




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

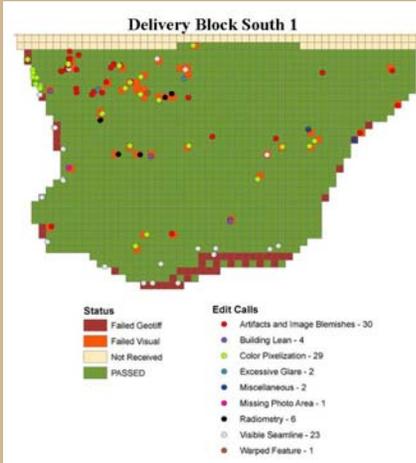


Dewberry's Major QA/QC Experience

<p>State Mapping Programs:</p> <ul style="list-style-type: none"> ◆ Florida ◆ South Carolina ◆ North Carolina ◆ Virginia ◆ Maryland ◆ Pennsylvania ◆ Indiana ◆ Mississippi ◆ Hawaii ◆ Texas ◆ Vermont 	<p>County Mapping Programs:</p> <ul style="list-style-type: none"> ◆ Los Angeles ◆ Baltimore ◆ Dozens of other counties, nationwide, for Lidar datasets only <p>Presented key address to NSGIC on "Lessons Learned from Independent QA/QC of Statewide Mapping Programs"</p>
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LAR-IAC2 (2008) QC'd 100% of Total Tiles

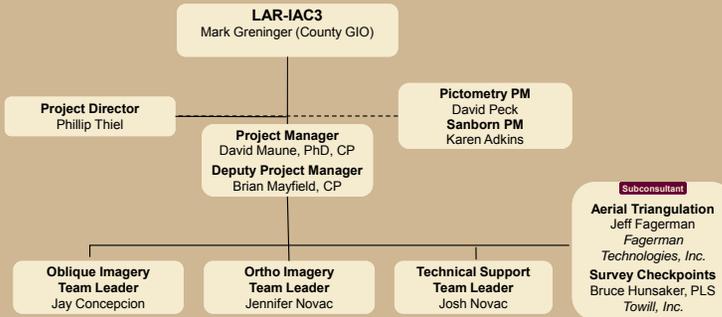


Colored tiles show tiles that pass (green) or fail (red or orange).

<p>Status</p> <ul style="list-style-type: none"> Failed Geotiff Failed Visual Not Received PASSED 	<p>Edit Calls</p> <ul style="list-style-type: none"> Artifacts and Image Blemishes - 30 Building Lean - 4 Color Pixelization - 29 Excessive Glare - 2 Miscellaneous - 2 Missing Photo Area - 1 Radiometry - 6 Visible Seamline - 23 Warped Feature - 1
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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

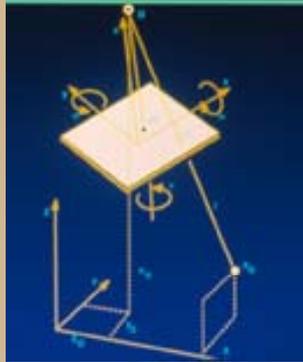
D	Tested Characteristic	Measure of Acceptability
D.1.	Report Format	Conforms to required convention
D.2.	Report Completeness	All information complete and readable
D.3.	PATB readable	Conforms to PATB output file for model setting.
D.4.	4" pixel orthophotos 1"=100' map scale AT Horizontal accuracy against 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)

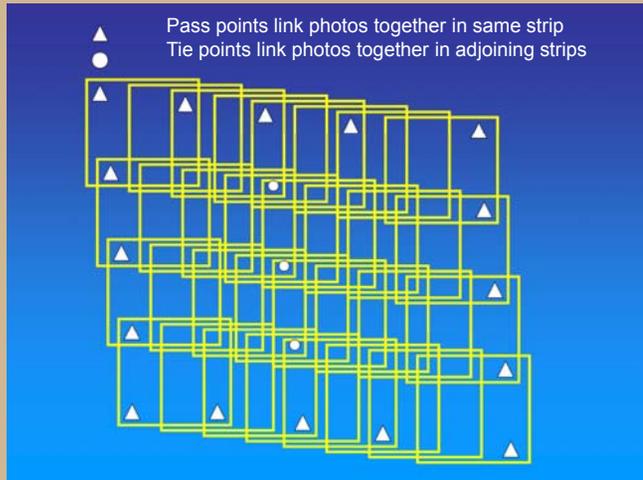
Pitch (ϕ)

Yaw (κ)

10



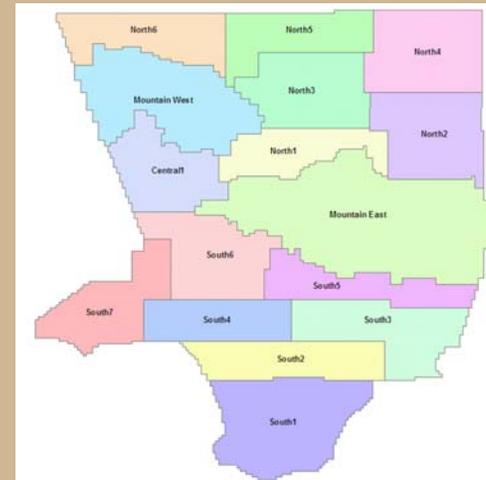
Triple Overlap, Pass and Tie Points



- ▲ Pass points link photos together in same strip
- Tie points link photos together in adjoining strips



Major AT Blocks

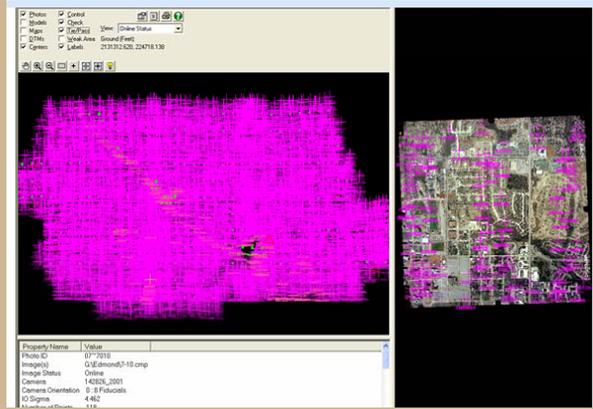


With over 20,000 photos in some AT blocks, and six unknowns for each photo ($x/y/z \omega/\phi/\kappa$), this requires over 120,000 simultaneous equations to solve for 120,000 unknowns.

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

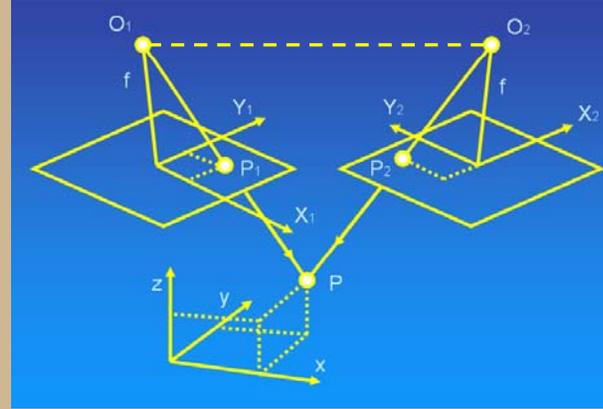


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AT yields Position (x,y,z) & Attitude (ω,φ,κ)

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 / Standards Page 8, Table 16, and NSSDA Part 3, Appendices 3-A and 3-D for explanation of formulas.	$RMSE_x = RMSE_y = 1.0\text{-ft}$ $RMSE_{xy} = 1.4142 * RMSE_x = 1.4142 * RMSE_y = 1.41\text{-ft}$
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

Project Area	Point Number	Northing (x) (US Survey Feet)	Easting (y) (US Survey Feet)	Elevation (z) (Feet)	Orthos measured by Dewberry Northing (y) (US Survey Feet)	Orthos measured by Dewberry Easting (x) (US Survey Feet)	Ortho minus surveyed coordinates Δy (Northing) (US Survey Feet)	Ortho minus surveyed coordinates Δx (Easting) (US Survey Feet)	Discrepancies Squared as required for RMSE calculations Δy' (ft) ²	Discrepancies Squared as required for RMSE calculations Δx' (ft) ²
243	***	***	***	***	***	***	***	***	***	***
244	25	LA607	1590734.5099	6448205.5844	1474.5513	1590734.5484	6448205.4572	0.0380	-0.127	0.001
245									Summs	124.520
246									MSE	0.532
247									RMSE (y)	0.730
248									RMSE (x)	0.951
249									ACCURACY (y) per NSSDA	0.95
									ACCURACY (x) per NSSDA	0.95

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 (6471760.020,1863119.940)
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



LAR-IAC Severe Distortion



Pixelation and Speckles (excessive)



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?



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>



Smears and Blurry Images



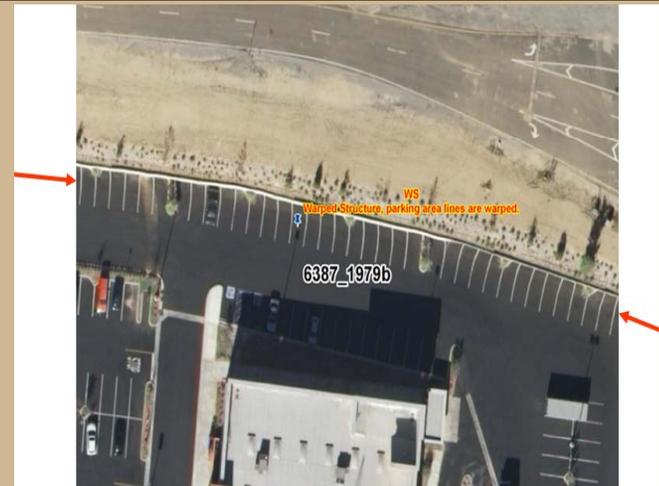
This passed because "middle of nowhere" on steep slope.



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



Fails waviness, poor breakline (arrows)



Fails 3/100 waviness criterion



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

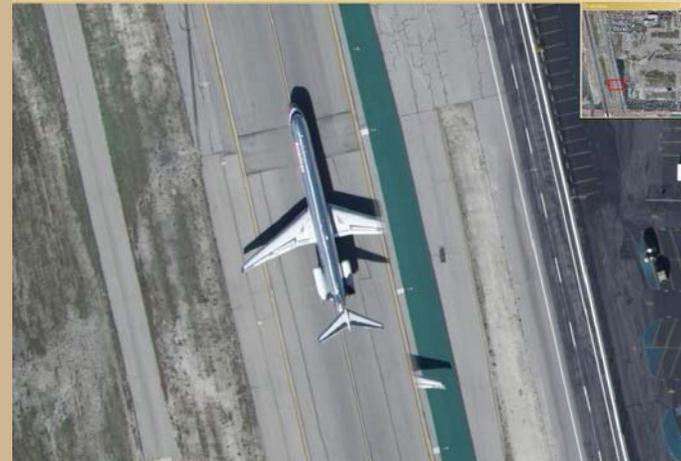


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Orthophoto Aesthetics (3)

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)

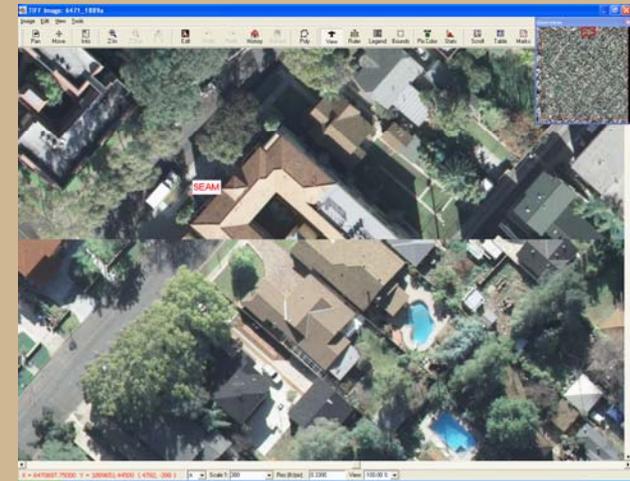


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Seamline through building



Major LAR-IAC Seamline Error



This seamline error very hard to see



Minor LAR-IAC Seamline Error



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



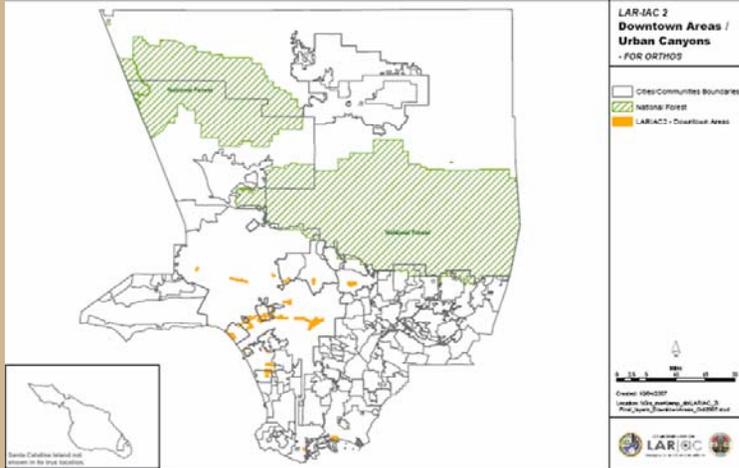
LAR-IAC2 failed "downtown"



But excellent detail in shadows at noon

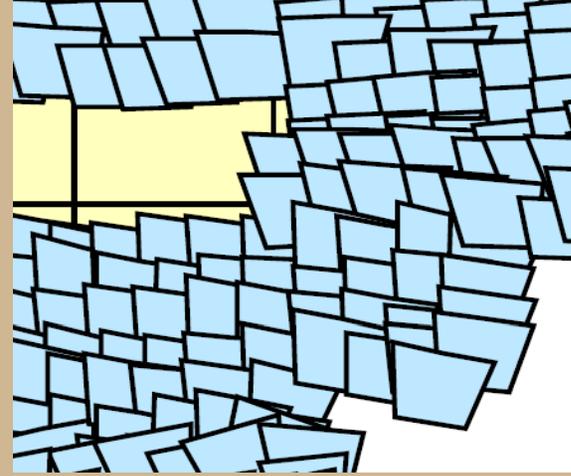


Urban Canyons



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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 _z	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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