and observations required for reduction.

5.1.3 IMAGERY ACQUISITION APPROACH

Surdex is widely acknowledged by both our clients and our colleagues as having a well-earned reputation for successful and timely acquisition of the imagery – the most critical phase of a project. We have a robust approach that emphasizes coordination between our staff and our clients as well as optimal balancing of our resources to ensure this phase is correctly executed. Although in many cases we use our own aircraft and sensors, we have coordinated efforts as large as a dozen subcontractor aircraft for a single project.

Surdex's Acquisition Approach

Feature	Benefit
Strong coordination with the client: (1) Start and stop acquisition timeframe. (2) Movement to/from the project area. (3) Adherence to client specifications on window, sun angle, etc.	Clients are always aware of our presence on their project.
Coordination with FAA and military operations centers if required. Surdex has successfully operated in some of the most highly sensitive airspaces in the US and Canada.	Assure clients of trouble-free access to restricted or military operations areas.
Monitoring of short and long term weather: (1) Use of weather resources. (2) Enterprise database retains weather reports at each project site during each acquisition window.	Achieves optimal utilization of resources to ensure success for all projects.
Near real-time reporting of status – acquisition and results of inspection.	Clients continuously aware of their project's progress.
Minimize the acquisition window length – oftentimes by putting multiple aircraft on the project. This minimizes the affects of weather and climate on image appearance.	Highest possible image quality across the entire project.
Our large fleet of aircraft and sensors	Ability to handle numerous projects across North America.
Our Enterprise database tracks all acquisition and inspection status: (1) Real-time tracking of our aircraft to monitor acquisition operations. (2) Flight plans updated daily. (3) Re-flights prioritized to ensure minimal time difference. (4) Daily issuance of status.	Maximum application of resources to ensure success.

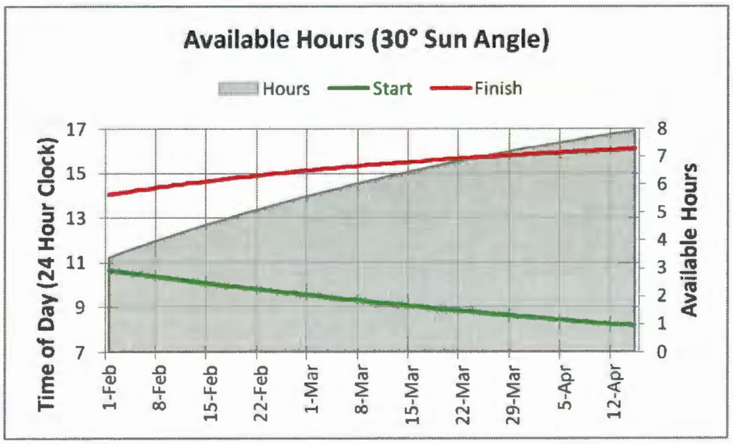
The following table summarizes the parameters, guidelines, and specifications for the project during the acquisition phase. Deviations from the specifications found during image inspection will be brought to the attention of the client as soon as they are detected to determine if a re-flight is required.

Orthoimagery Acquisition Specifications

Parameter/Specification	Value	Comment
Vegetation conditions	Leaf-off	
Acquisition season	February through mid-April, 2015	After first freeze and before spring leafing out.
Maximum sun angle	30°	
Cloud/cloud shadow cover	Less than 5% of project area.	
Ground conditions	Free of smoke Free of haze Free of standing water Free of ice and snow Free of excessive flooding (other than customary seasonal flooding)	May be cause for rejection – at discretion of client.
Specular reflection	Allowed provided alternative views of area available from overlapping imagery	May be cause for rejection – at discretion of client.
Forward overlap	Not applicable to the ADS100 pushbroom system	The ADS100 continuously collects imagery from the forward, aft, and nadir arrays
Side overlap	30% ± 5%	May be cause for rejection – at discretion of client.
Flight altitude	Planned ± 10%	May be cause for rejection – at discretion of client.

Varying to some degree by the latitude of the project area, the daylight is shortest at the Winter Solstice (December 21st) and the days longest at the Summer Solstice (June 21st). The following graphic portrays the acquisition period for the project against the start and finish times each day (governed by the minimum allowable sun angle) and the available "solar" acquisition hours each day. There are approximately 442 hours over the 74 days from 1 February through 15 April, 2015.

Available imagery acquisition hours for the project.



Before each acquisition day, a number of activities are undertaken by the aircrew:

- Aircraft, ABGPS, IMU, and camera are all inspected for proper operation.
- Final weather checks are made.
- Up-to-date flight plans are downloaded and reviewed.
- Flight plans are filed with the local airport/FAA.
- If required, base stations are setup.

At the end of each acquisition day:

- Aircraft, ABGPS, IMU, and camera are all inspected for proper operation.
- Aircraft flight logs are completed.
- Flight reports, in Surdex format, are completed.
- If necessary, imagery and data transferred from on-board storage to "transfer" hard drives.
- If appropriate, transfer drives are shipped priority overnight to the production center.
- Flight logs are emailed or faxed to the production center.

The results of each day's effort are used at the production center to update flight plans for the next day. Not only are the acquisition results used to modify the next flight plan, but results of inspection are combined to form a complete view of the acquisition status.

Surdex maintains a flight report for each mission that is used by the production center to appraise the results. For example, if extreme turbulence or cloud cover is cited by the aircrew for specific areas of the acquisition, prioritized attention is paid to these areas by the inspectors.

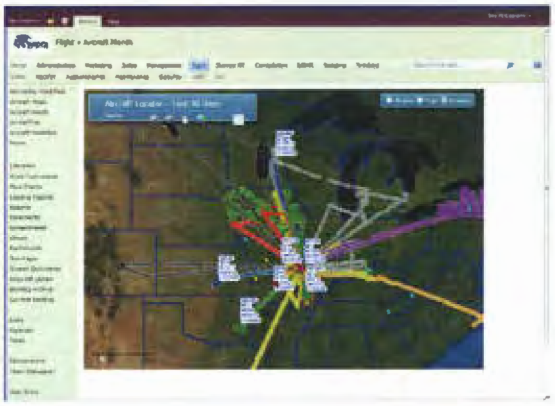
For flights involving restricted airspaces and/or Military Operations Areas (MOAs), extreme coordination with the Air Traffic Control centers and often military operations centers is required. In such cases, Surdex proactively provides the necessary information, including flight plans, to the proper authorities to ensure trouble-free access to the areas. Surdex has performed acquisition in and around highly sensitive airspaces, such as White Sands Missile Range (New Mexico), Nellis Air Force Base (Nevada), and the Washington, DC ADIZ (Air Defense Identification Zone). Experience has shown that high degrees of communication and adherence to directives results in long term success. In some cases, this has even required the presence of a government official on the aircraft.

It is critical to collect ABGPS/IMU data with the highest possible integrity, taking into account such factors as:

- Operation of base stations to maintain a reasonable distance from the aircraft to the base stations.
- Avoiding IMU drift by limiting the length of lines – generally less than 30 minutes.
- Using CORS (Continuously Operating Reference Stations) and/or local GPS reference networks to provide multiple observations.

Each of Surdex's aircraft is equipped with the Skytracker instrumentation that uses GPS to continuously report the position, airspeed, and altitude of the aircraft. Unlike flight tracking systems such as Flight Aware that only have access to aircraft operating under IFR (Instrument Flight Rules) or filed VFR (Visual Flight Rules) positioning, as long as the aircraft is powered up, Skytracker is reporting the status. Surdex has customized internal applications that allow the viewing of the aircraft status in various ways.

Surdex's internal Sharepoint site continuously tracks our aircraft.



5.1.4 THE LEICA ADS100 DIGITAL CAMERA

The ADS100 is the newest generation of Leica's line scanner (pushbroom) digital cameras. Delivered in July, 2013, Surdex's first two ADS100's were the first installed, integrated, and tested in the United States. Two additional ADS100's were purchased in late 2013. Based on the same fundamental architecture as the preceding ADS40 and ADS80 models, this camera is an improvement in virtually every regard.

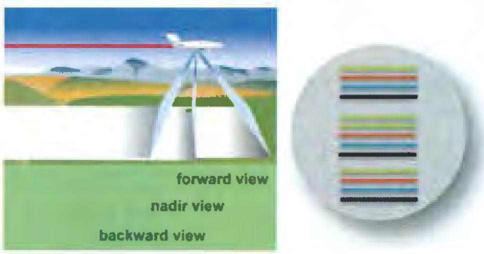
Features and Benefits of the ADS100

Feature	Benefit
20,000 pixels wide at nadir – largest swath of any digital sensor used today	Reduced acquisition effort Fewer resources required for large projects
Smallest pixel size (5um) of any sensor used today, allowing an increase in acquisition altitude	Reduced flight time in rugged terrain (fewer line breaks required) Operates above numerous problematic airspaces
Acquisition of all spectral bands at full resolution – pan-sharpening is not used	Sharp feature detail and imagery devoid of blooming and smearing caused by pan-sharpening utilized by virtually every frame-format camera.
Time-Delayed-Integration (TDI) image motion compensation for the first time in a pushbroom system: (1) Reduces integration/cycle time (2) Increases sensitivity (3) Increases airspeeds	Improved acquisition performance Higher image quality
With the telecentric lens design: (1) Image rays strike focal plane perpendicular to focal plane (2) Consistent response across entire array	No fall-off at edges of format as with conventional frame-format film and digital systems Easier to match color and tone with adjoining strips
Nadir, forward, back arrays have full color and near infrared	Improved stereoscopic viewing and exploitation
Superior stereoscopic geometry: (1) Best base-to-height ratio (0.8) of any sensor on the market – 33% better than traditional film mapping cameras (2) Superb horizontal and vertical accuracy	Superior accuracy for digital orthophotos and topographic mapping
Discrete (non-overlapping) spectral bands	Vibrant colors

	Robust natural color and color infrared Superior remote sensing application
Benefits of the pushbroom approach: (1) Near-nadir views of ground features (2) Fewer seamlines required in mosaicking process (3) Continuous stereoscopic imaging using the forward and aft arrays	Substantially less building lean Reduced production effort Reduced QC effort Unlike frame-format cameras, full stereoscopic coverage along the flight direction in rugged terrain

The following figures portray the imaging geometry of the ADS100. All arrays in the forward, nadir, and back configurations are collected simultaneously, providing alternative views of the ground scene and generating stereoscopic views.

ADS100 imaging operations (*Courtesy Leica Geosystems*).



Array	Bands	From Nadir	FOV	Pixels
Forward	RGBN	25.6°	65.2°	16,000
Nadir	RGGBN	0°	77.3°	20,000
Backward	RGBN	17.7°	72.5°	18,000

Pushbroom systems present the optimal imaging geometry for digital orthophotos. With the image displacement only varying across the format – and not radial from the center as with frame-format film and digital cameras – the amount of building/structural lean in the final product is dramatically reduced. Additionally, the "pixel carpet" acquired by the ADS100 substantially reduces the amount of seamlines required to mosaic the orthophotos together. This reduces and simplifies the production effort involved in the minimizing of artifacts surrounding seamlines. Correspondingly, the orthophoto QC effort is reduced since fewer seamlines need to be validated.

With each band (R,G,B,NIR) in each array collecting at full resolution, features imaged by the ADS100 are sharp and do not exhibit the blooming and smearing attributed to the pan-sharpening approach taken by virtually every large-format digital frame camera on the market today. This enhances interpretation and results in an aesthetically pleasing rendition of color.

ADS100 Installation in a Surdex Cessna 441 (Conquest) Aircraft.

The following tables summarize the details of the ADS100 system and sample flying heights for common Ground Sample Distances (GSD).

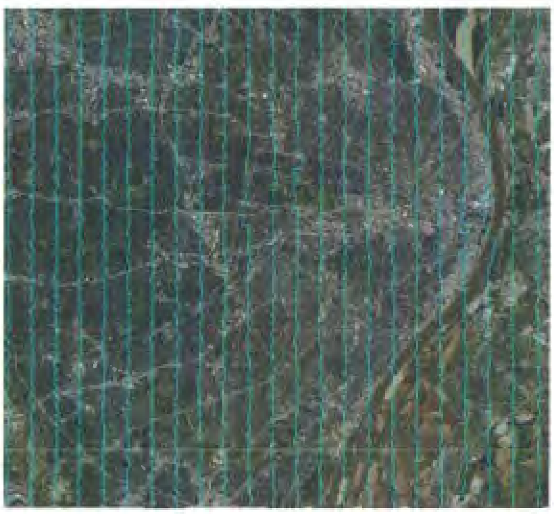
ADS100 Specifications

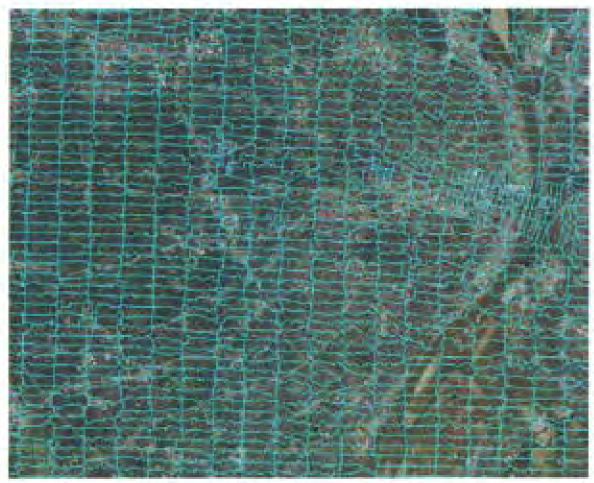
Parameter	Leica ADS100
Sensor Type	Pushbroom
Pan-sharpening	N/A
Cross-track pixels	Forward: 16,000 Nadir: 20,000 Backward: 18,000
Focal length	62.5 mm
F-number	f4
Pixel size	5.0 um
Pixel registration accuracy	1 um
Integration time	≥0.5 ms
Height:GSD ratio	12,500:1
Cross-track field of view (FOV)	77.3°
Along-track field of view (FOV)	Fwd: 25.6° Back: 17.7° Stereo: 43.3°
B/H Ratio	0.80 (Traditional film cameras: 0.6)
Radiometric resolution	14 bits/pixel
Imaging R= red G = green B = blue N = near infrared	13 Arrays: Fwd: RGBN Nadir: RGGBN Back: RGBN
Radiometric response (nm): Red Green Blue Near Infrared (NIR)	 619-651 525-585 435-495 808-882

ADS100 Flying Heights		
GSD		Flying Height (AGL)
3"	7.5cm	3,125'
6"	15cm	6,250'
1'	30cm	12,500'
2'	60cm	25,000'
2.6'	90cm	33,000'

Mosaicking of the ADS100 pushbroom image data is reduced in comparison to frame imagery due to the continuous swath of data collected: seamlines are primarily required only on the edges of the image swath. The following graphic shows ADS seamlines compared to the seamlines required for the DMC-1 covering the same project area (St. Louis, 2012, 6-inch GSD). *The linear miles of ADS seamlines is 1/10th that of the DMC-1 for this project.*

ADS Seamlines (left) compared to DMC-1 seamlines (St. Louis Area, 2012, 6-inch GSD).





Another distinct advantage of the pushbroom technology offered by the ADS100 is that a very large number of features are imaged in a near-nadir fashion. This is because features are only displaced to the left and right of the center of the flight path and not in the in-flight (downtrack) direction. This is not true of frame-format digital sensors, where displacement is radial in all directions from the center of the image. With nadir views of many elevated features, there is little (and sometimes no) need to create a DSM.

Image of bridge (left) and underlying DEM (right), demonstrating that with pushbroom technology elevated features do not always require localized elevation models to ensure proper treatment. Notice that the DEM does not include the railroad bridge.


Using a calibration range near our headquarters, each ADS100 is "bore-sighted" to determine the alignment and position of the sensor with respect to the GPS antenna and Inertial Measurement Unit (IMU). Flight lines are designed to limit the operation of the ABGPS/IMU within 20-30 minutes during on-line acquisition. ABGPS/IMU information is collected at fine intervals that support the derivation of sensor attitude and position for each line that is acquired. The automatic exposure mechanism is monitored by the sensor operator to avoid over-reaction to ground scenes that bias the settings for the project area. At the end of each day, aircrews transfer data from the on-board mass memory unit to hard drives which are shipped overnight to Surdex's production center.

During post-processing, the ABGPS/IMU data is used to construct images for the forward, nadir, and backward arrays. For each "line" captured by each array, a position and orientation is generated for each line and, correspondingly, to each pixel in each line. By stacking the lines together in order of acquisition, a pixel carpet is generated for each color. By combining the pixel carpets for each array, a complete 4-band pixel carpet from the forward, nadir, and backward views is constructed. During the post-processing, absolute radiometric and geometric calibration are automatically applied, including registration of the bands of each array with one another.

The Leica XPro software handles all image processing, aerotriangulation, orthorectification etc. This highly efficient software operates in a distributed processing environment. Features of the software include automated handing of atmospheric and BRDF (Bi-directional Reflectance Distribution Function) in a manner that minimizes the need to create intermediate image files. For example, even raw orthophotos can be reviewed without writing the files to disk until all adjustments are made.

The aerotriangulation of the ADS100 imagery is analogous to frame format imagery: points are collected in the overlap of the arrays down the flight line (pass points), points in the overlap with arrays from the adjacent line (tie points), and the measurement of control. During the aerotriangulation process, the ABGPS/IMU "trajectory" is corrected to achieve absolute accuracy.

Surdex uses the standard Leica workflow to capture and process the GPS & IMU data. ADS100 carries the Novatel SPAN GPS/GNNS inertial navigation system in the aircraft. Surdex uses Trimble R8 model receivers to collect ground base station GPS and GLONASS data during each flight. The position of the ADS100 sensor and the GPS antenna are measured within the coordinate system defined by the central axis of airplane. These measurements along with the GPS and IMU data captured on each flight are processed using Leica IPAS TC software. Leica IPAS produces a differential solution for the airborne positions and attitude more than a hundred times a second for the duration of the flight. As the Leica ADS100 is a line scanner there are no individual stations, but rather a stream of epochs or fixes are produced at a rate of 128 per second. Only during aerial triangulation are discrete fixes calculated at a spacing dictated by image measurement density.

5.1.5 SURDEX'S AIRCRAFT

Surdex is widely regarded by clients and colleagues as one of the premier aerial acquisition companies in North America. These accolades originate with the ownership of the company – three of whom are licensed pilots. It also comes from the pragmatic view that it is the most critical phase of any project we undertake.

The makeup of our fleet of aircraft is based on:

- Ability to host each of our aerial data acquisition instruments (film, digital, and LiDAR).
- All aircraft are made by the same manufacturer (Cessna) to standardize maintenance and operation.
- A mix of slower/lower and faster/higher aircraft to address our versatile acquisition equipment and projects.

Surdex's Acquisition Aircraft			
Four (4) Cessna 441 Conquest II-10 With RVSM*	Twin-Turbine Pressurized	Flight Range: 2,193 nm Altitude: 1,200 –35,000 AGL Certified Altitude: 35,000 MSL Approximate Cruise Speed: 310 knots	
Cessna 414A Chancellor III	Twin-Piston Pressurized	Flight Range: 900 nm Altitude: 1,200 –25,000 AGL Certified Altitude: 30,200 MSL Approximate Cruise Speed: 235knots	
Cessna 335 II	Twin-Piston	Flight Range: 928 nm Altitude: 1,200 –18,000 AGL Certified Altitude: 26,800 MSL Approximate Cruise Speed: 215 knots	
Two (2) Cessna TU-206F Turbo Stationair	Single-Engine	Flight Range: 720 nm Altitude: 1,000-10,000 AGL Certified Altitude: 26,300 MSL Approximate Cruise Speed: 148 knots	

** RVSM: Reduced Vertical Separation Module. This FAA-certified equipment allows operation above 28,000' (MSL).*

The Cessna 441 (Conquest) aircraft are the highest performance and most versatile aircraft in the fleet for imagery acquisition operations. They can host all of Surdex's imaging systems and can fly nearly as slow as our smaller aircraft as well as being the fastest in our fleet. Most importantly, the RVSM equipment and advanced radar allow us to ferry it safely at night, while most piston aircraft are ferried during daylight hours. For high-altitude projects such as the USDA National Agriculture Imagery Program effort, its superior endurance (up to 7 hours aloft), high airspeed (300+ knots), and ceiling (35,000' MSL) make it the ideal aircraft. With its ability to quickly move across the country, the Conquests often handle the widely diverse projects during the hectic spring flying season.

The Cessna 414 and 335 aircraft are well-suited for higher-resolution image acquisition as well as LiDAR acquisition. The Cessna 206 aircraft both host the LiDAR equipment as well as our Leica RCD30 Oblique Camera systems in 5-head and 3-head versions.

Our aircraft are housed in our 30,000 square feet hangar at Spirit of St. Louis Airport, only blocks from Surdex's headquarters in the St. Louis area. With our centralized position, we can efficiently handle projects throughout North America.

Surdex has a full-time aircraft maintenance staff licensed for A&P (Aircraft and Powerplant) with Inspection Authorization (IA) to support our fleet. This staff is qualified and licensed to perform FAA-mandated inspections, maintenance, and repair. Thus, we are not reliant on the schedule and cost of third parties. We have even transported maintenance personnel to project areas to perform inspection, maintenance, or repair in the field.

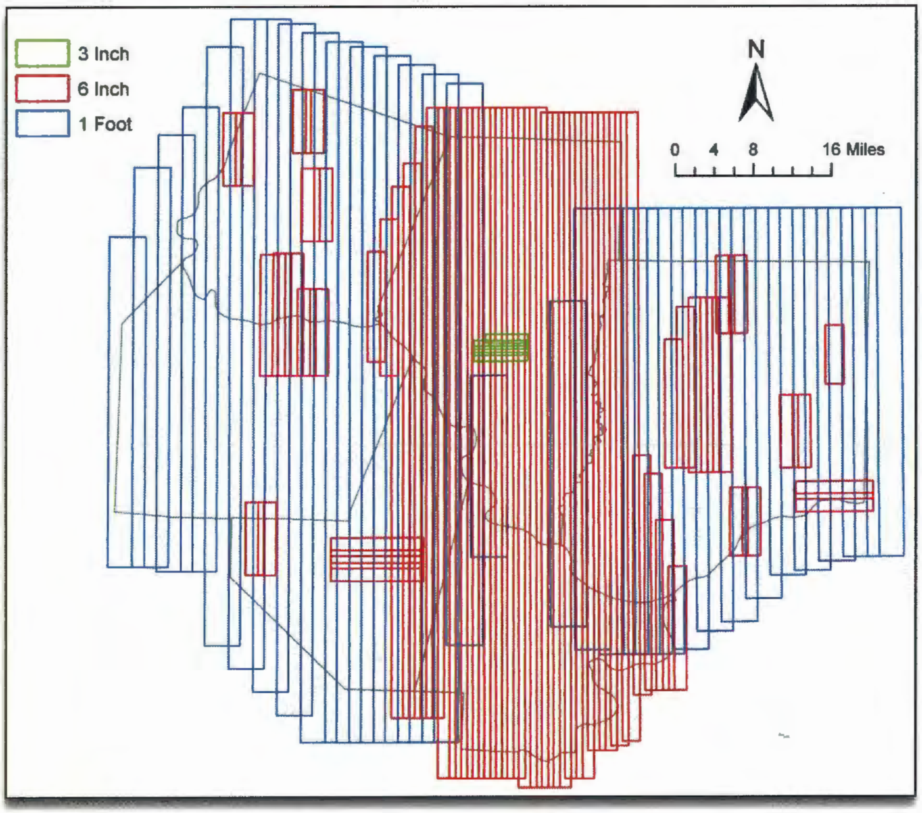
5.1.6 PROJECT DESIGN

The design of a project includes the key parameters of:

- The project boundary, defined by deliverable orthophoto tiles.
- A ground control point design.
- The flight design.

Surdex performs and initial design of the project and submits it for review by the client. In most cases, this is the subject of discussion at a Project Kick-Off Meeting. Once refined to the final design, all ground and aerial data collection follows this plan throughout the project. The design can be documented with shapefiles and/or map plots.

Flight design addressing the diverse resolutions in the project area.



The flight design for this project requires some creativity to economize the imagery acquisition over the diverse areas at varying resolutions. Our approach is as follows:

- Approximately the central one-third of the project will be flown at 6" GSD, covering both required 6" and 1' GSD areas.
- The eastern and western one-thirds of the project will be flown at 1' GSD with overflights at 6" GSD to address the pockets of higher-resolution imagery.
- The 3" GSD area is flown on top of the 6" GSD area in Boone County.

The following table presents preliminary estimates for the key factors.

Flight Design Overview

Resolution	Flight Lines	Flight Line Miles (FLM)	On-Line Hours
3"	4	13.2	0.6
6"	57	1,573.8	15.7
12"	24	1,064.5	7.2
TOTALS	85	2,651.5	23.5

Our experience indicates that we average approximately 4 flight hours per day. With 23.5 hours required, this amounts to approximately 6 days of flight for a single aircraft.

5.1.7 IMAGERY INSPECTION

Surdex performs 100% imagery inspection for each project – every single image is visually reviewed, graded, and the results stored in our Enterprise database. This is performed as quickly as possible and involves minimal image processing so as not to delay the process. The results of the inspection update the acquisition status in real-time. For example, an image failing inspection is automatically queued for re-flight and incorporated into the next version of the flight plans.

Inputs into the imagery inspection step include:

- The imagery itself.
- Flight reports.
- ABGPS/IMU data.
- Flight plans.

Surdex's Imagery Inspection Approach

Inspection Point	Benefit
Visual inspection for: (1) Against specifications for conditions such as cloud cover, standing water, smoke, haze, etc. (2) Delineation of specular reflection. (3) General quality of imagery. (4) Image artifacts. (5) Camera misfire.	Human eyes can quickly and accuracy discern issues, artifacts, etc. that cannot be confidently automated.
Processing and verification of ABGPS and IMU data for integrity and accuracy.	Assurance of project accuracy.
Automated checking of information against the flight plans, including position and altitude of each image.	Verification of as-flown against flight design.
Automated verification of date/time against seasonal window and acquisition specifications (such as sun angle, time-of-day, etc.)	Verification against temporal specifications.
Automated checking for crab, tilt, etc.	Verification against acquisition specifications.

Inspection failures are not always cut-and-dry and may include subjective decisions involving the Surdex Project Manager and the client. If the Project Manager believes it is in the best interest of the project to override a rejection, this may be brought to the attention of the client for final decision. For example, an image with crab exceeding a project specification – but not resulting in a gap in stereoscopic coverage and not interfering with the creation of a digital orthophoto – may be suggested for exemption if the seasonal window is closing and/or weather setting in.

Surdex uses both camera manufacturer-provided tools and custom-developed tools for the imagery inspection. The Image Processing department is ultimately responsible for image inspection and this group consists primarily of professionally-trained personnel with prior photographic lab experience. The key is the use of the Enterprise database to retain status and information (such as specular reflectance polygons) that can be used by the production staff later.

5.1.8 AEROTRIANGULATION

Aerotriangulation is a very critical step in the production process. It is ultimately responsible for the foundation accuracy of the project and for this reason it involves checks and balances to ensure accurate data is made available to the entire production process.

The fundamentals of AT are: using ABGPS/IMU data coupled with ground control, refine the position and attitude information of the imagery to make possible the accurate geopositioning of any point on the ground. The inputs to AT are:

- ABGPS/IMU data collected with the imagery.
- The imagery.
- Ground control points and check points.

The AT process involves:

- Processing of ABGPS/IMU data collected with the imagery.
- Automated measurement of pass and tie points appearing in the overlaps of the imagery.
- Interactive editing of pass and tie points.
- Measurement of control and check points.
- Solution of the refined imagery position and attitude as well as all point positions.
- If required, re-measurement of points and repetition of the solution.

The AT solution involves a sophisticated "bundle adjustment" using the method of least squares and employing a mathematical model of the imaging sensor geometry. This method also employs a model of the GPS approach and the "boresighting" of the sensor (relative position of the lens to the GPS antennas and relative orientation to the IMU) and synchronization of exposure time with the ABGPS signal. For example, a slight timing error can shift an image along the flight line. In addition, GPS and IMU data can involve drifting over time and need to be corrected. The bundle adjustment relies on the use of far more "observations" (initial values) than are required for a minimal solution and because of this employs a rigorous "weighted average" in the solution. This is the true virtue of the bundle adjustment: using extensive information to compute the best possible values.

Since there are far more observations than required, careful inspection is made of the various "residuals" reported by the solution. For example, an ABGPS position residual is the difference between the final adjusted value and the initial value from ABGPS processing. Should this differ more than the estimated ABGPS accuracy, this may signal flawed ABGPS data or processing. Since ground points involve measurements on numerous images, their ground positions and image measurements each have associated residuals.

During automatic pass/tie point collection, a streamlined version of the bundle adjustment is employed to help locate points in the overlaps. Imagery position and attitude as well as control point positions are "weighted" to reflect their estimated accuracy. From a high level viewpoint, the ABGPS/IMU and control point data provides a rigid solution that is used to refined initial imagery position and attitude to achieve high accuracy. The pass and tie points can be used to check products that are generated and, if easily recognizable, can be used as control points for further use.

There are several types of points that are measured during the AT process:

<table>
<tr><th colspan="3">Aerotriangulation Points</th></tr>
<tr><th>Type</th><th>Description</th><th>Measurement</th></tr>
<tr><td>Tie points</td><td>Points collected in overlapping images along a flight line/strip of imagery. Used to ensure images in the strip are tied together.</td><td rowspan="2">Mostly automatically collected and measured, but may require manual collection and/or editing in difficult areas (dense vegetation, water bodies, etc.).</td></tr>
<tr><td>Pass points</td><td>Points collected in overlapping images in adjoining and overlapping flight lines/strips. Ensures adjoining strips are tied together.
Pass points are often also tie points so as to strengthen the overall solution.</td></tr>
<tr><td>Control points</td><td>Points of known ground position. Often paneled for recognition and accurate measurement.</td><td rowspan="3">Manually measured.</td></tr>
<tr><td>Check points</td><td>Points of known ground position. Often paneled for recognition and accurate measurement.
Not held to their known position during the AT adjustment process. By allowing their positions to "float", they provide an independent check on the accuracy of the AT.</td></tr>
<tr><td>Blind check points</td><td>Handled much the same way as a check point, but their positions are not supplied. If used, these are provided by the client and their resulting values used by the client to perform a completely accuracy assessment. Often also used by the client as an independent assessment of product accuracy (such as digital orthoimage).</td></tr>
</table>

Analysis of the quality of the AT solution is performed by a Certified Photogrammetrist who is highly skilled and experienced with the process. Large blocks of imagery involve hundreds of thousands of points and/or measurements. For this reason, Surdex has developed numerous tools to examine the fidelity of the solution.

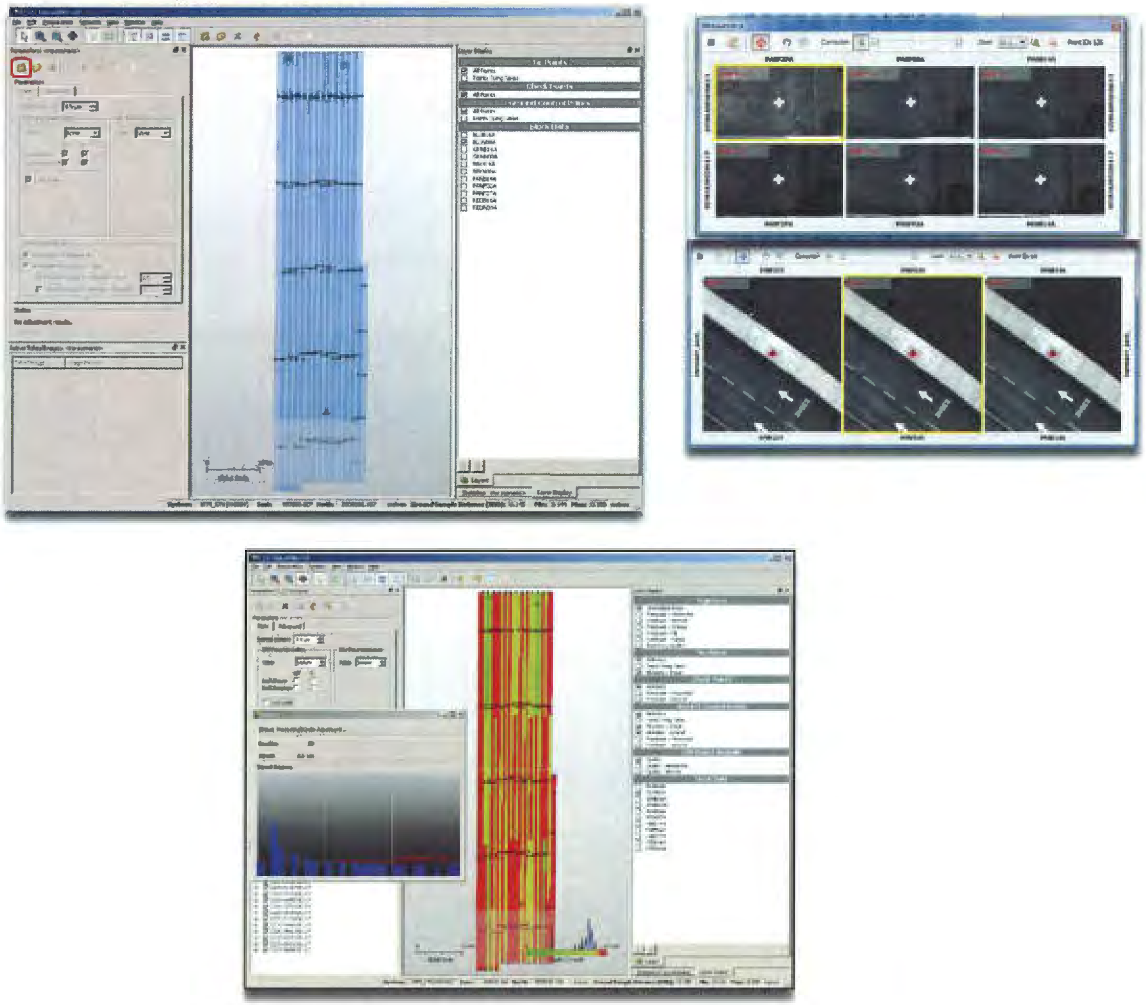
Upon the completion of the AT process, the results are stored in the Enterprise database and published (exposed) for use in the following production steps. For orthoimage projects, this also includes comparing the multitude of AT points to the elevation model. Although a small percent of the automatically generated points are not on the ground (bare earth) surface, the majority provide a very good check on (1) the fit of the AT and (2) the general quality of the elevation model. In many cases, this comparison illustrates changes required in the elevation model since the last project.

The Leica XPro software is used to aerotriangulate ADS100 imagery. It is important to point out that the forward, nadir, and aft arrays of the camera essentially form three separate images of the strip. Thus, the pushbroom scanner is analogous to a frame camera in that all points are imaged in three-way stereoscopic views. Initial trajectory information gleaned from ABGPS/IMU processing is combined with the measurement of pass, tie, and ground control points to determine corrections that will ensure all images match one another and the ground control. Leica's Orima software is used to perform the bundle adjustment in several steps:

- Pass points are automatically collected along strips that tie the nadir, forward, and aft arrays to one another, generally resulting in 3 measurements for each.
- Tie points are automatically collected between strips of images to tie them together and/or pass points transferred from one strip to another. As a result, tie points generally involve at least measurements.
- Ground control points are interactively measured.
- The bundle adjustment is performed with automated review and manual edit of suspect pass, tie, or control points.

Aerotriangulation of pushbroom imagery is simplified over the aerotriangulation of frame imagery. There are fewer images from a logistic standpoint, simplifying the amount of automatic matching and manual editing that must be performed. Additionally, the trajectory model ensures cohesive and accurate results within each strip.

Leica XPro aerotriangulation software interface.



Surdex provides a standard aerotriangulation report at the completion of each project. It has proven to be easily tailored to the requirements of each project.

Standard Aerotriangulation Report Contents

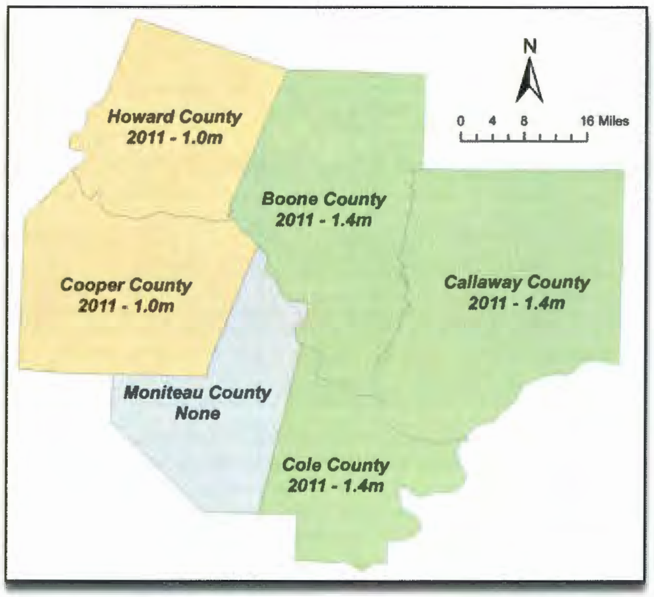
Item	Description
Reference frame	Definition of coordinate reference frame used for the aerotriangulation, to include map projection, horizontal datum, vertical datum, linear units (US Survey Feet, Meters, etc.).
Flight line indexes	Shapefile and/or graphical plot illustrating the imagery coverage against the project area. (1) For frame imagery, exposure stations represented as points. (2) For pushbroom imagery, the flight lines represented by polylines between the start and stop of imaging.
Point index	Shapefile and/or graphical plot illustrating the points used in the bundle adjustment, their type, and their identifier.
Weight values	List of weights (standard errors) assigned to all parameters.
Sigma naught (σ_0)	Fundamental single value that expresses the accuracy of the least squares bundle adjustment. Usually reported in microns or pixels and is on the order of 0.1-0.3 pixels.
Standard errors of control points	X,Y,Z standard errors of control points as reported by the bundle adjustment.
Final adjustment of control points	List of control points and a priori and final positions (X,Y,Z).
Identification of points removed from the bundle adjustment.	Points (any type) removed from the bundle adjustment and reasons why this action was taken.
Residual summaries: (1) Points (by type) (2) Measurements (3) Camera positions (frame) (4) Trajectory (pushbroom)	Summary of RMSE (Root Mean Square Error) values and estimated accuracy as reported by the bundle adjustment.
Narrative	Summary of software used for the measurement of points and bundle adjustment, issues encountered, etc.

5.1.9 DEM CREATE/UPDATE

The accuracy of an orthoimage is founded on the accuracy of the control, ABGPS/IMU, and aerotriangulation process. However, the limiting accuracy becomes the accuracy and quality of the elevation model. To achieve the accuracy standards, our approach is based on using existing LiDAR data, augmented where missing (or requiring update), by digital correlation and/or interactive editing.

The following graphic portrays our knowledge of the existing LiDAR data in the project area. Note that only Moniteau County is missing complete LiDAR coverage. If the option for new LiDAR for Boone County or any of the project area is selected, we would certainly process the new LiDAR first in order to use it for the Orthorectification process.

Available LiDAR in the project area.



Based on an initial review of the existing elevation data through the analytical triangulation process and stereoscopic review if required, the data will be edited in a stereoscopic environment where necessary. This may include new development, street alignment, drainage modification and large areas of grading. Mass spot points will be developed, consistent with existing spacing and density, to create an accurate surface model required for orthorectification.

If significantly large areas need an update, we may utilize digital autocorrelation with stereoscopic compilation editing where required. We use several approaches to ensure the elevation model is accurate and current enough to support the digital orthoimage accuracy requirements:

- Visual review of the elevation model for detection of obvious artifacts (eg: relief-shaded views, color-coded elevation views, etc.).
- Comparison of aerotriangulation points with the elevation surface. This allows technicians to more closely review "suspect" areas where vertical discrepancies exist between the surface and the AT. A final copy of this dataset will be provided to the State.
- Visual review of orthoimage products.

Of these approaches, the comparison of the aerotriangulation points (control, pass, and tie points) to the elevation model is very helpful in isolating areas of gross change.

Surdex prides itself in a job done write and including DEM updates as part of an orthoimagery project is a perfect example of that. In our industry, DEM updates are often an area left out of project design to save cost. We believe this is a corner that should not be cut.

5.1.10 SURDEX'S DIGITAL ORTHOPHOTO PRODUCTION PROCESS

Surdex's R&D staff has worked diligently over the last decade to improve accuracy, quality, and throughput of digital orthophotos. This effort has resulted in a mix of third party, open source, and custom-developed algorithms and software. Our approach is exemplified with engaging our clients throughout the process to ensure maximum satisfaction.

The generation of orthophotos from raw imagery and an elevation surface is largely a simple and fast computational step. However, the generation of an accurate, seamless, and consistent mosaic covering a large area requires specialized procedures and software operated by experienced technicians.

Our process handles digitized film and each of the various sensors operated by Surdex. We limit sensor-specific processing to the front-end of the production chain, utilizing source-independent processing to the maximum extent to ensure consistent results, including the mixing of sensor types within a project if allowed by the client. All image resampling is performed using bi-cubic or Lagrange interpolation kernels to eliminate aliasing and similar artifacts.

Features and Benefits of Surdex's Orthophoto Production Process

Feature	Benefit
Image color, tone, balance, etc. prototyped before production begins using "reference images".	Client participates in desired appearance of final product far in advance of delivery.
All image processing and production performed in "4x12" space (4 bands, 12 bits/pixel) until the cutting of deliverable image tiles: (1) Generate color and/or color infrared (2) 8 or 12/16 bits per pixel deliverables	Preserving full content provides maximum latitude in mosaicking process. Ensures highest possible quality products.
Internal production tiles are in a contiguous (seamless) format, with deliverable tiles generated at the final stage. This supports: (1) Overlapping deliverable tiles (2) Multiple deliverable tile layouts (3) Multiple map projections (4) Multiple product resolutions	Accommodates clients with requirements for multiple layouts of deliverable products at marginal additional cost. Accommodates last-minute changes. Edits to data only done once to support multiple products.
Highly automated absolute radiometry and atmospheric processing, reduces: (1) Level of subjectivity by technicians (2) Production labor effort (3) Changes to be made in final stages of production	Higher volume and throughput.
Customized seamline generation process: (1) Highly automated (2) Inclusion/exclusion areas (such as building footprints)	Allows 100% effort towards QC. Seamless final product. Minimal review and edit of final product.
Proven ability to incrementally produce large ortho projects while preserving a seamless appearance at completion.	Allows incremental QC and delivery to address client priorities, leveling of QC resources, and schedule compression.
Enterprise database underlying all imagery and data.	Complete lineage of all processing. Automated generation of FGDC-compliant metadata.
Web-based QC tool available free-of-charge for clients: (1) Eliminates cost and time associated with multiple deliveries of hard drives (2) Fast turnaround of fixes and validation of fixes (3) Progress tracking	Accelerates QC and acceptance process. Audit trail of all changes. Reduces need for costly and time-consuming 3rd party QC.

Efficient handling of digital imagery and production of digital orthophotos requires a robust infrastructure to maintain data integrity and throughput performance. Surdex's solution to this includes:

- Sufficient and expandable storage.
- Intelligence mix of on-line and off-line storage, including automated backup and restore.
- A distributed processing environment based on multiple CPU/blade servers and workstations interconnected by a high-speed network.
- An Enterprise database that not only tracks and monitors raw, intermediate, and final data, but also is used to automate processing steps. The database also generates extensive reports and graphics used by internal production and available to clients.

Surdex's Grouping Tool (GT) is the basis for the viewing and editing of a large number of tasks within the production group. It includes image processing, seamline generation and edit, radiometric balancing, and deliverable tile cutting in addition to a general GIS functionality. GT has been under continual enhancement and extension for since 2009 and has become the universal interface for much of Surdex's production and production management activities. Its direct interface to our Enterprise database allows technicians to mine a wealth of data while performing production tasks.

5.1.11 IMAGE PROCESSING

In many production shops, minimal image processing is done up front in the process and then color-balancing done in the final step. In contrast, Surdex's approach entails processing throughout the production chain, independent of such steps as aerotriangulation and elevation model generation/update. By doing so this reduces and/or eliminates critical paths that can become problematic for project schedules. Additionally, we are able to incrementally generate products in a project area while still preserving the same overall consistency, supporting prioritized production for our clients.

The following table summarizes the steps in the process and where they take place. Image "metrics" used to focus image processing on the desired colorimetry of the final process are used throughout and are tracked by the Enterprise database on all original, intermediate, and final images of all types.

Surdex's Image Processing

Feature	Benefit
Sensor-specific post-processing following each acquisition mission, including application of geometric and radiometric calibrations. (1) Supports image inspection. (2) Output is 4x12 format (4 bands, 12 bits/pixel).	Only for preparation for aerotriangulation and DEM generation/update.
Highly automated, preliminary image processing: (1) Atmospheric corrections based on absolute radiometric calibration of the sensor (2) Bi-directional Reflectance Distribution Function (BRDF) corrections (3) Development and application of image metrics using custom look-up tables (LUTs) and/or adjustment curves.	Supports reference imagery phase with client.
Global and Block Balance are used on orthophotos during mosaicking phase to achieve seamless and consistent appearance across entire project.	Removable of residual colorimetry differences between adjacent/overlapping orthos.

Each sensor has specific software used to apply radiometric and geometric calibrations to the raw ("L0", or Level 0) imagery to produce a "L1" (Level 1) image. In some cases, Surdex has customized portions of this step, but it is largely based on software developed by the sensor manufacturer.

From the image processing standpoint, a distinct advantage of digital sensors is the ability to perform an "absolute radiometric" calibration of each sensor. Using laboratory procedures, the response of each CCD is calibrated against true values. During post-processing, these are applied to normalize the response for a uniform appearance.

Automated top-of-the-atmosphere models and Bi-directional Reflectance Distribution Function (BRDF) corrections can be used to refine the appearance of an image without time-consuming effort by highly-skilled labor to achieve the same. BRDF corrections deal with the effects of the sun angle not being coincident with the viewing angle. After atmospheric and BRDF corrections, simpler alterations are made by technicians to tune the appearance of the image to the desired effect. In most cases, these corrections do not result in additional versions of the image, but rather represent cumulative modifications that are applied on-the-fly during orthorectification.

Block and then Global Balance tools are used to finalize the mosaicking phase of production. This eliminates any residual radiometric differences between adjacent/overlapping orthos.

5.1.12 Reference Images

Shortly after acquisition begins, Surdex will work with each client to find representative regions in the project area. Using "reference images" over these regions, Surdex will process the images to basic image metrics and expert judgment. These reference images will be submitted for review by the client and, if necessary, their colorimetry altered to meet the expectations for the project. Once agreed upon, these will be used to target all image processing until a "pilot" deliverable is used to finalize the appearance with the participation of the client. Since all data is retained in 12 bits/pixel format, final appearances can still be modified to large extent after the pilot project is agreed upon.

Surdex's web-based QC tool (CPAT) has the ability to render either a natural color or CIR view of 4-band products.

5.1.13 4-Band Imagery

Based on our experience, 4-band products are invaluable for remote sensing applications (eg: classification). The production of 4-band (red, green, blue, near infrared) imagery is inherent in our production process and requires only marginal additional effort to deliver an end-product to a client. The reference image, orthorectification, seamline, and balance processes automatically involve the near infrared band. However, additional effort is required to ensure the color infrared (CIR) view of the data is consistent with client expectations.

The CIR view (eg: as viewed in ArcGIS) uses the band ordering of near infrared (band 4), red (band 1), and green (band 2). It is intertwined with the natural color view (bands 1-3: red, green, blue) and therefore changes in the red or green bands affect both natural color and CIR views. As a result, only the near infrared band (band 4) can be altered. From our deep strong experience with 4-band products, we have found that client expectations for a CIR rendition vary, primarily due to exposure to color infrared film.

Image metrics have not yet been developed for 4-band imagery. Our approach is to match the near infrared band to the appearance desired by the client. This is addressed initially during the reference image process and during the pilot orthophoto delivery.

Color (left) and CIR (right) renditions of a leaf-off 4-band file (Houston-Galveston Area Council, 2014, 6-inch GSD).

5.1.14 ORTHORECTIFICATION AND MOSAICKING

Orthorectification is a computational process using the raw imagery, the orientation parameters of each image from aerotriangulation, and an elevation model. An orthophoto is created by tracing a point on the ground back to the image via the aerotriangulation model, and then interpolating for the pixel that corresponds to the ground point. As opposed to the inferior "anchor point" approach to rectification, for each orthophoto pixel an associated height is interpolated from the elevation model and the resulting 3D coordinates used to interpolate for the pixel from the image. With high-speed computing power and networks, each orthophoto is created in a matter of a few seconds. Surdex has developed its own software that has extreme versatility with regards to source image type (scanned film, frame digital, or pushbroom digital), elevation model type (grid or point network), and map projections. This software runs in a distributed environment that can take advantage of any available server and/or workstation in the facility or order to process thousands of images each day. Orthorectification and all other processes that involve resampling of imagery use a cubic convolution or equivalent (such as Lagrange) to minimize loss of image content and sharpness.

5.1.14.1 Elevated Structures

Elevated features, such as non-grade crossings of transportation lines and bridges, require a localized elevation model to ensure no layover and/or smearing is introduced into the final product. In contrast to most initial DTMs/DEMs which are "bare earth", these models actually become Digital Surface Models (DSMs). A DSM utilizes breaklines and is kept in a TIN (triangulated irregular network) format. TINs are not constrained to a grid of points that would affect the accuracy and quality of the final product. During ortho production, all overpasses, bridges, transportation lines, and even "urban canyons" are scrutinized to determine whether a localized DSM is required to maintain product quality. In essence, ortho technicians can use known locations of these types of features to "drive" to each and determine the amount of localized terrain modeling required.

Building lean in built-up areas (BUAs) can be minimized by increasing sidelap and using flight plans that align with the "urban canyons" present in dense metropolitan areas. The increased sidelap reduces the "neat area" to provide optimal near-nadir views of the features. Additionally, the increased sidelap is used by technicians for more potential sources of optimal views of leaning features.

5.1.14.2 Occlusion and Smearing

Surdex's orthorectification module has the ability to detect potential occlusions and smearing that may occur in rugged terrain. This software creates a graphical overlay that directs technicians to examine pixels that may be incorrect, alleviating them from the task of inspecting imagery for such issues. If an occluded or smeared area is encountered, the corresponding imagery from an overlapping ortho is inserted to replace it during the mosaicking process.

5.1.14.3 Specular Reflection

Sunlight reflecting off of large surfaces, such as bodies of water, can wash out portions of the imagery. During image inspection, imaging specialists isolate areas of concern, creating a shapefile used by ortho technicians in selecting an alternative view, if available. Minor specular reflection that does not affect shoreline and ground conditions and cannot be mosaicked around, may be present in the final orthophoto.

The ADS100 lends itself to potentially better treatment of issues of specular reflection, wind chop, and the like involving bodies of water that can result in objectionable artifacts. The ADS100 has continuous acquisition of forward and aft imagery through arrays mounted approximately 25.6° (forward) and 17.7° (aft) relative to the nadir array. Unlike the preceding ADS40 and ADS80 models, the nadir, forward, and aft arrays all collect full color (RGB) and near infrared (NIR) data (4 bands for every array).

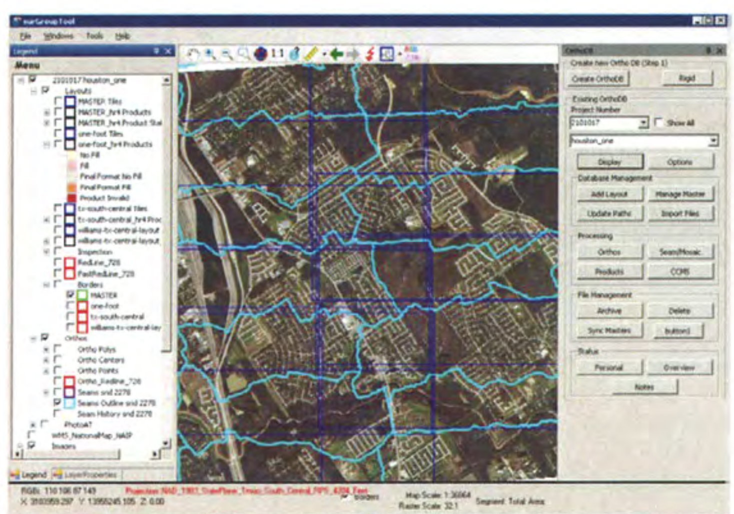
The ADS100 forward and aft arrays can sometimes present an advantage for ortho projects involving water bodies. Since the key issue with specular reflection and the like is the relative angle between viewing and the sun location, the two arrays provide alternatives to only using the nadir array. For example, if a mission is flown into the direction of the sun, it is logical to assume that the forward and nadir arrays may be adversely affected by resulting reflections. However, it is possible that the aft array would be unaffected since it is looking in the opposite direction. If this is the case, an ortho technician has the option of using imagery from this array to minimize the adverse affects. During image inspection, the nadir array is evaluated for specular reflection and each affected image/strip annotated in our Enterprise database. This same database also tracks the sun angle and azimuth at the exact time of imaging, setting the stage for the prediction of specular reflection effects. If a nadir image is flagged for specular reflection, the ortho technician is alerted to the situation and will address it during production.

5.1.14.4 Seamline Generation

Surdex has developed a suite of applications that automatically generate seamlines that are used to stitch overlapping orthophotos to one another. The results of the automated step are reviewed within Grouping Tool and edited. This seamline software accepts building footprints that can be used by the automated process to avoid cutting through these areas.

The following figure shows the results of automatic seamline generation using building footprints. This example is from Surdex's emergency response support of the 2011 Joplin, Missouri tornado disaster. Building footprints were extracted by technicians from pre-event imagery while the aircraft was acquiring the imagery. This allowed us to process 3" resolution orthos at production quality over the entire Joplin area within 12 hours of the return of the aircraft.

Review and editing of seamlines within Grouping Tool.



Seamlines before (left) and after (right) correction of seamline cutting through building.

Surdex's standard procedure is to deliver a seamline shapefile to all clients. This can be used to expedite the QC of delivered orthos and provides a date for each and every pixel in the product. Since the majority of the mosaicking errors are traceable to inappropriate seamline placement, inspectors can literally follow each seamline during review. Surdex's web-based QC tool also provides a selectable seamline layer for inspectors.

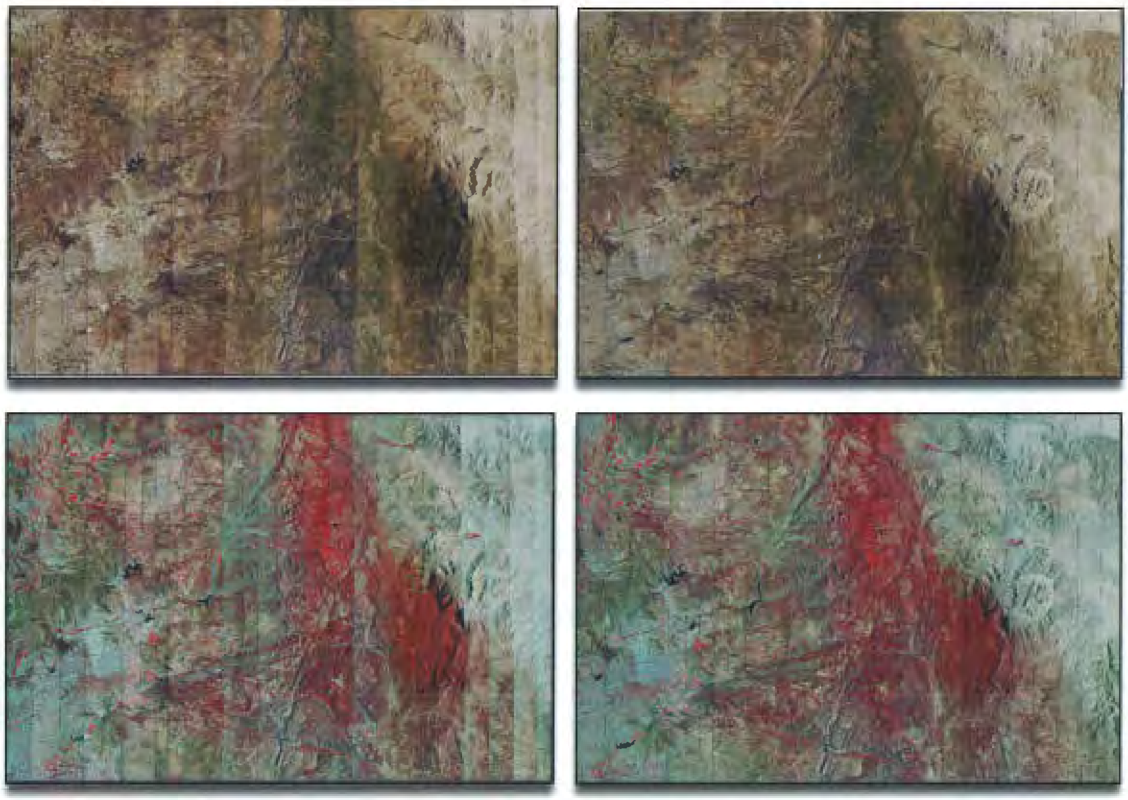
5.1.14.5 Global and Block Balancing

Surdex's custom-developed Global and Block Balance software used during mosaicking eliminates any residual atmospheric and radiometric anomalies that hamper the appearance of a seamless dataset. After application of BRDF and atmospheric correction each ortho strip still needs correction to match its neighbor.

- Block Balance fits correction models to each strip of images to correct to a single simultaneous bundle adjustment solution.
- Global Balance is then run to correct local differences in illumination between strips, even correcting to some extent the presence of cloud/cloud shadows.

Global Balance uses a "rigid body model" correction calculated for each ortho that best forms a normalized block fitting neighboring orthos. Higher-order polynomial versions of the rigid body result in a "flexible body" correction that transitions differences in the overlapping regions. As this is a model-based approach, it is possible to limit the influence of scene specific differences in overlapping orthos. For example, if crops are mature and green in one flight line and only tilled soil in the overlapping neighbor, the model will disregard these measurements as outliers and not force the green crops to match the brown soil. The Global Balance results can be previewed in Grouping Tool without the need to generate intermediate files.

Before (left) and after (right) both color (top) and CIR (bottom) global balancing.
(Seamlines not applied)



5.1.14.6 Tile Writing

The last step in the mosaicking process is the generation of ortho tiles in an internal production schema. During this step, all global balancing adjustments and seamlines are applied to the individual orthophotos. Once this is complete, all deliverable tiles are generated for the client.

For each project, an internal production digital orthophoto tile layout is devised that encompasses a buffered extent of the deliverable tiles. This "Master Tile" layout is based on contiguous tiles of a nominal 8,192 x 8,192 pixel tile size. Each Master Tile is in GeoTIFF form and in 4x12 (4 bands x 12 bits/pixel) format. Using custom Surdex software, virtually any client tile layout can be generated on demand using automated batch processing. This includes support for:

- Overlapping and contiguous client tiles.
- Multiple client tile layouts.
- Creating tiles in other map projections and/or linear units (eg: Meter vs US Survey Foot).
- Change of resolution – such as creating a 1' resolution tile set from a 6" tile set.
- Since the imagery is in 4x12 format, it can be delivered as such or remapped to 8 bits/pixel, color, or color infrared (CIR) forms.
- Supported output file formats include MrSID, GeoTIFF, JPEG, JPEG200, ECW, TIFF/TFW, etc.

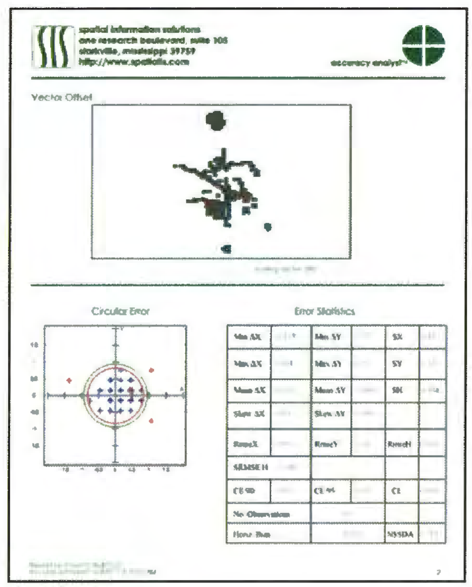
Besides the obvious ability to generate data in virtually any desired tile layout, the Master Tile concept makes error correction during QC very simple. Once an error is resolved in the Master Tiles, all applicable client tile layouts are automatically re-generated, limiting the correction to a single action potentially resolving numerous deliverables.

5.1.15 ACCURACY ASSESSMENT

Surdex uses the Accuracy Analyst software from CompassData for assessment of digital orthophoto accuracy.

This software accepts control point coordinates and guides the user through measuring points on the orthophoto tiles. It has extensive analysis and reporting tools that adhere to NSSDA specifications and guidelines.

Accuracy Analyst measurement and reporting.



5.1.16 CLIENT PRODUCT ACCEPTANCE TOOL (CPAT)

Surdex is offering, at no additional cost, a web-based approach to reviewing the orthoimagery.

Approximately 4 years ago, Surdex developed a web-based tool for the review and acceptance of our products. Our Client Product Acceptance Tool (CPAT) has been continually improved and has been used on numerous large projects with success. CPAT is a Silverlight application built over the ESRI ImageServer image service and interfaced to our Enterprise database. It operates within a web browser and features intuitive operation that requires no more than 1-2 hours of introductory familiarization. Surdex was a beta development partner for the ImageServer product and has continued to value-add this tool with applications developed in-house by Surdex's R&D staff and with assistance from ESRI experts.

Based on our experience, CPAT greatly streamlines the inspection process, remedial action, and delivery timelines. As call-outs are reported by reviewers, Surdex resolves each and notifies them to re-examine the correction. Since Surdex works off call-outs in parallel with the inspection process, in most cases the reviewers receive corrections in 1-2 business days. When all call-outs are resolved for the project, or a delivery area, the data can be shipped on hard drives for final delivery. In most cases, clients chose to have image products added to CPAT for inspection regardless of defined delivery areas/blocks, thus further expediting inspection and allowing our clients to level their inspection resources.

Selected details of the implementation include:

- Minimal requirements to operate: Windows Explorer or Firefox with the (free) Silverlight plug-in.
- Interfaced to Surdex's Enterprise database, which contains redline information and status of call-outs, overall status, remedial action, etc.
- Ability to define areas for assignment to individual inspectors.
- Selectable graphic overlays, including: tiles, seamlines, inspection status, etc.
- Roam and zoom within a window or from a related window (such as an overview window).
- Optional directed progression through tiles to provide structure to the inspection process.
- Clients can introduce vector layers for display, such as shapefiles of transportation layer.
- Ability to generate textual and graphical reports to assess inspection status.
- For "4-band" products, inspectors can toggle between color and CIR representations of the data.
- A 3X magnifier allows an inspector to maintain a constant zoom setting, leaving detailed examination (such as along seamlines) to the magnifier tool.

The illustrations on the following pages highlight some of the features of CPAT.

Standard Inspection Viewer

Inspection Window

Inspection Controls

Info Window

Progress Window

- (Pan/zoom enabled)

Locator Window

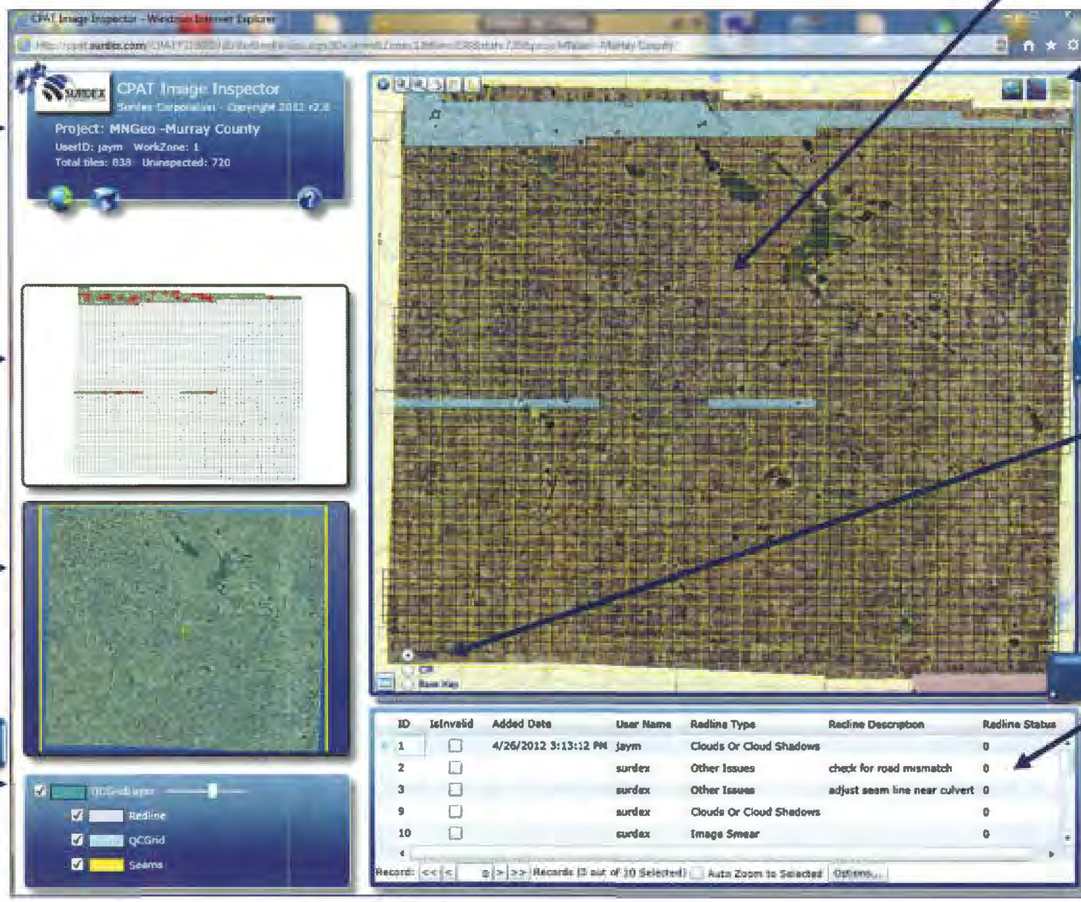
- Linked to Inspection Window

Layer Control

- (Visibility & Opacity)

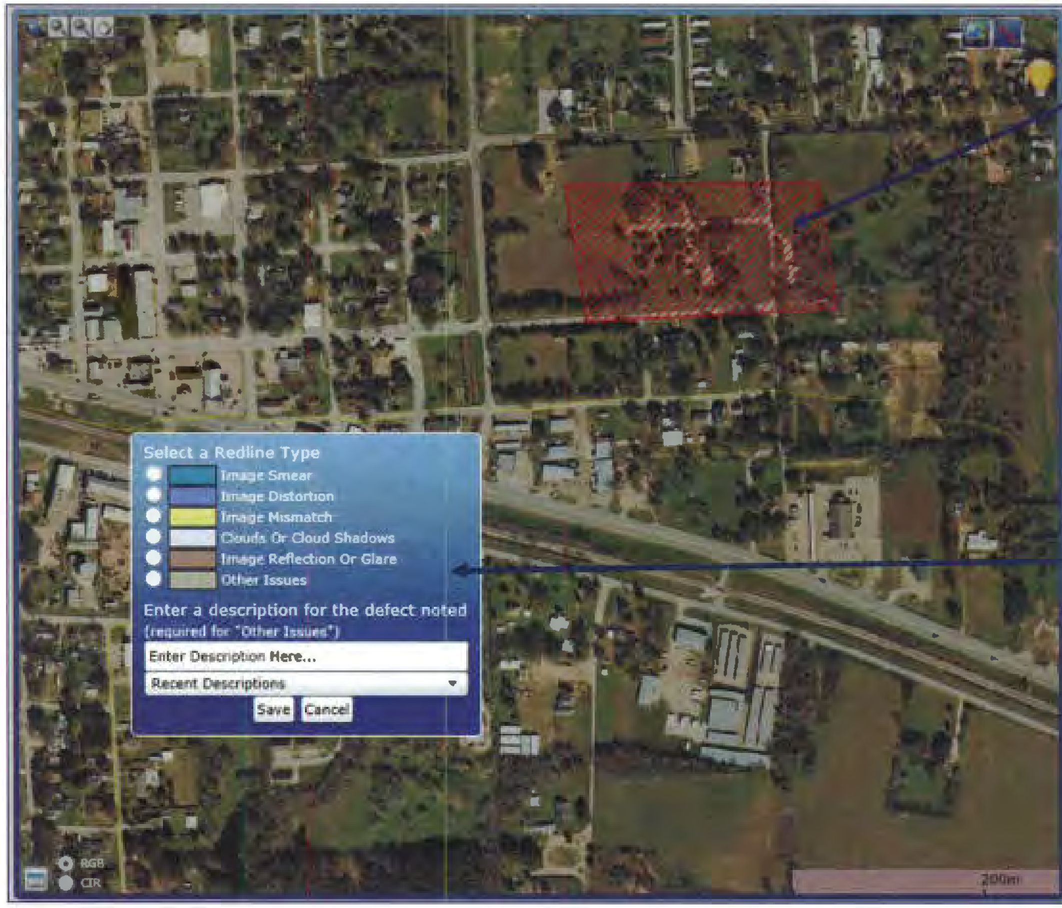
Image Layer Toggles

Edit Calls Table



Magnifier tool avoids time-consuming zoon In/out to examine detail

Edit call interface



Polygon Delineation of Edit Call

Select Call Type

Add Comments

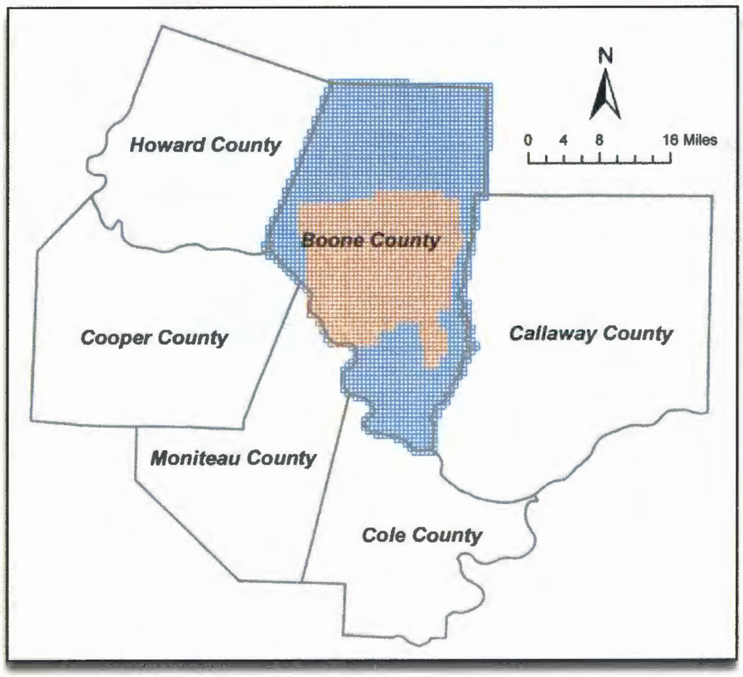
- Selectable Comment List during session

5.2 ITEM II – BOONE COUNTY LIDAR

5.2.1 PROBLEM UNDERSTANDING

The following graphic and table presents our understanding of the LiDAR portions of the project.

Summary of Orthophotography Requirements		
Density	Areas	Approximate Area
0.7-meter or 1.0-meter	Columbia Metro Area	264 sq mi
0.7-meter or 1.0-meter	Boone County	691 sq mi (complete county)
		432 sq mi (exclusive of the Metro area)



5.2.2 LiDAR Ground Survey

Our Team will provide the ground control field operations and GPS data processing, meeting all required accuracies and specifications, for the entire project supporting the LiDAR requirements. This includes:

- Control points required to support production of the deliverables.
- Check points required to validate the accuracy of the deliverable.
- Wherever possible, existing control will be used.
- Establishing GPS Base Stations as required.

As with the orthophotography portion of this project, all Survey operations will be conducted under the supervision of a Registered Land Surveyor in the State of Missouri. A control diagram will be furnished for all survey points utilized on this effort. This will include point positions and observed baselines designating beginning and ending points.

Two base stations will be identified in advance and will be located as close as possible to the center of that day's collection area, adhering to a 25 mile baseline requirement. The base station locations will incorporate existing NGS locations where acceptable.

The results from the processed base station data, ABGPS data and the GPS surveyed ground control data will be used to create an accuracy report for each mission and for the overall project once it is complete. Surdex has provided its preliminary control plan below. This plan may be adjusted upon contract negotiations and the current ground conditions found in the field.

5.2.3 The Leica ALS70HP LiDAR

Surdex will use its Leica ALS 70 HP SP3 Aerial LiDAR Sensor (SN1798_HP) equipped with Multiple-Pulse-in-the-Air (MPiA) technology for the LiDAR acquisition. The sensor is a multiple-return LiDAR system capturing multiple ranges for each pulse along with intensity images.

The ALS70HP specifications are:

- 500 kHz pulse rate
- 200 kHz scan rate
- Up to four pulse returns
- Up to 3 intensity returns
- Selectable scan patterns: sinusoid, triangle, and raster
- Automatic adjustment of scan rate for uniform along-track spacing
- Reduced noise
- Improved range correction.

The following are the capabilities of the ALS 70 HP and the parameters designed to meet all requirements for 0.7-meter density.

ALS 70 HP Capabilities	
Leica ALS 70 HP SP3	
Scan Angle	≤40º (+/-20º from Nadir)
Returns Collected Per Laser Pulse	4 Nominal
Single Swath Pulse Density	≥ 0.7m GSD
Intensity Range	1-255 for each return
Swath Overlap	≥10% side-lap
GPS PDOP During Acquisition	≤3.5 (Typically much less with GLONASS)
GPS Satellite Constellation	≥6
Maximum GPS Baseline	<40 km
Flying height (AGL)	2,700 meters
Field of view	40°
Max laser pulse rate	261,000 KHz
MPiA	Enabled
Swath width	1,529 meters
Maximum line spacing	1,379 meters
Minimum sidelap	10%
Average point density	2.21 pts/meter^2
Average point spacing	0.67 meters
Illuminated footprint diameter	0.48 meter

Surdex will provide progress reports daily providing flight trajectories, GPS reports and identify any days where collection was delayed due to weather or other environmental factors. Our plan is focused on collecting data day or night through the use of multiple pilots and operators to ensure that the project is collected in the most efficient manner possible.

5.2.3.1 Sensor Calibration

LiDAR is highly dependent on several sensor sub-systems working in conjunction with each other to produce accurate ranging data and the resulting point cloud. This includes the Base GNSS station, ABGPS/GNSS, IMU and the physical laser unit. Surdex's LiDAR system is routinely calibrated over our established boresight at our base of operations in Chesterfield, MO.

Surdex's procedure to calibrate the sensor consists of four lines of acquired data flown in cardinal directions with two lines at one altitude and the other two (opposing directions of the first two) are at a different altitude. This calibration is accomplished when the sensor is installed in the aircraft required for a given project. This procedure is also accomplished if anomalies are found and unresolved during processing.

A secondary method of validation/calibration is conducted on site during the project acquisition. This secondary calibration is accomplished by acquiring cross flight lines perpendicular to the "project" lines before and after each lift. These data are processed and used as validation and calibration of the data collected over the project site.

5.2.4 ACQUISITION WINDOW

Acquisition, to be completed between November, 2014 and mid-April, 2015, will begin within two weeks of Notice to Proceed, given favorable weather and ground conditions. Surdex will provide any pertinent weather forecast updates as we monitor Midwest weather forecasts and conditions during our normal course of business. Upon formal notice of selection and prior to completion of negotiations and contract execution, Surdex will elevate the priority of weather monitoring. If unexpected circumstances arise, Surdex will communicate our concerns and recommendations. Based on the given acquisition window and acquisition hours calculated in our project design, Surdex does not anticipate weather or unexpected mechanical issues to present delays.

Surdex will base the mobilization schedule on current and forecast weather conditions and verified environmental conditions. Conditions required for LiDAR collection require:

- Cloud and fog free (between aircraft and ground)
- Snow free (light snow may be acceptable with approval)
- Steam and rivers within normal levels (flood free)
- Leaf off vegetation

Should crews leave the project site due to extended unfavorable weather/ground conditions, notification will be sent detailing the reason for leaving the project site and Surdex's estimated re-mobilization date.

As daily shipments of the LiDAR arrive, the data are immediately backed up prior to any inspection or processing. This serves to secure all data in its native form should it be necessary for review or investigation during subsequent processing. After archival, the initial QC is accomplished on a daily basis. The data is inspected for coverage, continuity and general acceptability. Should an issue be found that requires re-flight, the anomaly is entered into the database as a "rejection" and notification sent to the Project Manager, Flight Manager and field crews automatically. The automatic notification eliminates the dependence on human interaction to report an issue. As stated previously, all re-flights are labeled as priority status requiring prompt attention.

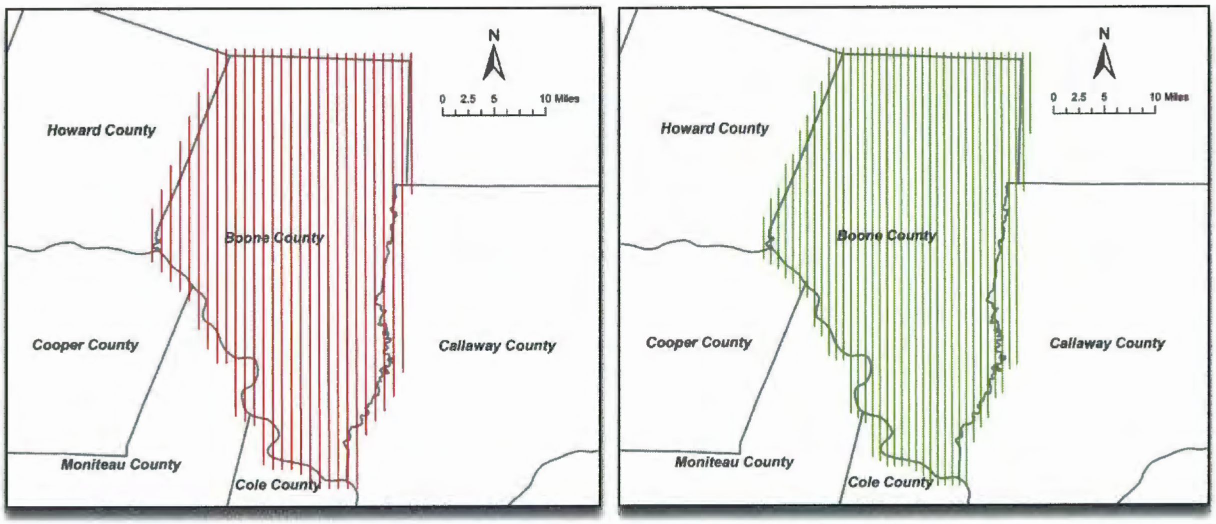
5.2.5 PRELIMINARY FLIGHT PLANS

The LiDAR flight planning is primarily based upon swath overlap, pulse density, and field of view (FOV). Derived parameters include the flying height above mean terrain. Detailed planning involves using elevation models to ensure variations in terrain do not result in gaps in coverage or loss of desirable swath overlap. The table below summarizes the acquisition requirements for AOI design.

Acquisition Requirements				
Parameter	Boone County		Columbia Metro Area Only	
	1.0 Meter	0.7 Meter	1.0 Meter	0.7 Meter
Flight Lines	29	38	21	27
Flight Line Miles (FLM)	931.3	1,173.7	350.0	418.9
On-Line Aircraft Hours	11.2	14.7	5.5	7.4

As can be seen from the table, approximately one-third more hours are required to capture at 0.7 meter post spacing than 1.0 meter post spacing.

Preliminary LiDAR flight plans for 1-meter (left) and 0.7-meter (right) post spacing coverage of Boone County.



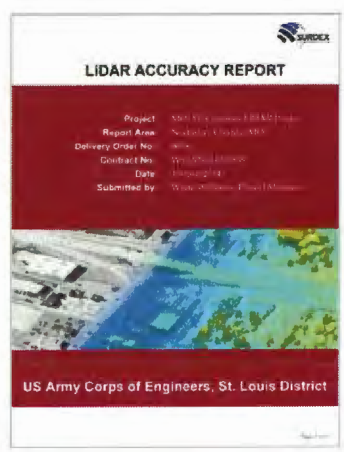
5.2.6 INITIAL POST PROCESSING AND DATA VERIFICATION

Post processing and verification of acquired data will be accomplished upon receipt of data from the field. Standard QC checks are designed to verify that data meets or exceeds all requirements of the project. Surdex is familiar with the specification as provided as they are derived primarily from the USGS V1 specification which Surdex has successfully delivered on numerous projects.

Data will be inspected to ensure nominal point density has been achieved on single swath data, excluding overlap. Although data voids caused by water bodies or areas of low reflectivity will most likely not be present due to the geography of the area to be collected, inspection will verify that proper planning, acquisition, sensor function have achieved the desired results.

In our experience, due to detailed project planning, spatial distribution of collected data from the Leica ALS 70 continually meets specifications relating to clustering and routinely meet all QC checks against minimum points contained in prescribed grid cells.

5.2.7 VERTICAL ACCURACY



Surdex provides a full LiDAR accuracy report include project overview and process and QA/QC description addressing all NDEP/ASPRS procedures and requirements:

- Accuracy check points are used that are:
  - Independent of the points used in production.
  - At an accuracy equal to or better than the target product accuracy.
- A number of points in the project area will be utilized.

The report provides documentation of project specifications, control and check point descriptions and photos. In addition to written descriptions, project graphics are used to illustrate AOI's and GPS survey locations. To support accuracy reporting an Excel spreadsheet is provided listing all survey positions including; individual points, land cover types and final accuracy results.

This table below is a highlight of information provided in a previous Surdex LiDAR project Accuracy Report to the USACE, St. Louis, Nodaway County project area.

Classified LAS QC Accuracy Results				
Stat	Overall	Hard Surface (HS)	Grass (G)	Trees (TR)
Count	81	20	20	21
RMSEz (FVA)	0.094	0.066	0.091	0.106
95% Confidence Level (FVA)	0.183	0.130	0.178	0.208
95th Percentile (CVA & SVA)	0.198	0.117	0.159	0.201

DEM QC Accuracy Results				
Stat	Overall	Hard Surface (HS)	Grass (G)	Trees (TR)
Count	81	20	20	21
RMSEz (FVA)	0.091	0.065	0.091	0.101
95% Confidence Level (FVA)	0.179	0.128	0.179	0.197
95th Percentile (CVA & SVA)	0.206	0.108	0.168	0.227

The accuracy report produced and provided to the State will follow NDEP/ASPRS guidelines documenting that LiDAR data meets accuracy standards stated below:

- FVA <= 19.6 cm ACCz, 95% (10 cm RMSEz)
- CVA <= 29.4 cm, 95th Percentile
- SVA <= 29.4 cm, 95th Percentile
- Horizontal Accuracy = 25.0cm RMSEr

5.2.8 DATA PROCESSING AND HANDLING

It is standard procedure (requirement) for all Surdex PM's to provide weekly status reports on all projects. The weekly reports addressing calibration and post processing will be in addition to the daily reports provided during the acquisitions phase of the project. The weekly status reports will include calibration progress and any issues encountered. Additionally, should an issue arise that is out of the ordinary, a discussion of the issue will be provided and Surdex's remediation plan and potential timeline will be provided.

As the project progresses, status of post processing will ultimately be incorporated into planned or projected deliveries. At the request of the State, Surdex will be pleased to participate in regular conference calls to discuss any outstanding or unforeseen issues.

5.2.8.1 Report on Delivery of Products and Percentage Completion

All reports will illustrate project progress by task as compared to the proposed schedule. The reports will identify a percent complete as they are finished and tracked against the master schedule using Microsoft Project. Following is the proposed project schedule.

5.2.8.2 Data Processing

Surdex will be ultimately responsible for all data reduction and processing. Surdex will accomplish all initial post processing of the collected LiDAR data, line to line matching and least squares adjustment to ground control. Surdex has incorporated the services of BPS to the team as a subcontractor to provide the somewhat labor intensive processing to bare earth surface. Surdex will QC ***all data*** submitted by subcontractors and will be responsible for the accuracy and fidelity of all deliverables.

5.2.8.3 Verify Data after Flying

Our workflow involves uploading all data to our home office checking for coverage, voids or other anomalies. As these areas are identified, flight crews will be notified of re-flights given priority status to ensure that the missing areas are collected as close to the previous environmental conditions as possible. All flight lines and data coverage will be initially verified for the entire project before we begin any de-mobilization from the project site. Surdex will conduct a "post-collection" briefing with the State, if deemed appropriate, to illustrate complete coverage before final de-mobilization activities commence.

LiDAR is highly dependent on several sensor sub-systems working in conjunction with each other to produce accurate ranging data and the resulting point cloud. This includes the Base GNSS station, ABGPS/GNSS, IMU and the physical laser unit. While the LiDAR system is periodically calibrated over a well controlled area to produce a boresight solution, the system may change between calibrations.

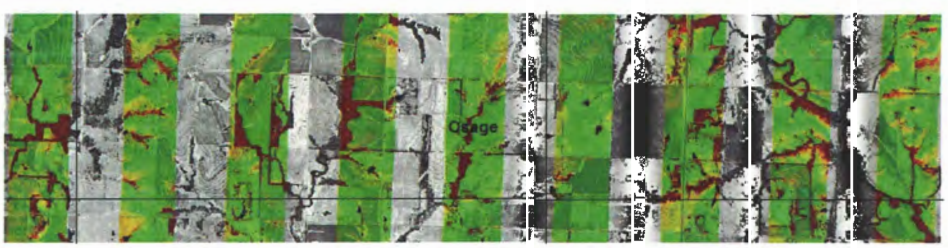
As stated previously, Surdex will acquire cross flight lines perpendicular to planned acquired lines. These flights will be acquired prior to and/or at the completion of each lift. These data are processed and used as validation and possibly calibration of the data collected over the project site.

These calibration lines are used to check repeatability between lines from both before/after the mission as well as to compare the pre-mission calibration lines to the post-mission calibration lines. If repeatability issues present, the data are put through either Attune or TerraMatch calibration software. Each of these packages, while differing in procedure, will allow the operator to determine values of correction (roll, pitch and heading) that are to be applied in the re-creation of the LAS flight lines.

Two base stations will be established; one at the airfield and a secondary station at an appropriate location selected to meet the needs of the day's scheduled acquisition. All GPS/GNSS base stations will consist of dual frequency survey grade GPS/GNSS receivers collecting data at least one second epochs. Proper planning and monitoring will ensure that data is only collected with a PDOP of ≤3.5 with a minimum of six satellites in view.

5.2.8.4 Strip to Strip Analysis

Occasionally, regardless of an excellent calibration solution, individual lines or blocks of lines may require adjustment to remove systematic error. Additionally, adjacent lifts may require a relative adjustment to align the point clouds. Our experience is that long lifts and lifts that are divided to avoid clouds or undesirable ground conditions are more likely to require post processing adjustments. One process used to evaluate large areas of LiDAR and the fit of adjacent lifts is the production of dZ images, see the image below. These images are color coded to show elevation differences between lines in the overlap areas. Below, the green represents a 0 to 5 cm difference, Yellow 5 to 10 cm, Orange 10 to 15 cm and Red greater than 15 cm. Note – this data set shows very good repeatability on all "bare earth" surfaces, the only red shown is in tall vegetation which is expected.



Sample Dz Image showing areas of disagreement between lines.

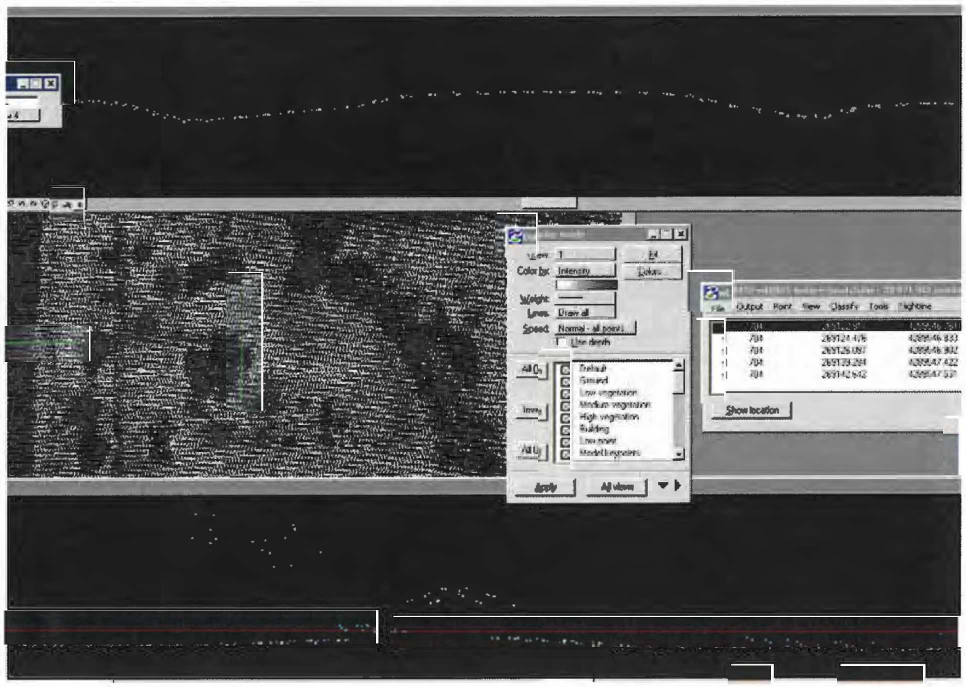
For this project all aerial LiDAR flight lines were analyzed with the DZ image review process. Once identified, areas of concern were further processed through the TerraMatch software to resolve remaining errors.

5.2.8.4.1 TerraMatch

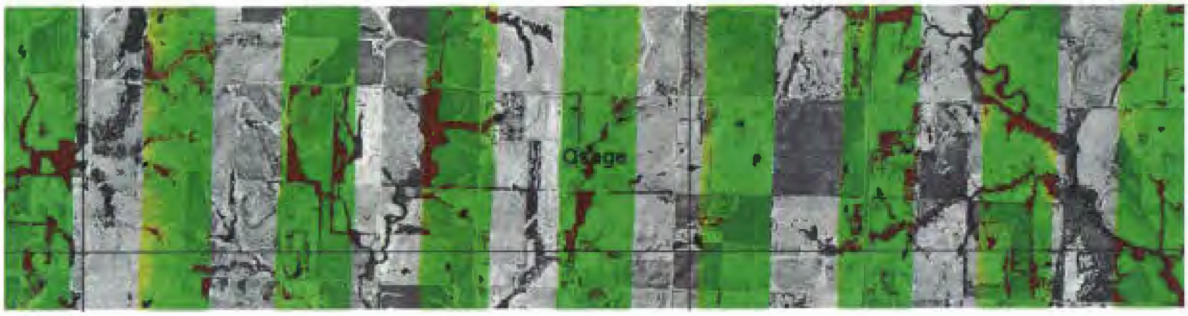
TerraMatch is a least squares adjustment function contained within the TerraSolid LiDAR production software suite. This software allows the operator to perform something similar to the aerial triangulation we perform on imagery on the LiDAR elevation data. The software provides methodology to select areas between common LiDAR flight lines to match points. Once the points are measured, the software performs an adjustment of the sensor parameters such as Dx, Dy, Dz, Domega, Dphi, Dkappa and time dependent variability of these parameters. Once resolved, these adjusted parameters are applied to each flight line to remove the identified misfits in the data.

When significant elevation differences are detected, the affected lines will be evaluated in TerraMatch. Several areas will be identified and an initial visual review of the point cloud is performed to characterize the nature of the differences. The image on the next page illustrates lines requiring a pitch adjustment. Note the separation of the points between the roofline of a residential home.

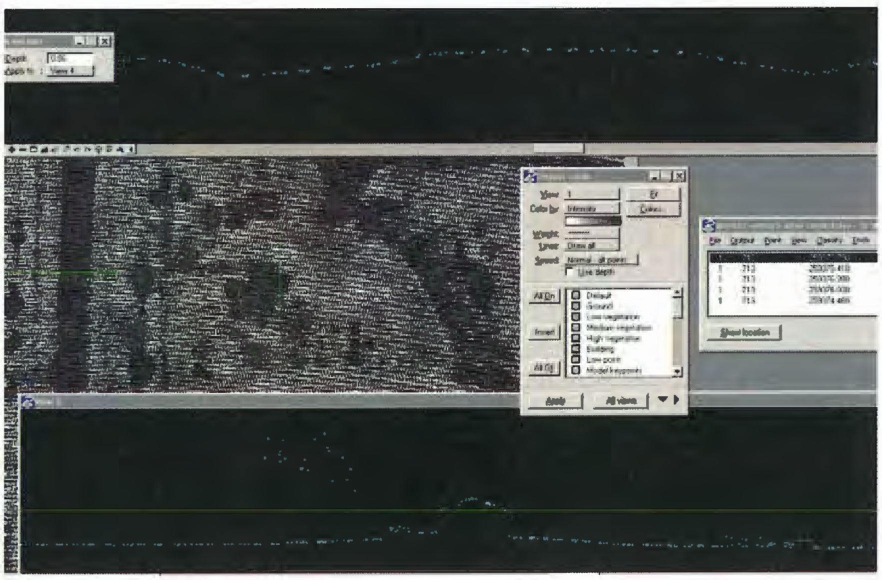
Example of a pitch error; top profile perdendicular to flight, bottom profile parallel.



Training patches are identified in TerraMatch and processed to determine the necessary parameter adjustments that need to be applied to the lines. These adjustments are applied to the training patches to evaluate their effect. This can be an iterative process to fine tune the parameters. Once the final parameters are determined, they are applied to the required lines. This provides a relative adjustment of the data and once a lift, or multiple lifts, have the relative adjustments applied, an absolute adjustment against the survey control is computed and applied. The most prevalent positional offsets are caused by the roll, pitch or heading, which once corrected produce well fitting lines both horizontally and vertically in the overlap areas. The next images illustrate the results of these adjustments.



Adjusted Dz image.



Adjusted Profiles.

Once the data is completely calibrated and meets the project accuracy, Terrasolid/TerraScan software is used to run automated classification routines. Several macros (filter algorithms) may be employed on this project given the variances in terrain and scene morphology to obtain high-yielding results for this project and minimize the time and cost for manual terrain editing.

TerraSolid/TerraScan software is used to run automated classification routines. Several macros (filter algorithms) will be employed on this project given the variances in terrain and scene morphology to obtain high-yielding results for this project and minimize the time and cost for manual terrain editing.

The final Digital elevation model (DEM) will be created once the data has been calibrated, edited and filtered using our workflows described above. This DEM will represent the ground surface, interpolated using a triangulated irregular network from identified ground points. All elevation points on vegetation, bridges, buildings, and other structures will be re-classified into appropriate classes so that they are available for other uses, as needed. Water Bodies (ponds and lakes), wide streams and rivers ("double-line"), and other non-tidal water bodies will be hydro-flattened within the DEM.

5.2.8.5 Product Development Remedies

Once the data has been processed, we are ready to create the DEM and metadata products. These are created from the processed data in an automated production environment. Our processing tools have been built to facilitate this process and make it easier for our QA/QC processors to check and validate each tile and area against its corresponding geodetic control.

5.2.8.6 Generate Tile-and Project Level Metadata

FGDC compliant, tile-level metadata for tiled products and project level metadata for non-tiled datasets will be created for this project using our ESRI-based tools. All metadata will meet required specifications and is further discussed in the Deliverables section below.

5.2.9 HYDRO-FLATTENING BREAKLINES

Surdex has a wide variety of tools available for the compilation of breaklines required for the hydro-flattening services. Surdex's process includes both manual and automated processes. This includes proprietary software developed to assist and improve efficiency in the hydro-flattening process.

Several sets of data are available to assist the technicians in developing the hydro-flattening breaklines. These data include: LiDAR data, color hillshade maps derived from the LiDAR data, NHD, intensity images and existing imagery, etc. – all useful for developing hydro-breakline data.

- **Methodology:** Surdex's methodology focuses on the use of color hillshade data as the source of hydro breakline development. Using color hillshade data in ArcMap is superior for both accuracy and efficiency in breakline compilation in that hillshades provide a much more intelligent representation of the bare-earth surface, allowing for precise determination of hydro features.

- **Create Gridded Hillshade:** The initial process creates a gridded 32-bit hillshade at a 1 meter grid from the bare-earth data, regardless of the final grid output deliverable. Surdex has determined, and built our proprietary software process, on this high resolution surface.

  After the hillshades are created, color cycles are applied depicting various elevations depending on the amount of relief in the project area. Concurrent with the application of color cycles, the hillshade data are converted into an 8-bit 2-D data set and readied for breakline extraction.

- **Digitize Breaklines:** Using the developed hillshades, GIS technicians digitize breaklines on water features consisting of ponds greater than 2 acres and streams/rivers wider than 100 feet-both recommendations from the USGS, LiDAR specification v1.0. To improve efficiency, the various data sets described above may be used as a guide directing the technician to areas containing hydro features and providing confirmation of the features as determined in the hillshades. The hydro-flattening is applied to ponds, again using Surdex proprietary applications, by converting the 2-D breaklines to 3-D lines. These data are then draped over the bare-earth data and, at the discretion of the technicians and based on terrain relief, apply either a "lowest elevation" or "average elevation" value to the 3-D breakline.

- **Streams and Rivers:** Hydro-flattening of streams and rivers is similar to impoundments; the initial compilation is derived from the hillshades as described above. Technicians compile 2-D breaklines at the edges of rivers and streams using techniques and resources as described above. For impoundments, however, rather than applying an average or lowest point elevation to the breaklines, technicians compile a profile centerline to be used in determining elevation. The 3-D shapefile centerline is processed through the Surdex application applying elevations to the breaklines at vertices perpendicular to the centerline creating 3-D breaklines.

By applying consistent elevations to both sides of the rivers/streams, hydro-flattening produces a level surface perpendicular to the stream in the correct direction of flow. Road fills will not be removed at culvert locations creating stream channel breaks at these locations. Streams and rivers will not be broken at locations containing elevated bridges. Hydro-flattening breaklines will be delivered as a non-tiled ESRI feature class for the entire area in polygon/polyline shapefile or geodatabase format.

5.3 ITEM III – TOPOGRAPHICS / PLANIMETRICS

5.3.1 TOPOGRAPHIC MAPPING

Contours can be generated several different ways:

- A LiDAR-only approach.
- A photogrammetric-only approach.
- A combined LiDAR and photogrammetric approach.

The decision as to which approach would be used depends partly on accuracy and partly on the resolution of the LiDAR data and/or photogrammetric imagery.

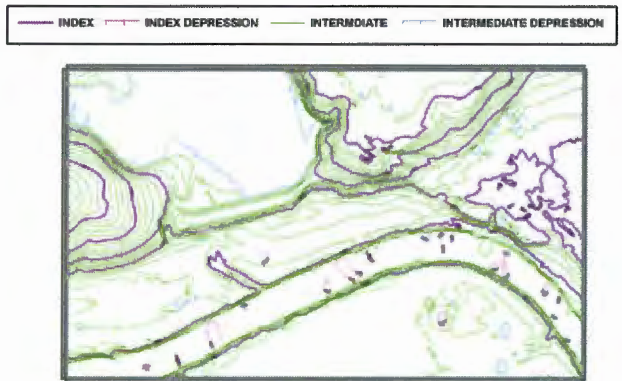
When creating contours from LiDAR, Surdex has defined various levels of contour datasets that reflect common practices, intended usage, and level of effort. The following table defines these levels which range from Level 1 (automatically generated contours) to Level 4 (intended for precise datasets usable for engineering efforts).

Contour From LiDAR Dataset Levels				
Feature	Level 1	Level 2	Level 3	Level 4
Contour index text	Yes	Yes	Yes	Yes
Attributes for depression contours	Yes	Yes	Yes	Yes
Cartographic edit (text and contours)		Yes	Yes	Yes
Hydrographic breaklines			Yes	Yes
Stereo-compiled breaklines				Yes
Planimetric features (optional)				Yes

The following examples illustrate the quality of each Level over the same area.

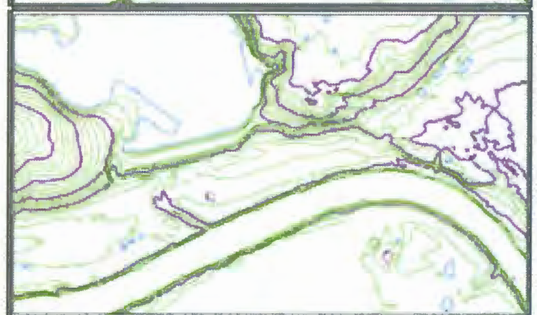
Level 1

- **Automatically generated from LiDAR.**
- **No manual editing.**



Level 2

- **Manual editing.**
- **Anomalies resolved.**
- **Smoothing.**

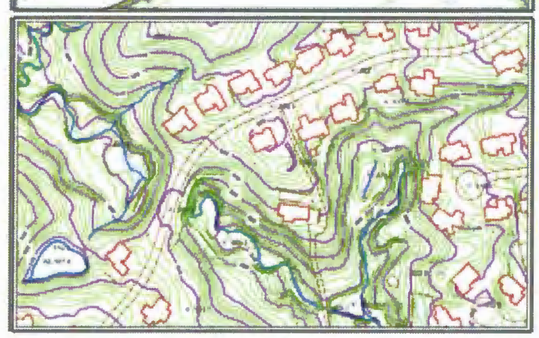


Level 3

- **Begins with Level 2 dataset**
- **Breaklines from LiDAR surface.**
- **Hydrologic enforcement.**
- **Aggressive cartographic editing.**

Level 4

- **LiDAR and/or photogrammetric DTM source.**
- **Stereocompilation.**
- **Highest level of breaklines and cartographic editing.**
- **Planimetric data is optional.**



For this project, it is not clear what level of contour datasets are required for each partner and/or area of interest. Additionally, without options known for fresh or new LiDAR acquisition, we are unclear as to whether the start point is LiDAR data or will require new photogrammetric compilation. In our pricing response, we have provided alternative pricing in this regard.

It is our recommendation to consider Level 3 contours from LiDAR. For large areas, Level 3 provides the best value for most clients. You can always upgrade to Level 4 by adding photogrammetric breaklines for small areas where engineering grade contours are needed.

We have taken the liberty to add options and verbiage in the pricing section to best explain these options.

5.3.2 PLANIMETRIC MAPPING

Fresh compilation of impervious surface features will be accomplished using the newly acquired stereo imagery. Stereo compilation will begin by creating a "seed file" developing specific layers associated with the required planimetric features. The layers will be tailored to meet the attribute requirements corresponding to the required impervious surface mapping. By developing, and adhering to, the layer design, ingestion into the geodatabase containing the required attribution is performed with minimal editing requirements.

5.3.2.1 Post Compilation Editing

Once the stereo compilation is completed, cartographic edits are performed on the feature data. Two types of editing programs available are automatic batching programs, and interactive editing programs.

5.3.2.1.1 Automatic Quality Control batch editing involves the use of user-defined support files that define the editing processes; therefore, special operator intervention is not required. Quality Control batch processing is used for the following tasks:

- Trim line work beneath annotations
- Delete selected line work within closed features
- Edge match and intersect nearly adjacent linear features from different stereo models
- Globally or selectively change feature attributes including: feature codes, character height, and character width
- Subdivide selected line work at all intersection points
- Snap and cut line ends to other lines to ensure connectivity
- Filter excess data points
- Concatenate multiple strings into a single feature.

5.3.2.1.2 Interactive editing allows the operator to perform editing operations at any time. This enables the technicians to correct their own work and allows other digitizing workstations to be used to perform edits ad hoc. Surdex uses the interactive editing program to perform the following tasks:

- Delete lines, symbols, and annotations
- Snap and cut end lines to other lines
- Generate parallels from existing lines
- Move symbols and annotations
- Cutline segments at intersections with other lines.

5.3.2.2 Visual Validation

The visual validation process involves the technician visually evaluating the mapping data. Here the technician views the mapping data along with the digital orthophotography on a workstation and visually reviews it to assure the following requirements are met:

- Topology items are valid
  - Existing dangling arcs are legitimate
  - Breaks in routes are legitimate.
- Evaluate errors of commission
  - Assigned attributes are correct (e.g. paved road is not coded as a dirt road)

   - Completeness of features represented (e.g. compilation of features represented is complete and precise).
- Errors of omission
   - All required features are delineated.

5.3.2.3 Topological Edits

Topology is a mathematical procedure for explicitly defining spatial relationships. Topology expresses different types of spatial relationships as features (e.g., polygon features for areas and lines for linear features). During this process, the Surdex technicians assure the following spatial relationships occur:

- Check for intersection errors (arcs intersecting without nodes)
- Check for data inclusion/exclusion (data was compiled correctly)
- Check for feature placement (everything is in the right place)
- Check for connectivity (features that should connect, actually do)
- Check for continuity (features are continuous, not broken)
- Check for contiguity (adjacent features touch each other).

5.3.2.4 Automated Validation

The automated validation utilizes custom applications that have been developed by Surdex programmers to assure that the following project parameters are met:

- File names adhere to the naming conventions set by the project design
- Topology is the correct type (point, line, polygon)
- Topology is current
- Certain characteristics of topology are correct
   - Polygon labels
   - Arcs intersecting without nodes.
- Data has reasonable geographic extent (i.e., it falls within project boundary)
- Features have appropriate tolerances
- Fuzzy
   - Dangle
   - Weed
   - Grain.
- Correct projection
- Database adheres to the data dictionary
   - Attribute items have the correct definitions
   - Values are in correct range.

Similar to our comments in the contour section, we took the liberty to modify the wording in the pricing section for planimetrics and impervious surface to best represent our process and our cost.

Section 6: Pricing

6. RESPONSE/PRICING PAGE

In compliance with this Request for Quotation and subject to all the conditions thereof, the Respondent agrees to furnish the services/equipment/supplies requested and proposed and certifies he/she has read, understands, and agrees to all terms, conditions, and requirements of this quotation and is authorized to contract on behalf of the Respondent named below. (Note: This form must be signed. All signatures must be original).

Company Name: Surdex Corporation

Address: 520 Spirit of St. Louis Blvd.

Chesterfield, MO 63005

Telephone 636-368-4400 Fax: 636-368-4401

Federal Tax ID (or Social Security #) 43-0690641

Print Name: Ronald C. Hoffmann Title: President

Signature: RC Hoffmann Date: 10/17/2014

E-Mail Address: RonHCorp@surdex.com

6.1 PRICING:

Pricing – The Agency is providing this Response Form for summarized pricing. Please attach a more detailed listing outlining all costs. As appropriate, items should include professional fees, materials, out of pocket expenses, sub-consultant fees and any other costs anticipated by the Respondent to satisfy the purpose of this Request for Quotation.

6.1.1 Item I – Orthophotography (See Attachment A)

A. OPTION 1 – Orthophoto Regional Flight

1.	Cost for 4.8 sqmi - 3" Color Orthophotography	$ 5,984
2.	Cost for 1,340 sqmi - 6" Color Orthophotography	$ 109,426
3.	Cost for 2,287 sqmi - 12" Color Orthophotography	$ 44,795
	Total	$160,205

Color-IR (cost list by County party to PAQ)

$500/county

Ground control targets (cost list by County party to PAQ)

Included in Orthophoto Pricing

Optional digital file format MrSID photomosaic (cost list per County party to PAQ)

$500/county

Alternate Bids

B. OPTION 2 – Alternate Pricing Per Square Mile Matrix

Square Miles	3"	6"	12"
30 to 100	$400	$150	$50
101 to 800	$300	$100	$35
801 to 2000	$255	$85	$29
2001 to 4000	$240	$80	$27
4001+	$225	$75	$25

Alternate Bids:

6.1.2 Item II – Boone County LiDAR

A. OPTION 1 – Classifying Bare-Earth LiDAR: County-wide Flight and Processing (See Attachment B)

1a.	Cost for 432 sqmi- 0.7m County LiDAR (bare earth and hydro flatten to USGS spec)	$ 72,835
1b.	Cost for 264 sqmi- 0.7m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 49,540
1c.	Other Additional Costs	$
	Total	$ 122,375
2a.	Cost for 432 sqmi- 1.0m County LiDAR (bare earth and hydro flatten to USGS spec)	$ 63,975
2b.	Cost for 264 sqmi- 1.0m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 43,205
2c.	Other Additional Costs	$
	Total	$ 107,180

B. OPTION 2 – Classified Bare-Earth LiDAR: County-wide Flight but only Metro Processing

1a.	Cost for 432 sqmi- 0.7m County LiDAR (no processing)	$ 39,430
1b.	Cost for 264 sqmi- 0.7m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 49,540
1c.	Other Additional Costs	$
	Total	$ 88,970
2a.	Cost for 432 sqmi- 1.0m County LiDAR (no processing)	$ 30,570
2b.	Cost for 264 sqmi- 1.0m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 43,205
2c.	Other Additional Costs	$
	Total	$ 73,775

C. OPTION 3 – Classified Bare-Earth LiDAR: Metro Only Flight and Processing

1a.	Cost for 264 sqmi- 0.7m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 63,285
1b.	Other Additional Costs	$
	Total	$ 63,285
2a.	Cost for 264 sqmi- 1.0m Metro LiDAR (bare earth and hydro flatten to USGS spec)	$ 53,820
2b.	Other Additional Costs	$
	Total	$ 53,820

6.1.3 Item III – Topographics / Planimetrics

The City of Columbia has topographic and planimetrics of the requested area from 2007 and 2002. It is left to the discretion of the Offeror to base the cost on updating the City's current information or recreating the planimetrics from the new flight information. Each Offeror will be provided with a sample of several of the panels to help with their determination.

A. <u>Topographics</u> / Planimetrics Deliverables: Orthophotography & LiDAR Based

Option 1 (See Attachment C)

1.	Cost for 264 sqmi - Metro Area New 2' Contours – Surdex Level 3	$ 25,055
2.	Cost for 264 sqmi - Metro Area Impervious Surface	$381,980

3.	Cost for 8.5 sqmi - New Planimetrics		$ 25,380
4.	Cost for 6 sqmi – Updated Planimetrics		$ 2,345
		Total	$ 434,760
5.	Additional Cost for Surdex Level 4 Contours		$ 268,905
		Total	$ 703,665

Option 2 (See Attachment D)

1.	Cost for 264 sqmi - Metro Area New 2' Contours – Surdex Level 3		$ 25,055
2.	Cost for 264 sqmi - Metro Area Impervious Surface		$ 381,980
3.	Cost for14.5 sqmi - New Planimetrics		$ 33,035
4.	Cost for 5 sqmi – Updated Planimetrics		$ 3,210
		Total	$ 443,280
5.	Additional Cost for Surdex Level 4 Contours		$ 268,905
		Total	$ 712,185

Option 3 (See Attachment E)

1.	Cost for 264 sqmi - Metro Area New 2' Contours – Surdex Level 3		$ 25,055
2.	Cost for 264 sqmi - Metro Area Impervious Surface		$ 381,980
3.	Cost for 19 sqmi - New Planimetrics		$ 44,240
4.	Cost for 5.5 sqmi – Updated Planimetrics		$ 1,915
		Total	$ 453,190
5.	Additional Cost for Surdex Level 4 Contours		$ 268,905
			$ 722,095

Option 4 Topographics / Planimetrics Price Matrix

Cost Per Sq. Mile	New Planimetrics	Updated Planimetrics	New 2' Contours (Level 3 / Level 4)	Impervious Surface
Urban	$7640	$5350	$95 / $1115	$6882
Suburban	$3005	$2640	$95 / $1115	$2640
Rural	$1345	$1120	$95 / $1115	$1120

B. Topographics / Planimetrics Deliverables: Orthophotography Based ONLY (LiDAR not flown)

Option 1 (See Attachment F)

1.	Cost for 6 sqmi - New Planimetrics and Topographics		$ 33,680
2.	Cost for 8.5 sqmi – Full Update Planimetrics		$ 35,350
3.	Cost for 2 sqmi – Minimal Update Planimetrics		$ 3,165
		Total	$ 72,195

Option 2 (See Attachment G)

1.	Cost for 14.5 sqmi - New Planimetrics		**$ 64,850**
2.	Cost for 5 sqmi - Full Update Planimetrics		**$ 15,415**
3.	Cost for 5 sqmi - Minimal Update Planimetrics		**$ 5,650**
		Total	**$ 85,915**

Option 3 (See Attachment H)

1.	Cost for 19 sqmi - Full Update Planimetrics		**$ 60,820**
2.	Cost for 47.5 sqmi - Minimal Update Planimetrics		**$ 101,430**
		Total	$ 162,250

Option 4 Topographics / Planimetrics Price Matrix

Please indicate pricing per square mile for Planimetics | Planimetrics + Topo for the ground feature density categories below.

Cost Per Sq. Mile	Full New		Full Update		Minimal Update Only	
	Plan	Plan+Topo	Plan	Plan+Topo	Plan	Plan+Topo
Urban	$8255	$12,370	$5,780	$8,660	$4,125	$6,185
Suburban	$3245	$7,360	$2,270	$5,150	$1,625	$3,680
Rural	$1450	$4,050	$1015	$2,840	$725	$2,025

6.1.4 Additional Charges / Alternate Deliverables (if any)

List any additional charges below – Attach supporting documentation, if necessary and note if charges a specific cost per certain county/entity or a standard rate for the regional flight area.

	$
	$
	$
Total	$

6.1.5 Delivery Dates

a. Estimated number of planes used for flight(s): Ortho: 2 LiDAR: 1

b. Estimated delivery date for ITEM I (Orthophotography): 5/15/2015

d. Estimated days to complete ITEM II (LiDAR): 8/5/15

e. Estimated delivery date for ITEM III (Topographics / Planimetrics): TBD

Surdex has given our best estimate on realistic delivery dates above. The options selected for the final scope of work will affect the delivery dates. For instance, if LiDAR is selected, we will want to delay ortho production for the LiDAR areas to produce the new DEM before producing orthos. We will work with the partners during final scoping of the project to optimize the delivery schedule to meet your needs.

6.2. CONTACT PERSON:

Provide a contact person who will be responsible for coordinating the efforts and personnel of all parties involved in the response, to include, but not be limited to, oral presentations, demonstrations, site visits and responses to request for clarification, if any. Provide the following:

Information on the following page page.

Name: Ronald C. Hoffmann

Organization: Surdex Corporation

Address: 520 Spirit of St. Louis Blvd. Chesterfield, MO 63005

E-mail: RonHCorp@surdex.com

Phone Number: 636-368-4400

Fax: 636-368-4401

6.3 IDENTIFICATION OF BIDDERS/OFFERORS:

Identification of Bidders/Offerors: How were you notified or heard about this bid/quotation?

_____ Newspaper advertisement

_X_ Boone County Electronic Bid Notification

_____ other, please list:

Addendum Acknowledgement

OFFEROR has examined copy of **Addendum #1** to Request for Proposal ***48-17OCT14 – PAQ Request for Photogrammetric Products & Services*** receipt of which is hereby acknowledged:

Company Name: Surdex Corporation

Address: 520 Spirit of St. Louis Blvd. Chesterfield, MO 63005

Phone Number: 636-368-4400 Fax Number: 636-368-4401

E-mail: TimD@surdex.com

Authorized Representative Signature: Tim Donze Date: 10/17/2014

Authorized Representative Printed Name: Tim Donze

BOONE COUNTY, MISSOURI
Request for Proposal #: 48-17OCT14 – PAQ Request for Photogrammetric Products & Services

ADDENDUM #1 - Issued October 15, 2014

This addendum is issued in accordance with the Request for Proposal and is hereby incorporated into and made a part of the Request for Proposal documents. Offerors are reminded that receipt of this addendum should be acknowledged and submitted with Offeror's Proposal Response.

Scope of Work for the above noted Request for Proposal and the work covered thereby are herein modified as follows, and except as set forth herein, otherwise remain unchanged and in full force and effect:

I. The County has received the following questions and is providing a response:

1. **Question:** Can you provide a sample of the existing planimetric mapping data?

   Response: Some additional sample data for the planimetric mapping has been posted for the vendors at http://maps.showmeboone.com/downloads/files/City_of_Columbia_Plan_&_Impervious_Samples.zip

2. **Question:** Please identify the features desired in the impervious surface option as well as key differentiators between the desired planimetric collection and the new impervious surface data collection.

   Response: Key feature is impervious, as defined in the planimetric geodatabase data dictionary. Vendors are welcome to offer options for impervious surface differentiation based on other data elements in the planimetric geodatabase data dictionary, which also includes building footprints (poly), road edge (previously only line), parking (previously only line), driveway (previously only line).

   The goal of the impervious surface product is to provide baseline 2015 data. Primary uses include stormwater billing based on amount of impervious surface by parcel and environmental modeling of stormwater run off. The key differentiation is imperviousness, or surface on real property where infiltration into the earth has virtually been eliminated by the works of man. Impervious surfaces include but are not limited to: roofs, paved driveways, patio areas, sidewalks, parking lots, storage areas, and other concrete, oil, or macadam surfaced areas which prevent percolation of stormwaters into the earth's surface. Differentiation among types of impervious is not expected in the "Cost for $264 sqmi - Metro Area Impervious Surface," although vendors are welcome to specify alternate deliverables in section 6.1.4.

   The City has some impervious data from other projects including impervious for dense and commercial areas based on 2011 leaf off imagery and 2007 leaf on impervious land cover. Other data that may aid in generation include: maintained structure footprints, street centerlines, and sidewalks (with widths); and 2007 planimetrics including road edge (line), parking (line), and driveway (line). Samples of the current impervious surface data are included. Samples of the 2007 planimetrics including road edge, parking, and driveway are provided as Esri geodatabase and DWG (the DWG for the convenience of select tiles).

3. **Question:** Is there a possibility of speaking with the technical contact at the City of Columbia regarding question #2 and likely follow up questions?

   Response: Please review the response provided to Question #2 and email any follow up questions as indicated in the Request for PAQ document.

By: Amy Robbins
Amy Robbins
Senior Buyer

OFFEROR has examined copy of **Addendum #1** to Request for Proposal ***48-17OCT14 – PAQ Request for Photogrammetric Products & Services*** receipt of which is hereby acknowledged:

Company Name: Surdex Corporation

Address: 520 Spirit of St. Louis Blvd. Chesterfield, MO 63005

Phone Number: 636-368-4400   Fax Number: 636-368-4401

E-mail: TimD@surdex.com

Authorized Representative Signature: Tim Donze   Date: 10/17/2014

Authorized Representative Printed Name: Tim Donze

JASON KANDER
MISSOURI SECRETARY OF STATE

MISSOURI ONLINE UCC FILING

Online Help

Gen. Business - For Profit Details as of 11/17/2014

- Forms
- Filing Fees
- FAQ
- Corporation Filings
- SOS Home
- Contact Us

*Required Field

If you wish to file online, select the filing from the Filing drop-down list, then click the FILE ONLINE button.

To file a registration report, click the FILE REGISTRATION REPORT button.

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Select filing from the list.

Filing Type Acceptance of a General Business to a Non Pr

FILE ONLINE

ORDER COPIES/ CERTIFICATES

General Information Filings Address Contact(s)

Name(s) SURDEX CORPORATION
Address 520 Spirit of St.Louis Blvd Chesterfield, MO 63005
Type Gen. Business - For Profit
Charter No. 00082902
Domesticity Domestic
Registered Agent EARL R. HOFFMAN 520 SPIRIT OF ST LOUIS BLVD CHESTERFIELD, MO 63005
Status Good Standing
Date Formed 6/22/1954
Duration Perpetual
Renewal Month January
Report Due 4/30/2015

SAM Search Results
List of records matching your search for :

Search Term : Surdex* Corporation*
Record Status: Active

ENTITY SURDEX CORPORATION			Status:Active
DUNS: 006332415	+4:	CAGE Code: 8G253	DoDAAC:
Expiration Date: Jan 22, 2015	Has Active Exclusion?: No	Delinquent Federal Debt?: No	
Address: 520 SPIRIT OF ST LOUIS BLVD			
City: CHESTERFIELD		State/Province: MISSOURI	
ZIP Code: 63005-1002		Country: UNITED STATES	