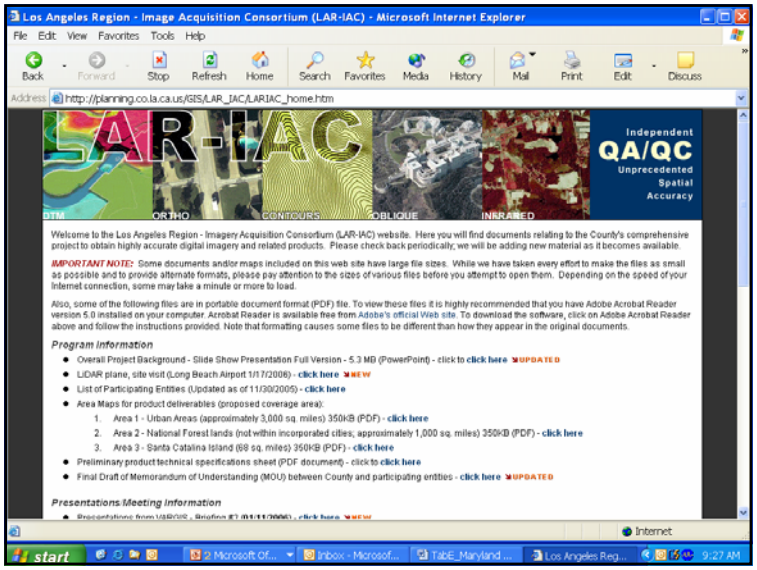
LAR-IAC

Independent QA/QC
Status Briefing
May 11, 2006

Dave Maune, PhD, PS, GS, CP

Project Manager

Dewberry & Davis



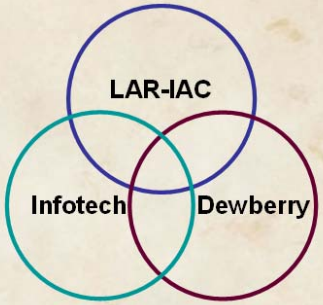
Conventional aerial cameras would need three rolls of film and still yield 8-bit data

12-bit DMC imagery (b/w, color & CIR), more data content

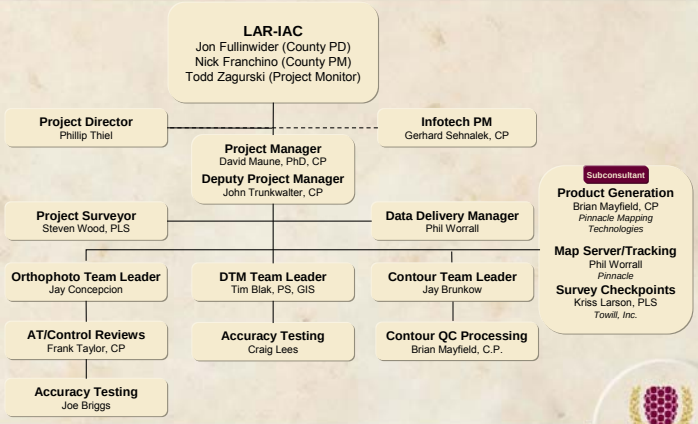
Quality Assurance/Quality Control (QA/QC)

QA: Ensure the government gets what it paid for

QC: Validate production procedures used



Los Angeles Region – Imagery Acquisition Consortium (LAR-IAC)



Major Responsibilities of Dewberry Team

Dewberry Tasks:

- Project Management
- Quality Plan
- AT/control reports
- Horizontal & vertical accuracy assessments
- Orthophoto QA/QC
- LiDAR DTM QA/QC
- Review of contour QA/QC

Pinnacle Tasks:

- Map Server
- AT/control reports
- Contour QA/QC
- Completeness reviews
- Product generation
- Product delivery/training

Towill, Inc. Tasks:

- Survey QA/QC checkpoints

Why Independent QA/QC

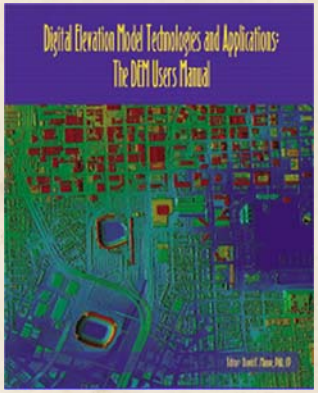
- Paper maps were previously produced manually by cartographers, taking years to produce; cartographic contour lines took especially long; paper maps were designed for human viewing and analysis
- GIS data, used for computer analyses for rapid decision making (e.g., EOCs), replacing paper maps. DTMs and digital orthophotos are GIS base maps, overlaid with GIS layers. Orthophotos are far less expensive, produced in mere months, mostly by automated processes.
- The more automated the process, the greater the need for independent QA/QC; most products are not reviewed in any detail by humans prior to delivery

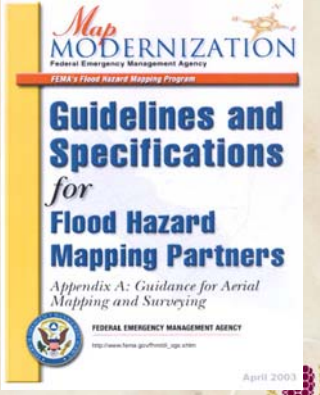
EOC: "I need a map that shows all the locations of *this* and *that*. I'll be back in 10 minutes for it"

Why Dewberry

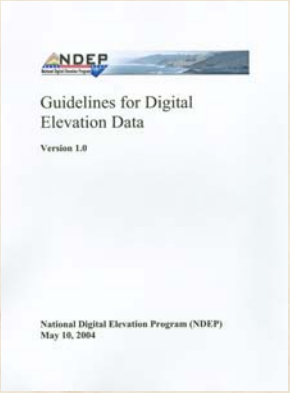
- Dewberry has written the major accuracy standards and guidelines
- We specialize in independent QA/QC of digital orthophotos and DTMs produced by others (NC, VA, MD, IN, VT, plus many individual counties)
- We have no inherent conflict of interest with producers; we don't compete for production
- All clients, as well as producers being evaluated, have thanked Dewberry for project success.

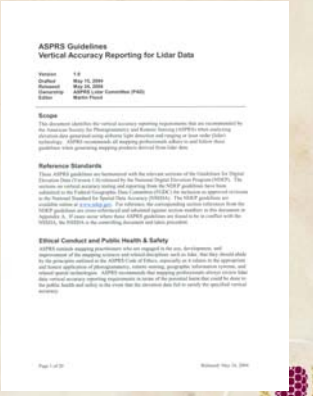
Dewberry specializes in "user requirements"





Dewberry drafted these accuracy guidelines

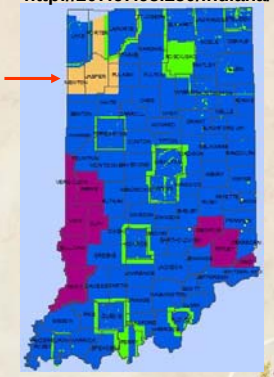




On one project, Dewberry failed all DVDs in the box; they had been rushed by producer

LAR-IAC Quality Plan based on Dewberry's lessons learned elsewhere

http://207.67.95.250/indiana/

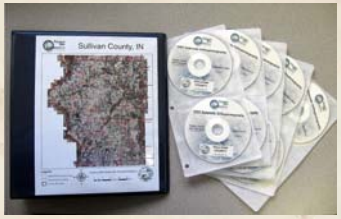


Dewberry/Pinnacle Synergy in Indiana

Dewberry performed QA/QC on up to 15,000 tiles/week, made edit calls

Pinnacle reviewed revised tiles for edit call corrections, performed reviews for completeness, generated value-added products, prepared all county and township deliverables, and provided training/data installation assistance →

Separate countywide deliverables in Indiana similar to spatially-limited datasets in L.A.



Spatially-limited datasets

Agoura Hills	El Segundo	Palos Verdes Estates
Arcadia	Glendale	Paramount
Beverly Hills	Inglewood	Pasadena
Burbank	La Habra Heights	Redondo Beach
Carson	Lakewood	Santa Clarita
Cerritos	Long Beach	Santa Monica
Covina	Manhattan Beach	Torrance
Culver City	Monrovia	Westlake Village
Diamond Bar	Palmdale	Whittier

Part I — QA/QC of Digital Orthophotos

- Aerial triangulation (AT) analyses
- Horizontal accuracy assessments
- Aesthetics QA/QC on 4,500 of 12,000 4”, none of 1’
- Completeness QA/QC
- Product generation of all countywide and “limited area” deliverables
- Assistance with data installation and training

To Date:

- Accepted 10 AT blocks for 4” orthophotos
- Identified problems with both AT blocks for 1’ orthophotos; recommend additional photo-ID points, new AT

Orthoimagery Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
A.1	Media: DVD 2.0, 4.7 Gb single-sided, (4.3 Gb usable), snap server with 2 Tb	Media is readable, all files accessible, no files corrupted Snap servers provided by LAR-IAC.
A.2	Media label	As specified by L.A. County
A.3	File organization	Files written in tile sheet order
A.4	File name	Conforms to required convention - based on CA SPCS Zone 5 xxxx_yyyya for 4 inch and xxxx_yyyy for 1 foot orthos
A.5	GeoTIFF format	File reads in ESRI (see sample of Geotiff header
A.6	Files must open in correct location	Files must open with ESRI software
A.7	Pixel definition	File must reference the pixel located in the upper left hand corner of the tile as the point of origin

File naming convention (4” tile)

If tile index northwest corner is:

- Easting (x-coordinate): 6,565,280.000 ft
- Northing (y-coordinate): 1,822,640.000 ft

Then, file name will be

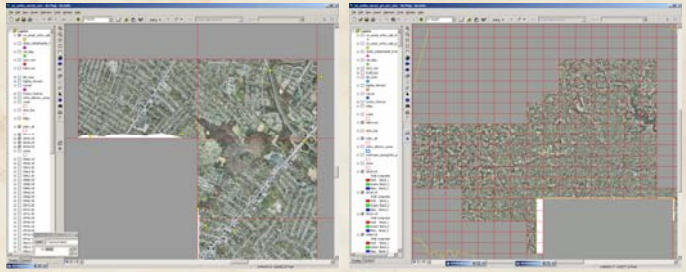
6565_1822a

(This example is in L.A. near 34º 118º)

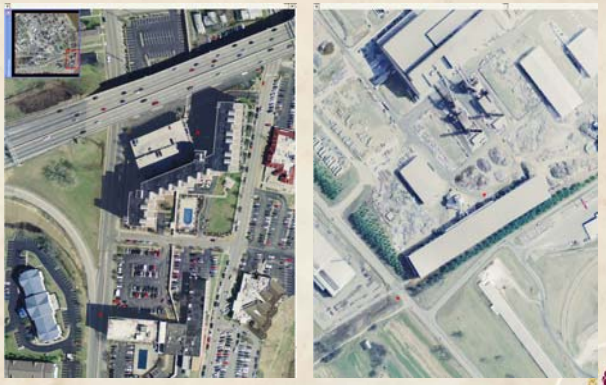
Orthoimagery Acceptance Criteria (cont’d)

Criteria	Characteristic	Measure of Acceptability
A.8	Georeferencing	For correct pixel size 0.33 ft (4 inch) and 1 ft
A.9	Vertical Datum	NAVD88
A.10	Projection	NAD83 State Plane – California Zone 5
A.11	Horizontal Datum	NAD83
A.12	Units	U.S. Survey Feet
A.13	24 bit natural color	256 levels of value for each band, 0=black, 255=white
A.14	Tonal quality	<2 percent of values at 0 or 255, to the extent possible per client’s radiometry choices
A.15	DMC sensor anomalies	TBD
A.16	Conformance of tile index grid	Tile matches grid, no gaps between tiles at 1:1 view

Tiles may be incomplete >200’ outside boundary

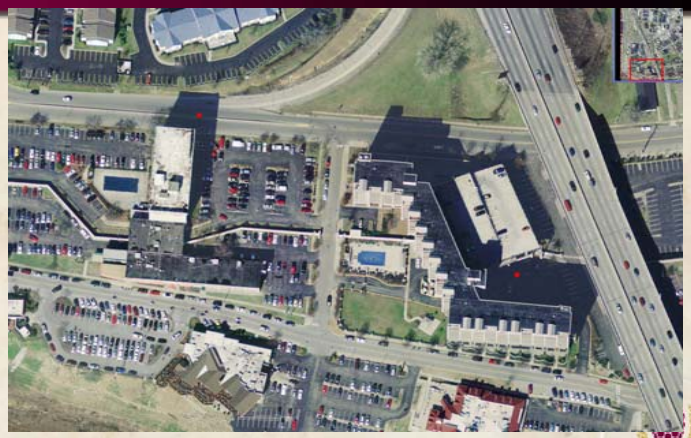


<2% of pixels should be white or black



LAR-IAC has no separate criteria for shadows …

…but 12-bit DMC imagery will be better



Dewberry will look for echoes or ghosting

We will look for spectral reflection, speckles and pixelation

If we see this, we'll ask Infotech if they can fix

Orthoimagery Acceptance Criteria (cont'd)

Criteria	Characteristic	Measure of Acceptability
A.17	Image appearance	The difference in average pixel values on either side of a mosaic seam-line should generally not exceed 70 (30 preferred), when measured on a homogeneous surface with similar characteristics (water surfaces are exempt from this requirement). Greater differences may be allowed if the correction will cause significant degradation of the image content on either side. No image will be rejected for such radiometry inconsistencies without prior approval of L.A. County. Image acquisition should be obtained with acceptable weather conditions per ASPRS standards.

These are seamlines between two scales; this could happen in L.A. County's National Forests

Individually, these tiles look OK.

Side-by-side, these tiles look wrong

Orthoimagery Acceptance Criteria (cont'd)

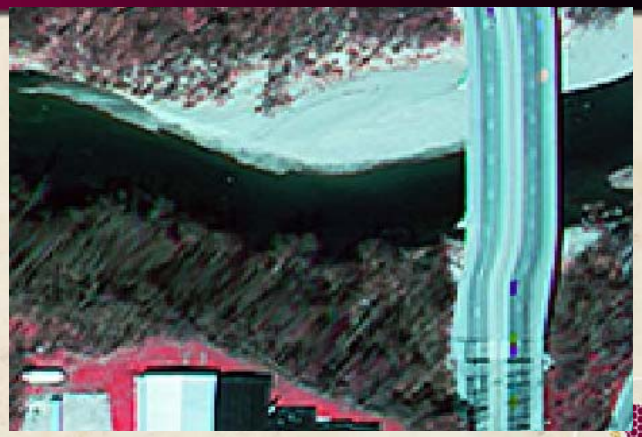
Criteria	Characteristic	Measure of Acceptability
A.18	Radiometry	Radiometry should be consistent throughout the imagery, on large and small scales. Mosaic seamlines should not produce great visual (tonal, brightness) differences in imagery on either side (water being exempt from this requirement). In some instances, greater differences may be allowed if the correction will cause significant degradation of the image content on either side. Color balancing between tiles should be as consistent as possible. Radiometry target chips will be reviewed and approved by the LAR-IAC prior to orthoimagery production. The chips will provide a guide and expectation of final imagery appearance.

Sometimes, radiometry may be just plain wrong

Orthoimagery Acceptance Criteria (cont'd)

Criteria	Characteristic	Measure of Acceptability
A 19	Smears	Normally corrected by adding mass points or breaklines to DEM/DSM as necessary to reflect actual terrain or by image processing where appropriate. Where DSM/DEM corrections or image processing will result in reduced horizontal accuracy or misrepresentation of the location or appearance of important features (buildings, roads, etc.), the smear will remain untreated. No image will be rejected for smears without prior approval of L.A. County.
A.20	Wavy features	Distinct linear ground features (such as road markings and curbs) should not deviate from their apparent path by more than 3 feet measured perpendicular to the feature within any 100 foot distance measured along the feature length.

Smeared and distorted from wrong DTM



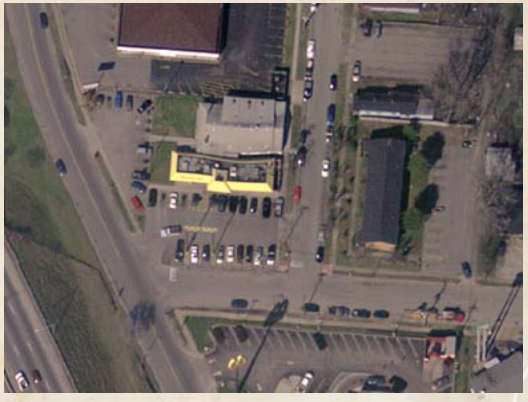
Crooked roofline, before and after revised DTM

Anybody could see this bridge was wrong

Many would not recognize this bad overpass

“Hourglass” bridge, before and after breaklines

Even if warp is less than 3 ft in 100, this fails the “Mayor’s test.” Also, appears artificially brown



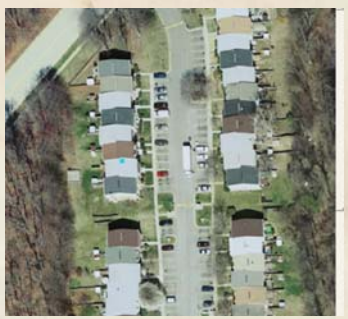
Orthoimagery Acceptance Criteria (cont’d)

Criteria	Characteristic	Measure of Acceptability
A.21	Mosaic lines	No mosaic lines through buildings. No mosaic lines through above-ground transportation structures carrying automobiles or trains unless unavoidable.
A.22	Metadata	Complies with standard (project-specific metadata that points to web site for details). Meets minimum FGDC Content Standard.
A.23	Building lean within Downtown areas (polygons provided by LA)	The maximum displacement of a 10 story building at the edge of a model will be 16 feet (approximately 1.6 feet per story) LAR-IAC will provide building heights or number of stories when Dewberry cannot determine from imagery.
A.24	Bridges	Accuracy of multi-layered bridge decks identified by L.A. County
A.25	Coverage	At least 200’ beyond LAR-IAC boundary.
A.26	Tile grid layout	At least 200’ buffer around LAR-IAC boundary.

Multi-layer bridge decks must have breaklines

Other elevated features don't justify breaklines

Note subtle erroneous seamline on the left



Seamline errors often difficult to see

These are examples of why we like to receive files showing seamlines

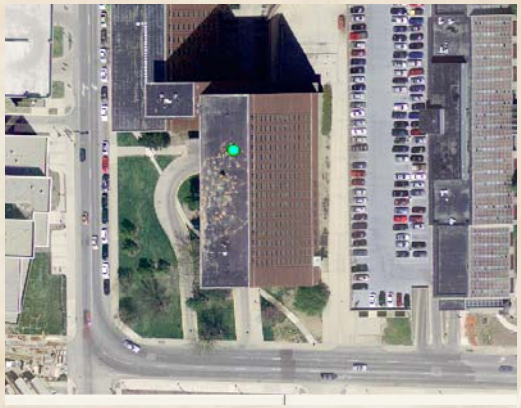
Common seamline errors on roads

Seamline criteria for moving objects

- This barge looks like it is sinking
- L.A. County may have similar concerns
- Normally seams may occur through moving objects, but not if it becomes cause for controversy

Building lean examples

We can't always count the stories to determine if lean is less than 1.6 ft per story



Major components of our QA/QC

1. Aesthetics
2. Accuracy
3. Completeness
4. Deliverables
5. Training

Acceptance Criteria (1-foot GSD, 1”=200’) Horizontal Accuracy Testing

Criteria	Characteristic	Measure of Acceptability
B.1	Ground Resolution	1.0 U.S. Survey Foot
B.2	Tile size	5280’ x 5280 ‘ (5280 x 5280 pixels)
B.3	RMSE of QA/QC points measured on the image (ASPRS Class I)	$RMSE_x = RMSE_y = 2$ ft (2 pixels) Or $RMSE_r = 1.4142 * RMSE_x = 2.83$ ft
B.4	NSSDA radial accuracy	NSSDA accuracy (95% confidence level) such that $1.7308 * RMSE_r$ </= 5 ft
B.5	Mismatch of features along mosaic lines and production block boundaries of equal scale	Equal to or less than 3 pixels (3-ft) on well defined ground features (roads, sidewalks, curbs, etc.)

Acceptance Criteria (4-inch GSD, 1”=100’) Horizontal Accuracy Testing

Criteria	Characteristic	Measure of Acceptability
C.1	Ground Resolution	0.33 U.S. Survey Foot (2 decimals)
C.2	Tile size	2640’ x 2640’ (8000 x 8000 pixels)
C.3	RMSE of known ground points measured on the image	$RMSE_x = RMSE_y = 1.00$ ft (3 pixels) or $RMSE_r = \sqrt{(RMSE_x^2 + RMSE_y^2)} = 1.41$ ft
C.4	NSSDA radial accuracy	NSSDA accuracy (20+ points) such that $1.7308 * RMSE_r$ </= 2.5 ft
C.5	Mismatch of features along mosaic lines between pixel resolution blocks of equal scale	Equal to or less than 4 pixels on well defined ground features (roads, sidewalks, curbs)
C.6	Mismatch of features between 1-foot and 4-inch images	Equal to or less than 3 pixels (1 ft) on well defined ground features (roads, sidewalks, curbs).

Horizontal comparison of National Map Accuracy Standard (NMAS) and National Standard for Spatial Data Accuracy (NSSDA)

NMAS Map Scale	NMAS CMAS 90% confidence level (1/30th inch)	NSSDA $RMSE_r$ [function of $RMSE_x$ & $RMSE_y$]	NSSDA $Accuracy_r$ 95% confidence level
1” = 50’	1.7 ft	1.1 ft	1.9 ft
1” = 66’	for LAR-IAC 4” pixel orthos		2.5 ft
1” = 100’	3.3 ft	2.2 ft	3.8 ft
1” = 132’	for LAR-IAC 1’ pixel orthos		5.0 ft
1” = 200’	6.7 ft	4.4 ft	7.6 ft

NMAS relevant to hardcopy maps printed at these scales
NSSDA relevant to digital geospatial data compiled at these scales
Multiply $RMSE_r$ x 1.7308 to get $Accuracy_r$

Horizontal QA/QC Point Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
G.1	Visibility on digital imagery	QA/QC checkpoints must be clearly photo-identifiable on images at map scales evaluated (4-inch and 1-foot orthos)
G.2	Well defined	Points must be clearly visible and not elevated (no fence posts, fire hydrants, etc. that cast shadows)
G.3	Documentation	Each point is documented to describe the photo-identifiable feature surveyed
G.4	Terrestrial images	Each point is photographed from the ground to help in photo-identification
G.5	Survey accuracy and description of survey procedure used	Accuracy estimate, to include description of survey procedures used to achieve such accuracy.

NSSDA (3.2.2) Accuracy Test Guidelines

- "Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points[3] in the dataset with coordinates of the same points from an independent source of higher accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy."
- "A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level allows one point to fail the threshold given in product specifications"
- NOTE: Dewberry normally tests AT blocks separately, but uses 6 points/block (min) and 20 points/block (max)

[3] See Appendix 3-C, Section 1

NSSDA Appendix 3-C, section 1

Well-Defined Points

- "A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points."
- "For orthoimagery, suitable well-defined points may represent features such as small isolated bushes, in addition to right-angle intersections of linear features."

QA/QC checkpoints must be photo-identifiable We need to know what to look for on images

QA/QC checkpoint surveys preferably 3 times more accurate than the mapping product being tested for horiz./vert. accuracy, with same datum and epoch.

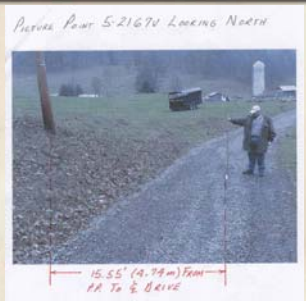
LAR-IAC provided control point requirements

- Known network (absolute) accuracy better than $RMSE_x$ and $RMSE_y$ of 4 inches relative to NSRS or California HARN monuments
- Known datum and epoch
- Control points must be clearly identifiable on the digital orthophotos
- If not painted X's, we prefer terrestrial photos or description of the point, preferably showing the color of the point and surrounding features.

Control points used for AT

Lesson Learned in Virginia & North Carolina

- In this example, Dewberry challenged the VDOT survey, saying *"the coordinates for the point (telephone pole) plotted in the middle of the road, about 16' away."*
- We ultimately learned the surveyor failed to apply the 15.55 ft offset
- Of >11,000 QC points used, Dewberry identified ≈ 20 survey errors in VA and NC; the original surveyors <u>never once</u> acknowledged their own errors



Note: Telephone poles and other elevated features often make poor QC points because of shadows and potential offset errors

Typical Accuracy Assessment Spreadsheet

Reference: FGDC's Geospatial Positioning Accuracy Standards
National Standard for Spatial Data Accuracy (NSSDA), FGDC-STD-007.3-1998

Block O	QA/QC Points as surveyed by Woolpert & Major Engr.			Orthophotos measured by Dewberry		Ortho minus surveyed coordinates		Discrepancies Squared as required for RMSE calculations	
	Indiana SPC West NAD 83(1986)		NAVD 88	Indiana SPC West NAD 83 (1986)		Indiana SPC West NAD 83 (1986)			
Point Number	Northing (y) (US Survey Feet)	Easting (x) (US Survey Feet)	Elevation (z) (Feet)	Northing (y) (US Survey Feet)	Easting (x) (US Survey Feet)	Δy (Northing) (US Survey Feet)	Δx (Easting) (US Survey Feet)	Δy^2 (ft^2)	Δx^2 (ft^2)
504	2,175,759.671	3,026,651.145	700.694	2,175,757.764	3,026,651.944	-1.907	0.799	3.637	0.639
502	2,299,695.987	3,046,894.161	798.908	2,299,695.846	3,046,894.315	-0.021	0.154	0.000	0.024
Ofcm_32	2,226,762.929	2,994,705.723	690.411	2,226,762.415	2,994,706.409	0.296	0.706	0.092	0.507
Ofcm_33	2,192,123.040	3,002,518.940	666.198	2,192,122.967	3,002,519.579	-0.073	0.639	0.005	0.408
Ofcm_34	2,263,732.826	3,005,160.634	730.963	2,263,732.359	3,005,160.846	-0.167	0.212	0.028	0.045
Ofcm_36	2,354,388.428	3,002,557.780	695.491	2,354,388.489	3,002,558.192	0.061	0.392	0.004	0.154
Ofcm_35	2,192,135.591	3,042,770.622	694.651	2,192,134.640	3,042,772.606	-0.951	1.984	0.904	3.937
Ofcm_44	2,340,186.470	3,071,241.749	776.564	2,340,187.462	3,071,243.037	1.008	0.288	1.016	0.083
Ofcm_45	2,263,505.197	3,074,197.271	691.426	2,263,504.936	3,074,197.005	-0.261	-0.266	0.068	0.035
Ofcm_46	2,357,871.570	3,100,100.097	701.386	2,357,871.060	3,100,100.569	-0.510	0.472	0.260	0.223
							Sums	6.012	6.134
							MSE	0.601	0.613
							$RMSE_{xy}$ (ft)	0.775	0.783
							$RMSE_x$ (ft)	per NSSDA	1.192
							ACCURACY (ft)	per NSSDA	1.908

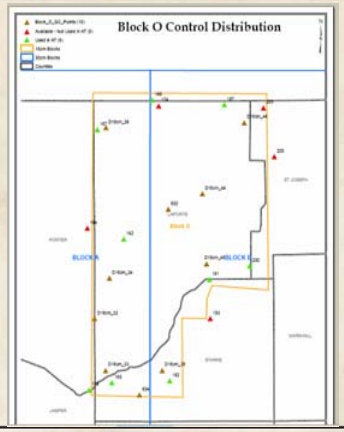
Point numbers in orange were surveyed by Woolpert
Point numbers in gray were surveyed by Major Engineering
RESULT: Block O PASSES 7/25/2006

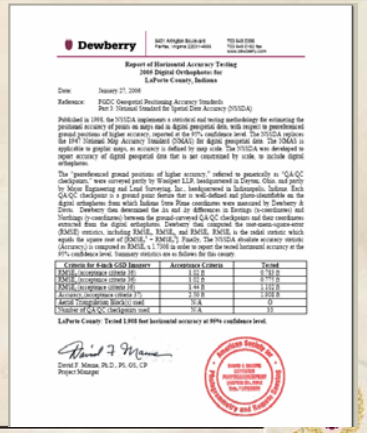
Horizontal Accuracy Acceptance Criteria
RMSEx and RMSEy should = 1.02 ft or less
RMSEr must = 1.44 ft or less
ACCURACY must = 2.5 ft or less at 95% confidence level

PLS needs to certify these coordinates

CP needs to certify these coordinates & accuracy statistics

Horizontal Accuracy Certification




Dewberry

Report of Horizontal Accuracy Testing
2006 Digital Orthophoto for
LaPorte County, Indiana

Date: January 27, 2006
Reference: FGDC Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy (NSSDA)

Published in 1998, the NSSDA implements a statistical and testing methodology for estimating the positional accuracy of points on maps and in digital geospatial data, with respect to geodetically ground positions of higher accuracy, reported at the 95% confidence level. The NSSDA replaces the 1947 National Map Accuracy Standard (NMAS) for digital geospatial data. The NMAS is applicable to graphic maps, as accuracy is defined by map scale. The NSSDA was developed to report accuracy of digital geospatial data that is not constrained by scale, to include digital orthophotos.

The "geodetically ground positions of higher accuracy" referred to generically as "QA/QC checkpoints," were surveyed partly by Woolpert LLP, headquartered in Dayton, Ohio, and partly by Major Engineering and Land Surveying, Inc., headquartered in Indianapolis, Indiana. Each QA/QC checkpoint is a ground point feature that is well-defined and photo-identifiable on the digital orthophotos from which Indiana State Plane coordinates were measured by Dewberry & Davis. Dewberry then determined the Δx and Δy differences (x-coordinates) and Northings (y-coordinates) between the ground-surveyed QA/QC checkpoints and their coordinates extracted from the digital orthophotos. Dewberry then computed the root-mean-square-error (RMSE) statistics, including $RMSE_x$, $RMSE_y$, and $RMSE_r$. $RMSE_r$ is the radial statistic which equals the square root of ($RMSE_x^2$ + $RMSE_y^2$). Finally, The NSSDA absolute accuracy statistic (Accuracy) is computed as $RMSE_r$ x 1.7308 in order to report the tested horizontal accuracy at the 95% confidence level. Summary statistics are as follows for this county:

Criteria for 6-inch GSD Imagery	Acceptance Criteria	Tested
$RMSE_x$ (acceptance criteria 36)	1.02 ft	0.783 ft
$RMSE_y$ (acceptance criteria 36)	1.02 ft	0.775 ft
$RMSE_r$ (acceptance criteria 36)	1.44 ft	1.192 ft
Accuracy (acceptance criteria 37)	2.50 ft	1.908 ft
Aerial Triangulation Block(s) used	N/A	0
Number of QA/QC Checkpoints used	N/A	37

LaPorte County: Tested 1.908 feet horizontal accuracy at 95% confidence level.

David F. Moran, Ph.D., PE, GS, CP
Project Manager

Report of Ground Control and Aerial Triangulation

Dewberry Pinnacle

Review of Ground Control and Aerial Triangulation

Dewberry Pinnacle

Review of Ground Control and Aerial Triangulation

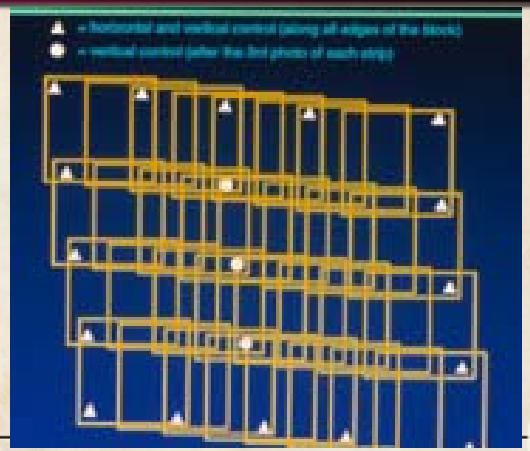
Aerotriangulation Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
D.1	Report format	Conforms to required convention
D.2	Completeness	All information complete and readable
D.3	PATB readable	Conforms to PATB output file for model setting
D.4	1”=100’ AT Horiz. accuracy against ground control	$RMSE_x$ and $RMSE_y$ values acceptable up to 0.35’. $RMSE_r$ acceptable up to 0.5’. Higher RMSE values are subject to review **10 passed**
D.5	1’=200’ AT Horiz. accuracy against ground control	$RMSE_x$ and $RMSE_y$ values acceptable up to 0.6’. $RMSE_r$ acceptable up to 0.84’. Higher RMSE values are subject to review **2 failed**
D.6	RMSE of control and tie points	<10 microns. Higher RMSE values are subject to review
D.7	RMSE of survey check points	Not to exceed 12 microns
D.8	NSSDA analysis [E, N] of 20+ QA points	95% within 1.7308 * RMSE for corresponding scale

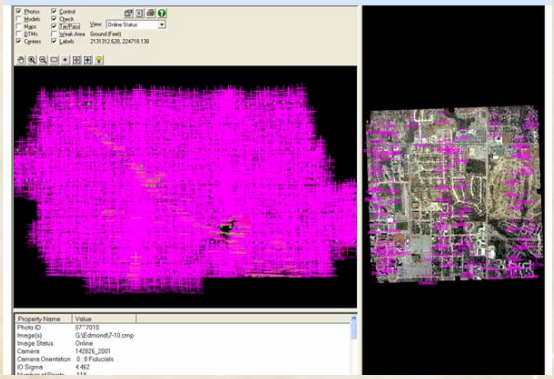
Reviews of Control and AT

- Both Infotech and Pinnacle routinely use Z/I’s ISAT software for aerotriangulation
- Dewberry’s Quality Plan provided an example of statistics that are evaluated.
- We routinely look for control around the perimeter and interior of each AT block, and analyze the various RMSE statistics
- To date, 12 AT reports analyzed by ASPRS Certified Photogrammetrists from Pinnacle and Dewberry; negotiating now with Infotech on two failures. This is not unusual.

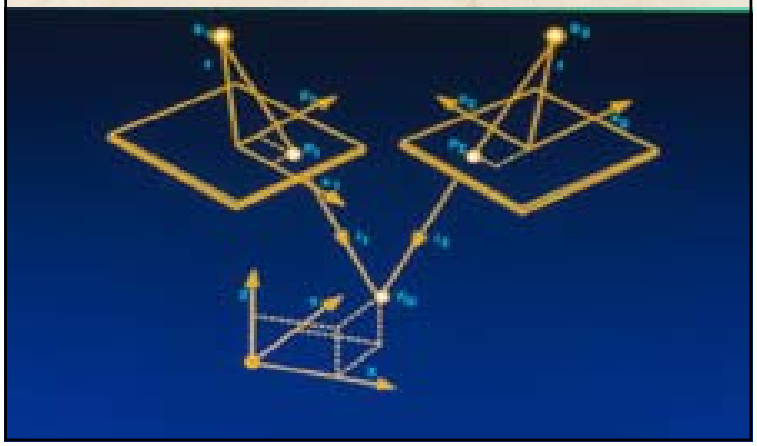
Control, pass points and tie points used in AT



Pass Point/Tie Point Density from ISAT



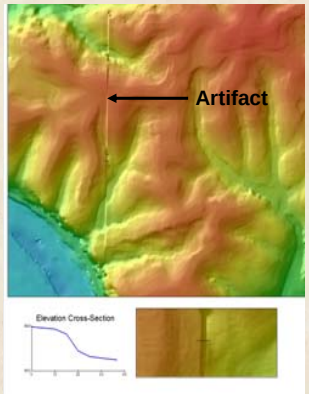
AT yields x,y,z coordinates and ω,φ,κ attitude for each photo; needed also for stereo compilation



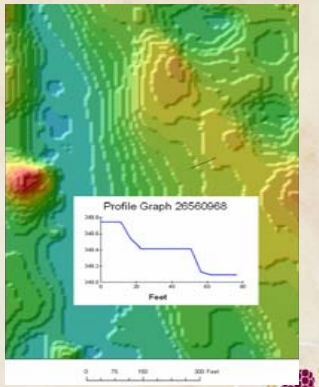
DEM/DSM Acceptance Criteria (suitable for orthorectification)

Criteria	Characteristic	Measure of Acceptability
F.1	Media	Same as A.1
F.2	File organization	Files written one per ortho tile delivered.
F.3	File name	Conforms to required convention.
F.4	Format	ArcGIS raster
F.5	Format	Microstation .dgn Version V8
F.6	Georeferencing	Locates in proper tile grid cell
F.7	Mass point locations	Mass points sufficient to accurately build terrain to support orthophotos
F.8	Breakline locations	Breaklines as needed to control bridges, edge of pavement, hydrographic features, ridgelines, retaining walls as needed for orthorectification
F.9	Continuity	No spikes, holes or blunders; no gaps of size to affect orthorectification, regardless of perspective
F.10	Breakline format	Microstation .dgn Version 8

Color shades with exaggerated elevations

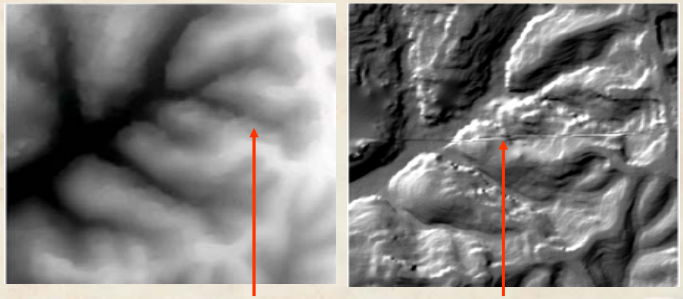


Elevations rounded to 0.1 meter



Dewberry also uses hillshades for QA/QC

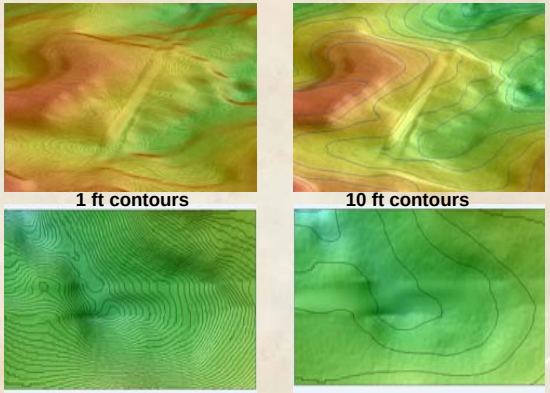
DEM used for orthorectification **Same DEM with hillshade**



Linear artifact not visible **Artifact clearly visible**

There is no road or linear feature on this tile.

We then determine if artifacts are significant



It's very rare for DEMs to be found unsuitable for orthorectification

Part II — QA/QC of LiDAR DTMs & breaklines

- Vertical accuracy assessments — complies with FEMA, NDEP and ASPRS requirements for LiDAR elevations to be tested in five separate land cover categories
- Qualitative assessments to identify systematic errors in the Digital Terrain Model (DTM)
- Completeness QA/QC
- Product generation of DTM/breakline datasets for all countywide and "limited areas" (cities)

Bare-Earth Lidar DTM Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
H.1	Point spacing	Max. 11 feet on all raw random collected points
H.2	Vertical accuracy	Lidar mass points equivalent to 2 ft contours: $RMSE_z$ = 18.5 cm (0.607 ft) $Accuracy_z$ = 36.3 cm (1.190 ft) at 95% conf level
H.3	Satisfy FEMA testing requirements in land cover categories: •Open terrain •Weeds & crops •Scrub & bushes •Forested •Built-up areas	•Fundamental Vertical Accuracy *must* equal 1.190 ft or better at the 95% confidence level, based on $RMSE_z$ x 1.9600 for checkpoints in open terrain •Supplemental Vertical Accuracy in each land cover category *should* equal 1.190 ft at the 95% confidence level based on the 95th percentile errors for each category. This is desirable but not mandatory •Consolidated Vertical Accuracy in all land cover categories combined *must* equal 1.190 ft at the 95% confidence level based on the 95th percentile errors for all categories combined

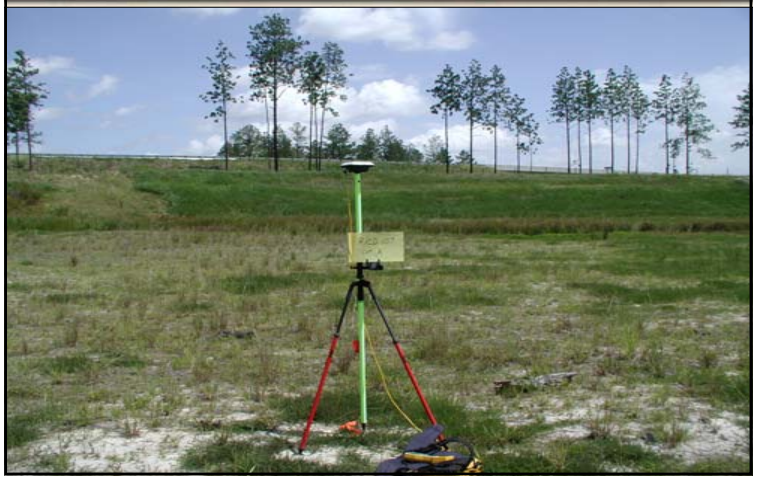
Correlation between National Map Accuracy Standard (NMAS) and National Standard for Spatial Data Accuracy (NSSDA)

NMAS Equivalent Contour Interval (CI)	NMAS VMAS 90% confidence level	NSSDA $RMSE_z$ (multiply $RMSE_z$ by 1.9600 to get $Accuracy_z$)	NSSDA $Accuracy_z$ 95% confidence level
1 ft	0.5 ft	0.3 ft (9.25 cm)	0.6 ft
2 ft	1.0 ft	0.6 ft (18.5 cm)	1.2 ft
4 ft	2.0 ft	1.2 ft (37.0 cm)	2.4 ft
5 ft	2.5 ft	1.5 ft (46.3 cm)	3.0 ft

NMAS relevant to hardcopy maps printed at these contour intervals

NSSDA relevant to digital elevation data compiled at equivalent CI's

Open Terrain, nominally 20 checkpoints/county



Weeds and Crops, nominally 20 checkpoints/county

Scrub and Bushes, nominally 20 checkpoints/county

Forested Areas, nominally 20 checkpoints/county

Built-Up Areas, nominally 20 checkpoints/county

Two Testing Methods

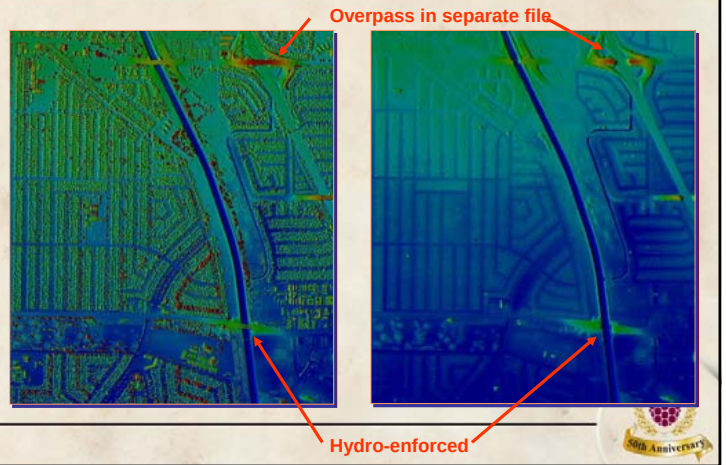
Land Cover	No.	RMSE	Skew	Std Dev	Mean	Min	Max
Open Terrain	20	0.38'	-0.02	0.32'	-0.21'	-0.91'	+0.41'
Weeds/Crops	22	0.40'	+0.20	0.36'	-0.15'	-0.98'	-0.61'
Scrub	21	0.44'	+1.42	0.45'	+0.01'	-0.54'	+1.30'
Forest	20	0.34'	-0.35	0.28'	-0.20'	-0.86'	+0.28'
Built-Up	21	0.67'	+0.52	0.35'	-0.58'	-1.18'	+0.31'
Consolidated	104	0.44'	+0.43	0.38'	-0.22'	-1.18'	+1.30'

Land Cover	No.	Fundamental Vertical Accuracy (FVA)	Supplemental Vertical Accuracy (SVA)	Consolidated Vertical Accuracy (CVA)
Open Terrain	20	0.74'	0.61'	
Weeds/Crops	22		0.62'	
Scrub	21		0.88'	
Forest	20		0.70'	
Built-Up	21		1.16'	
Consolidated	104			-0.89'
LAR-IAC Criteria		**1.19 ft**	**1.19 ft**	**1.19 ft**

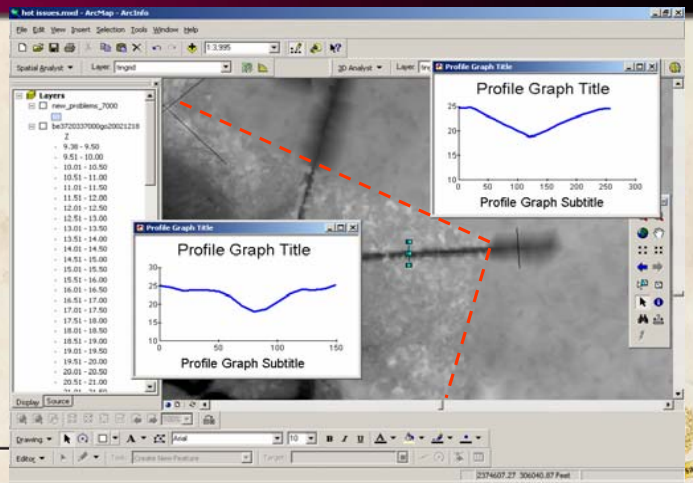
Bare-Earth Lidar DTM Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
H.4	Qualitative criteria	Post-processed to remove structures & vegetation with minimum residual artifacts (subjective)
H.5	QC checkpoints	Minimum of 20 QC points for each of the five land cover categories, i.e., 100 total minimum
H.6	QC checkpoint survey accuracy and description of survey procedure used	Surveyed to NGS-58 procedures for 5-cm. Checkpoints located per guidance specified by FEMA and ASPRS.
H.7	Data type & datum	NAVD88 orthometric heights
H.8	Coordinate system	California Coordinate System of 1983, Zone 5
H.9	Epoch	Epoch 2004
H.10	File format	ArcGIS raster, Microstation dgn V8
H.11	File organization	Files written one per ortho tile delivered
H.12	File name	Conforms to tile naming convention

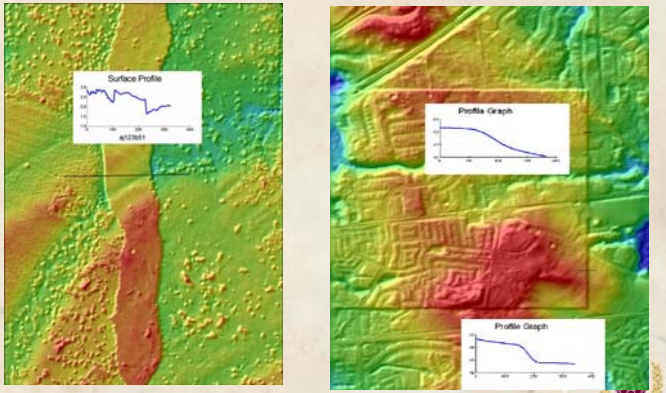
Lidar last return, before/after post-processing



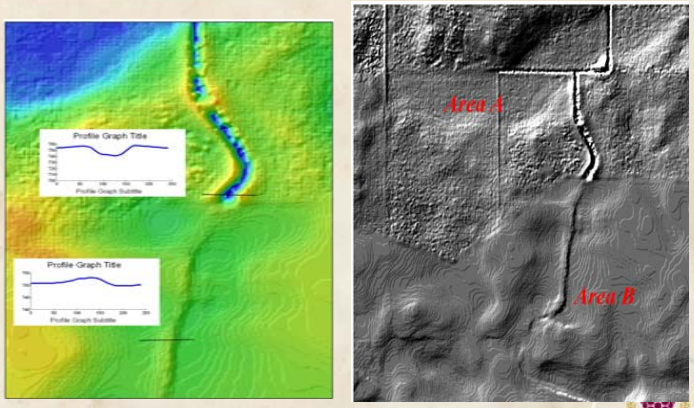
"Over-smoothed" drainage canal



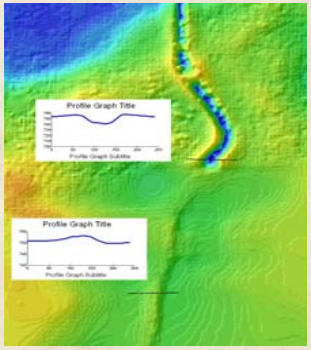
Systematic errors (+ artifacts) in bare-earth DTMs

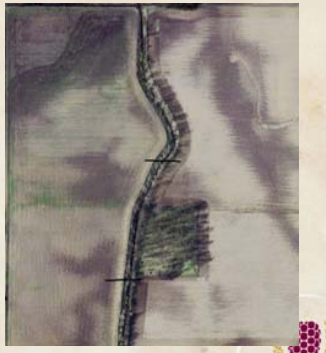


Inconsistent DEM Processing

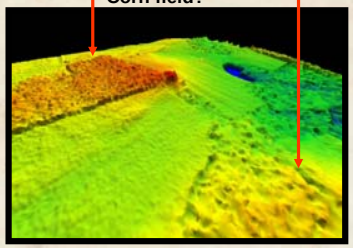


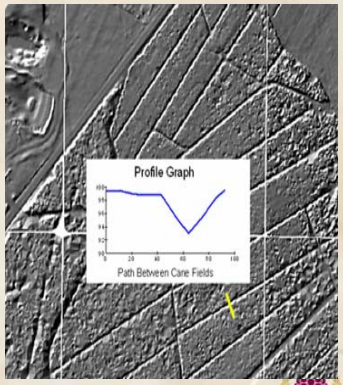
DEM Compared with Ortho





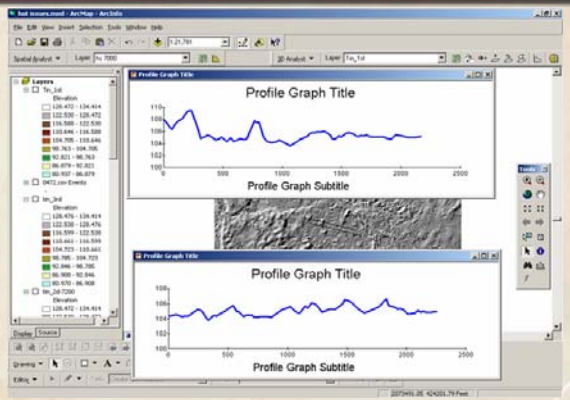
Uncleaned artifacts (agricultural fields)



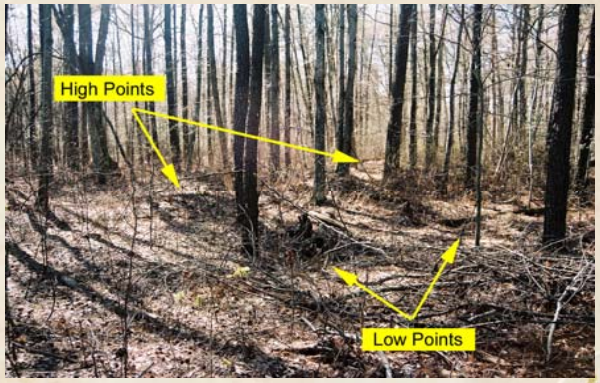


Sugar cane in Hawaii →

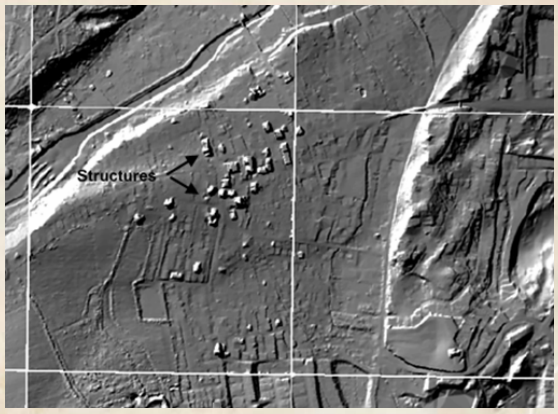
Profiles through apparent artifacts



Forest floor and artifacts



Uncleaned artifacts (structures)

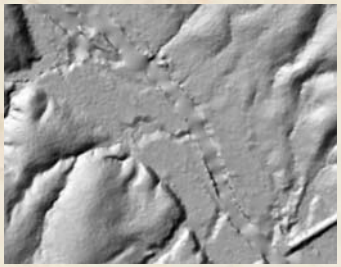


Dewberry qualitative reviews

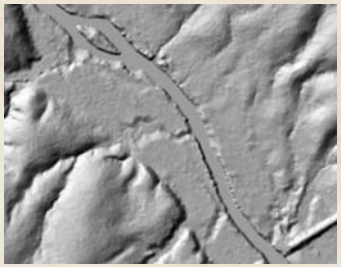
- Dewberry does not perform such labor-intensive qualitative reviews on all DTM tiles because the costs would be prohibitive
- We QC approximately 20% of the tiles to identify systematic issues so that corrections, when applied, will correct all DTM tiles

LAR-IAC streams will not be fully hydro-enforced

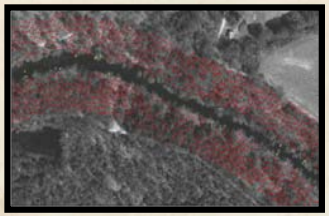
Stream not hydro-enforced

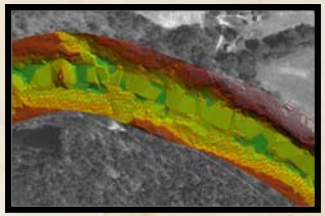


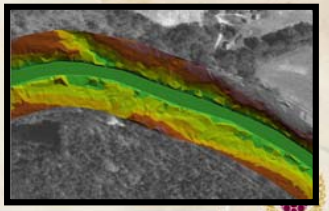
Stream hydro-enforced



Example of hydro-enforced stream







Hydro-enforcement is more expensive

Part III — QA/QC of 2’ and 4’ contours

- Qualitative QA/QC — both automated and visual QA/QC to determine if contours satisfy Acceptance Criteria
- Completeness QA/QC
- Product generation of all contour datasets for all countywide and “limited areas” (cities)

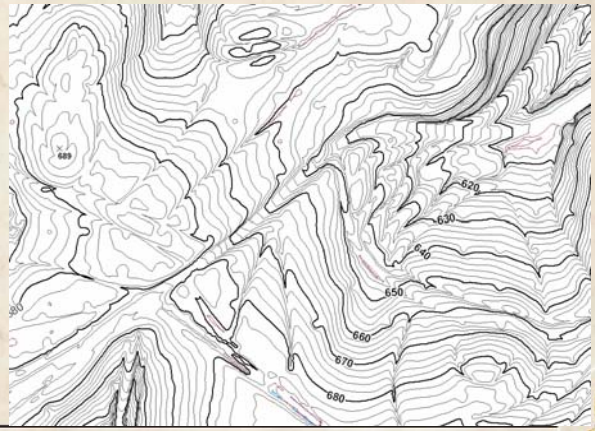
2 foot Contours, Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
I.1	Media	Same as A.1. Media is readable, all files accessible, no files corrupted
I.2	File organization	Files written one per ortho tile delivered
I.3	File name	Conforms to required convention
I.4	Tile size	2640’ x 2640’
I.5	Format	ESRI ArcGIS shapefile
I.6	Format	ACAD 2000 .dwg
I.7	Georeferencing	Locates in proper tile grid cell
I.8	Appearance smoothing	TBD, will review Infotech examples today
I.9	Accuracy	Meet ASPRS accuracy for 2 foot contours
I.10	Continuity	Continuous, no voids or gaps

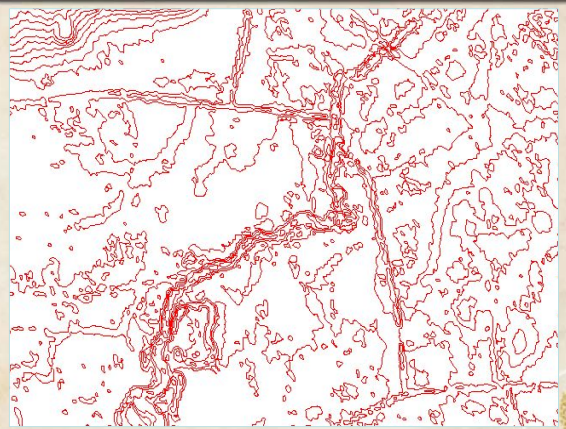
4 foot Contours, Acceptance Criteria

Criteria	Characteristic	Measure of Acceptability
I.1	Media	Same as A.1. Media is readable, all files accessible, no files corrupted
I.2	File organization	Files written one per ortho tile delivered
I.3	File name	Conforms to required convention
I.4	Tile size	5280’ x 5280’
I.5	Format	ESRI ArcGIS shapefile
I.6	Format	ACAD 2000 .dwg
I.7	Georeferencing	Locates in proper tile grid cell
I.8	Appearance smoothing	TBD, will review Infotech examples today
I.9	Accuracy	Meet ASPRS accuracy for 5 foot contours
I.10	Continuity	Continuous, no voids or gaps

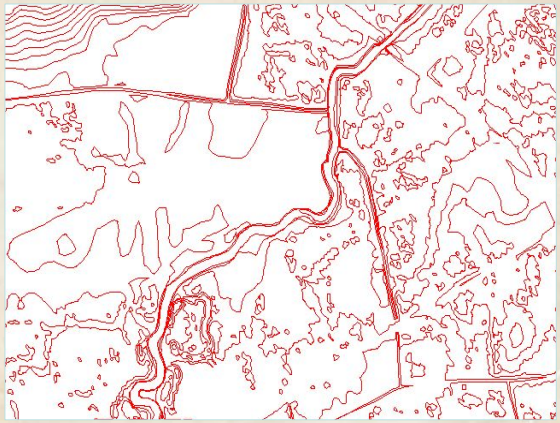
These are cartographic contours; most are not



Lidar raw contours are noisy

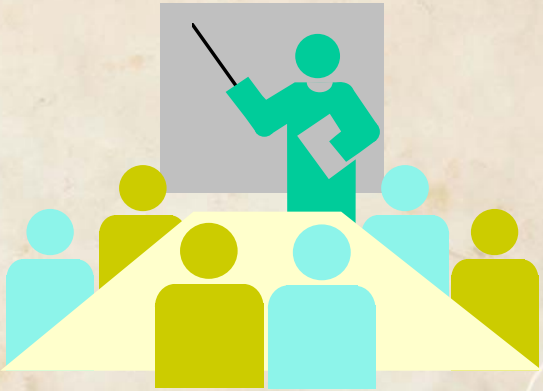


Even with breaklines and smoothing, lidar contours may disappoint clients



Contour visual QA/QC

An estimated 80% of our QA/QC effort for contours is visual.

Acceptance criteria depends upon provisions of Infotech's contract with LAR-IAC and/or verbal agreements concerning the type and quality of the contours.

Questions?