




**Quality Assurance/Quality Control
(QA/QC) Services**

**Los Angeles Region Imagery Acquisition
Consortium (LAR-IAC3)**

Dewberry & Davis LLC

July 29, 2010

Dewberry Highlights

- ◆ Full-service A&E firm, headquartered in Virginia
- ◆ 1800+ employees in 31 offices nationwide, including L.A. (Stanley Ellis)
- ◆ Major mapping contractor for FEMA, USGS, NOAA, USDA, selected States, counties and communities
- ◆ Major geospatial service provider
- ◆ ESRI Business Partner of the Year for 2009
- ◆ America's leading provider of independent QA/QC of geospatial data produced by others



Dewberry's Major QA/QC Experience

State Mapping Programs:

- ◆ Florida
- ◆ South Carolina
- ◆ North Carolina
- ◆ Virginia
- ◆ Maryland
- ◆ Pennsylvania
- ◆ Indiana
- ◆ Mississippi
- ◆ Hawaii
- ◆ Texas
- ◆ Vermont

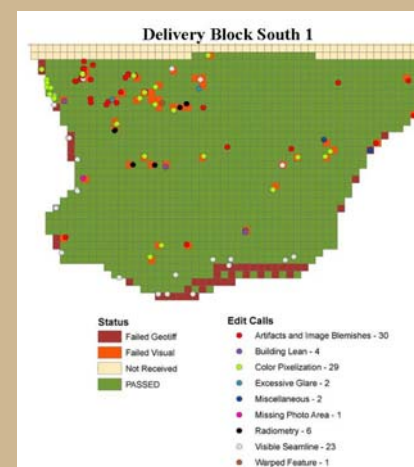
County Mapping Programs:

- ◆ Los Angeles
- ◆ Baltimore
- ◆ Dozens of other counties, nationwide, for Lidar datasets only

Presented key address to NSGIC on "Lessons Learned from Independent QA/QC of Statewide Mapping Programs"



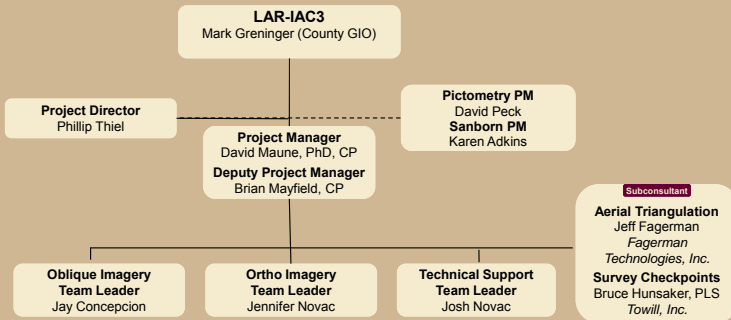
LAR-IAC2 (2008) QC'd 100% of Total Tiles



Colored tiles show tiles that pass (green) or fail (red or orange).



Los Angeles Region – Imagery Acquisition Consortium (LAR-IAC3)



Dewberry Scope of Work (LAR-IAC3)

Tasks:

1. QA/QC management
2. QA/QC of aerial triangulation
3. QA/QC of 4" orthophotos
4. QA/QC of 1' orthophotos
5. QA/QC of DTM spot updates
6. QA/QC of oblique imagery
7. Full delivery & countywide and SLDS
8. Production of additional data products (resampled, JPEG 2000, SDE Export)
9. Mosaic Generation (MrSID, ECW)
10. Production management

QA/QC of 4" orthophotos

- ◆ Horizontal accuracy
- ◆ Metadata
- ◆ Completeness/usability
- ◆ Aesthetics (appearance, tone, radiometry, smear, waviness, seamlines, buildings/lean, bridges, "Governors test", shadows)

QA/QC of 1' orthophotos

- ◆ Similar to 4" orthophotos



Aerial Triangulation Acceptance Criteria

D	Tested Characteristic	Measure of Acceptability
D.1.	Report Format	Conforms to required convention
D.2.	Report Completeness	All information complete and readable
D.3.	PATB readable	Conforms to PATB output file for model setting.
D.4.	4" pixel orthophotos 1"=100' map scale AT Horizontal accuracy against ground control	For 100' AT blocks, $RMSE_x$ and $RMSE_y$ values are acceptable up to 0.35'. $RMSE_r$ is acceptable up to 0.5'. Higher $RMSE$ values subject to review.
D.5.	1' pixel orthophotos	N/A for LAR-IAC3
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 $1.73 * RMSE$ for corresponding scale



Aerial Triangulation starts with Survey Control



AT yields six parameters per photo



- ◆ Aerial Triangulation uses survey control, pass/tie points to compute the 3-D position & orientation of the camera for each photo taken:
- ◆ x, y, z coordinates in air-space
- ◆ roll (ω), pitch (ϕ) and yaw (κ)



IMU - Orientation



Roll (ω)

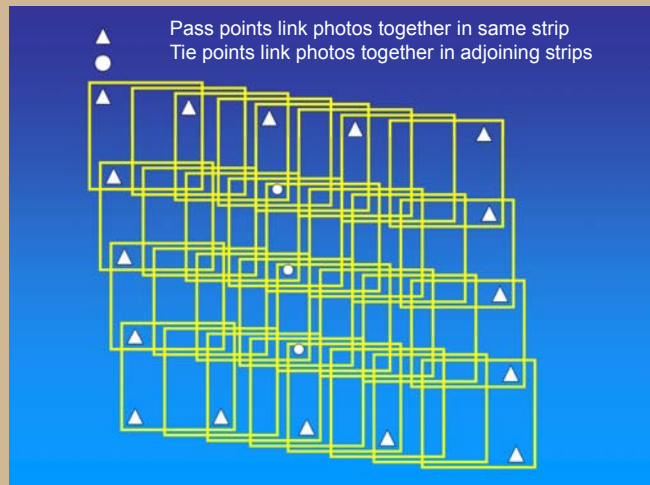
Pitch (ϕ)

Yaw (κ)

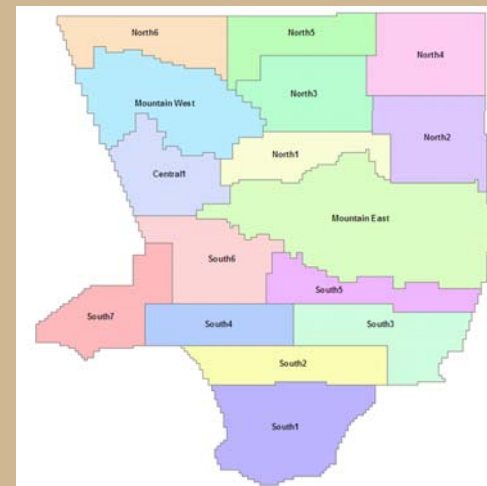
10



Triple Overlap, Pass and Tie Points



Major AT Blocks

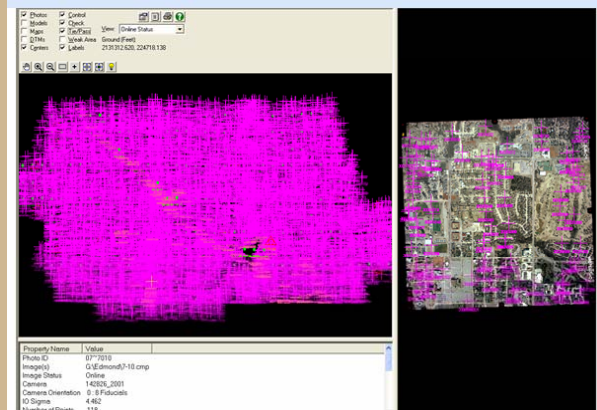


With over 20,000 photos in some AT blocks, and six unknowns for each photo ($x/y/z \ \omega/\phi/\kappa$), this requires over 120,000 simultaneous equations to solve for 120,000 unknowns.

Pictometry's AT solutions with over 20,000 images per block are among the most complex in the industry today.



Pass Point/Tie Point Density

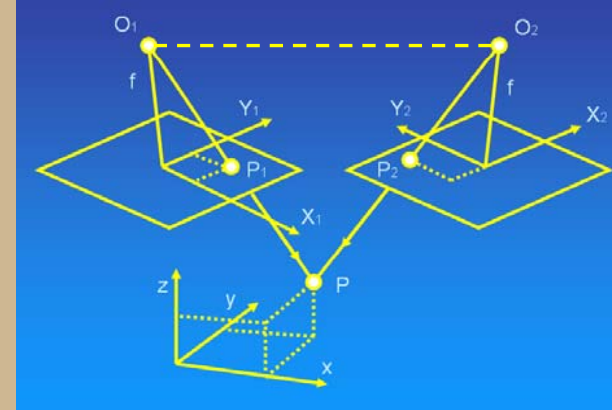


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AT yields Position (x,y,z) & Attitude (ω,φ,κ)

Strong AT yields good orientation of each image to adjoining images; lines will intersect at all points "P" as shown.

Weak AT yields poor orientation of each image to adjoining images; lines will not intersect perfectly at points "P."



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Horizontal Accuracy Acceptance Criteria

C	Tested Characteristic	Measure of Acceptability
C.1.	Ground Resolution	0.33 U.S. survey foot (2 decimals)
C.2.	Tile size	2640' x 2640' (8000 pixels x 8000 pixels)
C.3.	RMSE of known ground points measured on the image. See ASPRS Class I Standards Page 8, Table 16, and NSSDA Part 3, Appendices 3-A and 3-D for explanation of formulas.	$RMSE_x = RMSE_y = 1.0\text{-ft}$ $RMSE_r = 1.4142 * RMSE_x = 1.4142 * RMSE_y = 1.41\text{-ft}$
C.4.	NSSDA radial accuracy	NSSDA accuracy (20+ points) such that $1.73 * RMSE_r < 2.5'$
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).

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Accuracy Testing and Reporting

	A	B	C	D	E	F	G	H	I	J	K
6			GA/OC Points			Orthos measured by Dewberry		Ortho minus surveyed coordinates		Discrepancies Squared as required for RMSE calculations	
7			California State Plane Zone V FIPS 8405, RAD83		NAVD 88	California State Plane Zone V FIPS 8405, RAD83		California State Plane Zone V FIPS 8405, RAD83			
8	Project Area	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)	Ay (Northing) (US Survey Feet)	Ax (Easting) (US Survey Feet)	Ay' (ft)	Ax' (ft)
10	1	LA107	1740489.9905	6463928.4275	322.8395	1740489.2099	6463928.2891	0.218	-0.139	0.048	0.019
11	1	LA108	1757945.7886	6478942.9440	37.6879	1757945.5996	6478942.9707	-0.199	0.026	0.040	0.001
12	1	LA110	1726983.2778	6486178.1382	29.0419	1726983.7799	6486178.2172	0.502	0.078	0.252	0.008
13	1	LA111	1758933.2490	6500864.5792	87.8955	1758930.8824	6500868.2526	-2.266	1.873	5.005	0.000
14	1	LA116	1731210.4027	6527762.0733	13.0616	1731210.7258	6527762.1410	0.323	0.068	0.104	0.005
15	1	LA117	1755842.1176	6539880.0536	27.6112	1755841.9103	6539880.2650	-0.207	0.211	0.043	0.045
16	1	LA122	1728034.3838	6452053.8365	201.5745	1728034.8918	6452053.8801	0.309	0.034	0.095	0.001
17	1	LA123	1737489.9870	6435447.0261	233.9290	1737489.9820	6435448.7894	0.298	-0.257	0.089	0.066
18	1	LA124	1757524.8057	6445012.8528	86.4721	1757524.7819	6445012.7143	-0.014	-0.139	0.000	0.019
19	1	LA206	1753217.8809	6523662.6628	24.1762	1753218.0854	6523662.7526	0.205	0.080	0.042	0.008
20	1	LA216	1728652.7232	6503988.9073	18.8484	1728653.2992	6503989.0881	0.575	0.181	0.331	0.033
21	1	LA222	1751316.3332	6497217.5322	20.9404	1751316.3331	6497217.6331	0.000	0.101	0.000	0.010
22	1	LA227	1740450.9200	6532154.2088	28.4758	1740451.2630	6532154.2726	0.343	-0.027	0.118	0.001
23	1	LA228	1748724.1686	6514726.6170	92.7972	1748724.4427	6514726.6231	0.273	0.006	0.075	0.000
24	1	LA229	1742388.0615	6480323.2958	27.7560	1742388.2688	6480323.3200	0.207	0.024	0.043	0.001
25	1	LA283	1752706.5081	6510536.2705	60.3645	1752706.5519	6510536.4059	0.044	0.135	0.002	0.018
26	1	LBC2	1746587.3294	6509030.6018	26.6030	1746587.4407	6509030.5422	0.111	-0.060	0.012	0.004
243	...	...	...	...	...	...	...	...	...	...	...
244	25	LA607	1590734.5099	6448205.5844	1474.5513	1590734.5484	6448205.4572	0.038	-0.127	0.001	0.016
245										Sums	124.520 51.192
246										Horizontal Accuracy Acceptance Criteria	MSR 0.532 0.219
247										RMSE (m)	0.005
248										RMSE (ft)	0.016
249										ACCURACY (m) per NSSDA	0.005
249										ACCURACY (ft) per NSSDA	0.016

Professional Land Surveyor (PLS) certifies coordinates in columns C, D, E.

Certified Photogrammetrist (CP) certifies coordinates in columns F and G, calculates and reports accuracy statistics at bottom of columns J and K.

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Orthophoto Completeness/Usability (1)

A	Tested Characteristic	Measure of Acceptability
A.1	Media: USB External hard drives	Media is readable, all files accessible, no files corrupted
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 L2xxxx_yyyy for 4 inch orthophotos
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	GeoTIFF file must reference the top left corner of the top left pixel of the tile as the point of origin.



Header for GeoTIFF: 6471_1865a.tif

```

Version: 1
Key_Revision: 1.0
Tagged Information:
ModelTiepointTag (2,3):
0 0 0
6471760.02 1865759.94 0
ModelPixelScaleTag (1,3):
0.33 0.33 0
End_of_Tags.
Keyed Information:
GTModelTypeGeoKey (Short,1): ModelTypeProjected
GTRasterTypeGeoKey (Short,1): RasterPixelsArea
GeoAngularUnitsGeoKey (Short,1): Angular_Degree
ProjectedCSTypeGeoKey (Short,1): PCS_NAD83_California_5
ProjLinearUnitsGeoKey (Short,1): Linear_Foot_US_Survey.
End_of_Keys.
End_of_Geotiff.
PCS = 26945 (NAD83 / California zone 5)
Projection = 10435 (SPCS83 California zone 5 (meters))
Projection Method: CT_LambertConic_2SP
ProjFalseOriginLatGeoKey: 33.500000 (-33d30' 0.00"N)
ProjFalseOriginLongGeoKey: -118.000000 (118d 0' 0.00"W)
ProjStdParallel1GeoKey: 35.466667 (-35d28' 0.00"N)
ProjStdParallel2GeoKey: 34.033333 (-34d 2' 0.00"N)
ProjFalseEastingGeoKey: 2000000.000000 m
ProjFalseNorthingGeoKey: 500000.000000 m
GCS: 4269/NAD83
Datum: 6269/North American Datum 1983
Ellipsoid: 7019/GRS 1980 (6378137.00,6356752.31)
Prime Meridian: 5901/Greenwich (0.000000, 0d 0' 0.00"E)
Projection Linear Units: 9003/US survey foot (0.304801m)
Corner Coordinates:
Upper Left (6471760.020,1865759.940)
Lower Left (6471760.020,1865311.940)
Upper Right (6474400.020,1865759.940)
Lower Right (6474400.020,1863119.940)
Center (6473080.020,1864439.940)

```



Orthophoto Completeness/Usability (2)

A	Tested Characteristic	Measure of Acceptability
A.8	Georeferencing	For correct pixel size 0.33 ft (4 inch)
A.9	Vertical Datum	NAVD88
A.10	Projection	State Plane – California Zone V
A.11	Horizontal Datum	NAD 83
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	Conformance with tile index grid	Tile matches grid, no gaps between tiles at 1:1 view.
A.15	Coverage	Full tiles; no missing photo areas
A.16	Tile grid layout	At least 500' buffer around LAR-IAC boundary
A.17	Metadata	Complies with LAR-IAC3 pilot



LAR-IAC Missing Photo Area (MPA) Examples



Orthophoto Aesthetics (1)

A	Tested Characteristic	Measure of Acceptability
A.18	Pictometry sensor	No sensor anomalies
A.19	Radiometry	< 2 percent of values at 0 or 255
A.20	Image Appearance	No artifacts. Imagery should not appear speckled or pixilated when viewed at assumed compilation scale of 1" = 100' (water surfaces are exempt from this requirement).
A.21	Color Consistency	Colors should be consistent throughout the imagery. 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. No image will be rejected for radiometry inconsistencies without prior approval of L.A. County.

LAR-IAC Ghosting



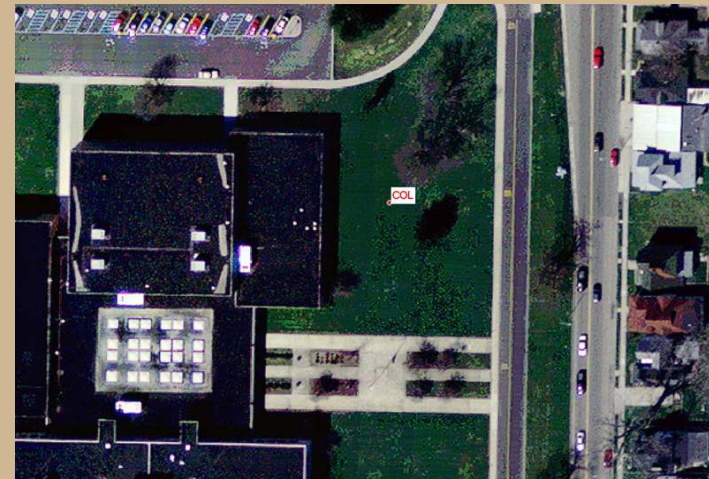
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LAR-IAC Severe Distortion



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Pixelation and Speckles (excessive)



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Were LAR-IAC "spider webs" legitimate?



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LAR-IAC Artifact



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Landmark Feature



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Color Variations (normal in water)



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Color inconsistency + poor seamline



Should
this fail
for color?

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Orthophoto Aesthetics (2)

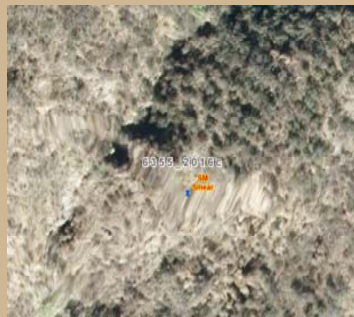
A	Tested Characteristic	Measure of Acceptability
A.22	Smears	Normally corrected by adding mass points or breaklines to DEM/DSM as necessary to reflect actual terrain or by image processing where appropriate. Where DSM/DEM corrections or image processing will result in reduced horizontal accuracy or misrepresentation 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.23	Wavy features	Distinct linear ground features (such as road markings, and curbs) should not deviate from their apparent path by <u>more than 3 feet measured perpendicular to the feature within any 100 foot distance measured along the feature length.</u>

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Smears and Blurry Images



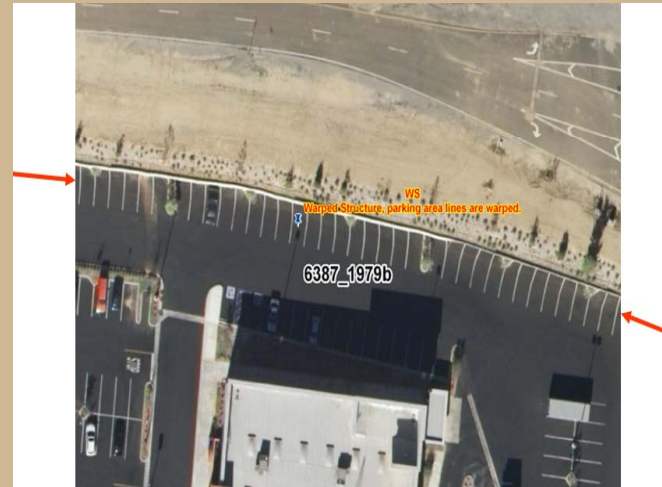
This passed because "middle of nowhere" on steep slope.



This also passed. Would fail in built-up area.

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Fails waviness, poor breakline (arrows)



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Fails 3/100 waviness criterion



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Passes 3/100 but fails "Governor's Test"

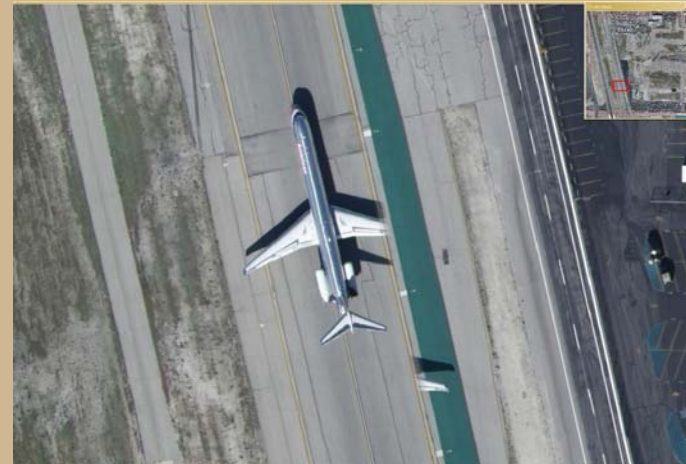


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Orthophoto Aesthetics (3)

A.	Tested Characteristic	Measure of Acceptability
A.24	Mosaic lines	<u>Minimize</u> mosaic lines through buildings. No mosaic lines through above ground transportation structures carrying automobiles or trains unless unavoidable, as well as foot bridges crossing 2-lane roads or larger. Mosaic lines may pass through power transmission towers, cars, trucks and railroad cars.
A.25	Building lean	The maximum displacement of a 10 story building at the edge of a model will be 16 feet (approximately 1.6 feet per story). Building lean must not obscure transportation features.
A.26	Bridges	Accuracy of multi-layered bridge decks identified by L.A. County. 3D breaklines required to ensure continuity of deck surfaces. LA County will provide bridge locations countywide in shapefile format (polyline layer)
A.27	"Governor's Test"	Imagery should not cause alarm by giving false impression that a bridge is sagging or that there are serious hazards to public safety.

Fails "Governor's Test" (LAR-IAC)



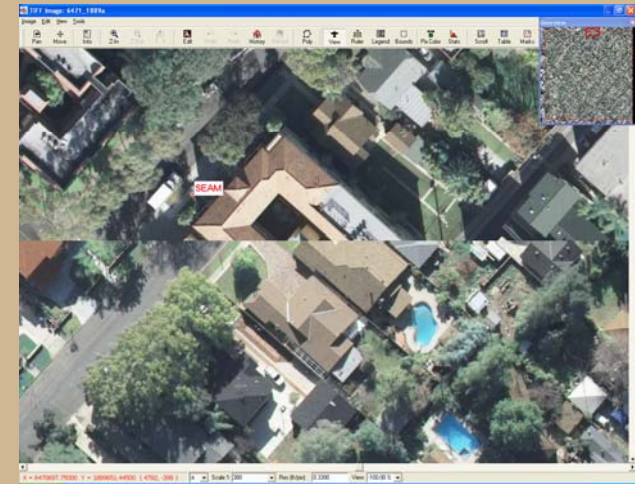
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Seamline through building



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Major LAR-IAC Seamline Error



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This seamline error very hard to see



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Minor LAR-IAC Seamline Error



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LAR-IAC Multiple Errors



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LAR-IAC Warped Bridge



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"Hourglass" bridge is always wrong



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LAR-IAC: This passed



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LAR-IAC; this also passed



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LAR-IAC Interchanges are critical



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LAR-IAC2 Excessive Lean



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LAR-IAC2 Excessive Lean



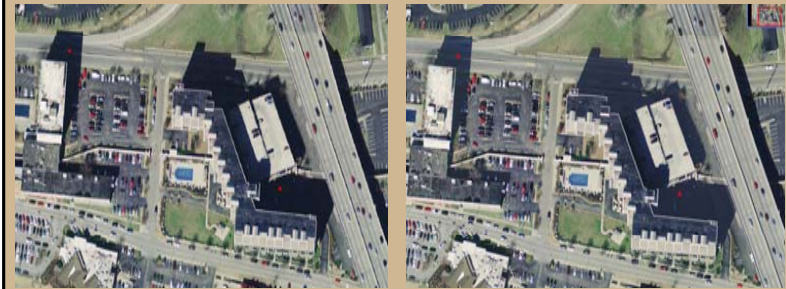
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Orthophoto Aesthetics (4)

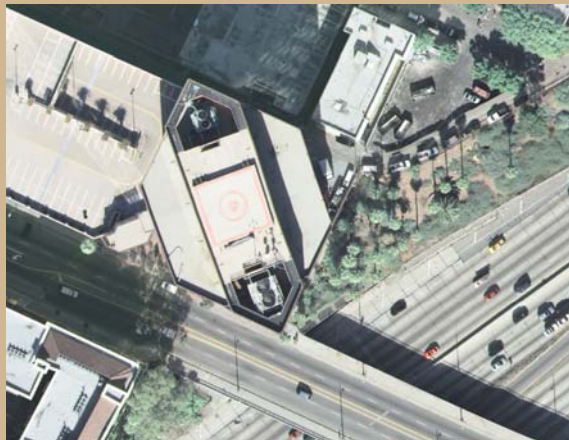
A	Tested Characteristic	Measure of Acceptability
A.28	Shadows	TBD
A.29	Leaf-off	N/A
A.30	Urban Canyon ("Downtown Areas")	Specified "Downtown Areas" have been indicated via shapefile and sent to Contractor and Dewberry. Special care will be made in these areas to reduce building lean and shadows. Flying patterns may need to be adjusted for this including restricting capture times to optimal sun angles.



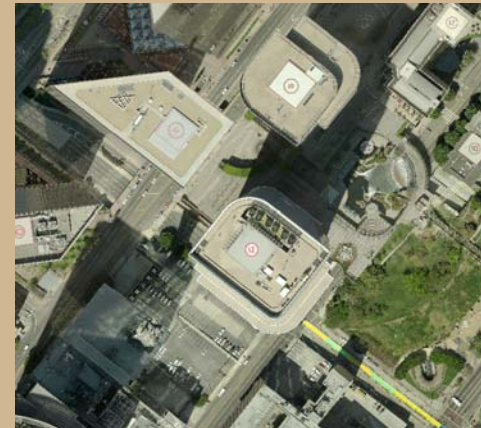
12-bit imagery "tweaked" in shadows



LAR-IAC Good Visibility in Shadows



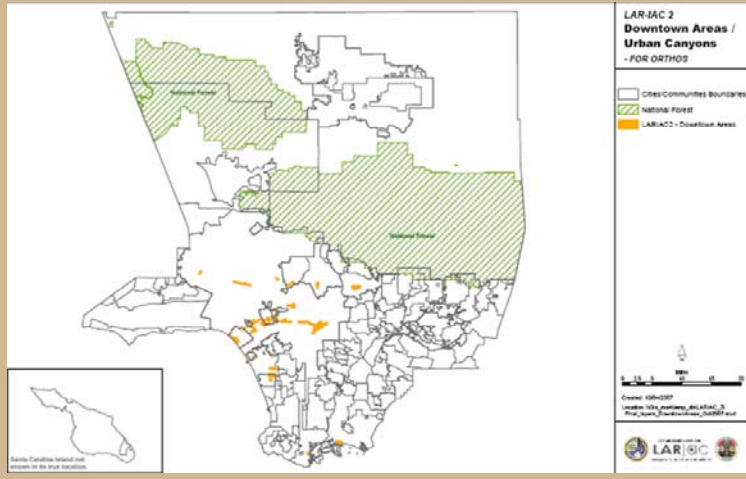
LAR-IAC2 failed "downtown"



But
excellent
detail in
shadows
at noon

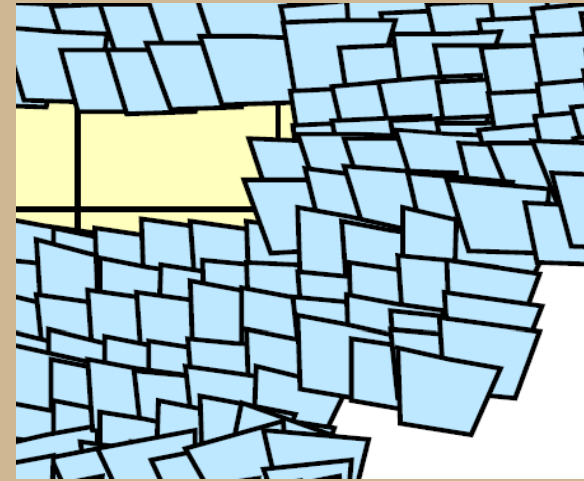


Urban Canyons



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Electronic Field Study and Sector Planner



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Oblique Imagery Accuracy Statistics

Pictometry Airborne Oblique Imagery	Accuracy Statistic	North View (feet)	South View (feet)	East View (feet)	West View (feet)	Average of All Views ¹ (feet)
Number of Points Visible on 216 Usable Targets		186	188	188	188	190
Horizontal Accuracy	RMSE _x	1.26	1.3	2.76	2.29	0.91
	RMSE _y	2.69	2.36	1.34	1.40	0.85
	RMSE _z	2.97	2.70	3.07	2.68	1.25
	Accuracy _r	5.14	4.67	5.31	4.65	2.16
Vertical Accuracy	RMSE _z	1.50	1.16	1.53	1.21	1.22
	Accuracy _z	2.94	2.27	2.99	2.38	2.39

¹ Average is of 4-views if the target point was visible from all four directions; average is of 3-views if the target point was visible only from three directions; average is of 2-views if the target point was visible only from two directions; a few points were visible from only one direction.

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Questions?



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