Quality Assurance/Quality Control (QA/QC) Services

Los Angeles Region Imagery Acquisition Consortium (LAR-IAC2)

Dewberry & Davis LLC

January 17, 2008

Dewberry Highlights

- Full-service A&E firm, headquartered in Virginia
- 1700+ employees in 31 offices nationwide
- Major mapping contractor for FEMA, USGS, NOAA, USDA, selected States, counties and communities
- Major geospatial service provider
- ESRI Business Partner of the Year for 2005
- America's leading provider of independent QA/QC of geospatial data produced by others

Dewberry

Dewberry's Major QA/QC Experience

State Mapping Programs:

- Florida
- South Carolina (LiDAR)
- North Carolina (LiDAR)
- Virginia
- Maryland (LiDAR)
- Pennsylvania
- Indiana
- Mississippi
- Hawaii (LiDAR)

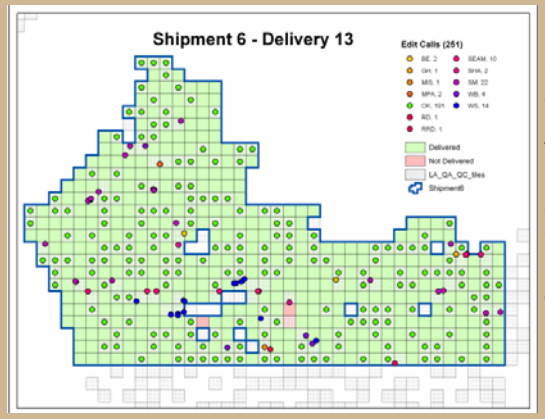
County Mapping Programs:

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

Presented key address on "Lessons Learned from Independent QA/QC of Statewide Mapping Programs," NSGIC, 2006

Dewberry

LAR-IAC (2006) QC'd ≈ 1/3 of Total Tiles



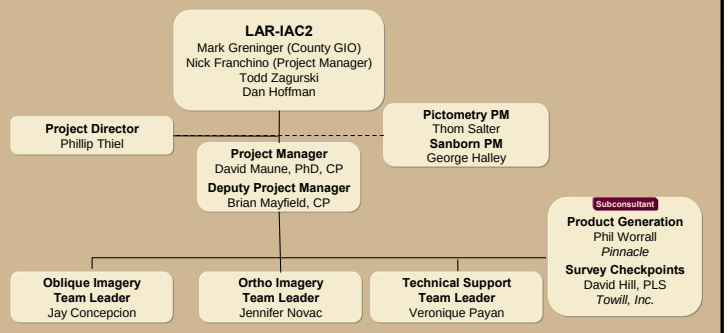
Colored dots show tiles that pass (green) or fail (colored).

Many tiles deliberately not QC'd

Hard to check edge-joins when piecemealed

Dewberry

Los Angeles Region – Imagery Acquisition Consortium (LAR-IAC2)



Dewberry

Dewberry Scope of Work (LAR-IAC2)

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 & SLDS
8. Production of additional data products
9. Generation of mosaics
10. Production management
11. Optional work

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

Dewberry

Aerial Triangulation Acceptance Criteria

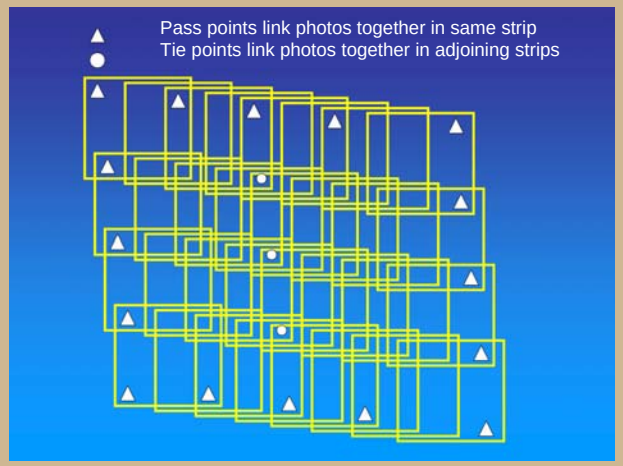
D	Tested Characteristic	Measure of Acceptability
D.1.	Report Format	Conforms to required convention
D.2.	Report Completeness	All information complete and readable
D.3.	PATB readable	Conforms to PATB output file for model setting.
D.4.	4" pixel orthophotos 1"=100' map scale AT Horizontal accuracy against 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-IAC2
D.6.	RMSE of control and tie points.	<10 micron. Higher RMSE values are subject to review.
D.7.	RMSE of survey check points	Not to exceed 12 micron
D.8	NSSDA analysis [E, N] of 20+ QA points	95% within 1.73 * RMSE for corresponding scale

Dewberry

Aerial Triangulation starts with Survey Control

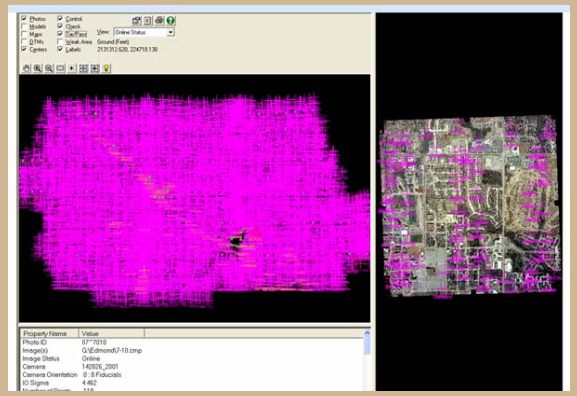
Dewberry

Triple Overlap, Pass and Tie Points



Dewberry

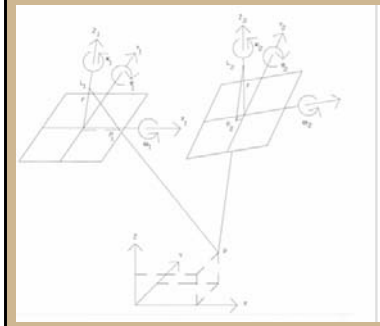
Pass Point/Tie Point Density



Dewberry

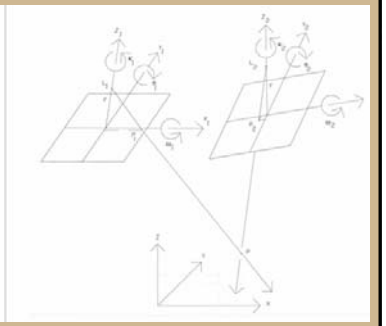
AT yields Position (x,y,z) & Attitude (ω,φ,κ) of each photo/image

Strong AT yields good orientation of each image to adjoining images



Match of ground features at mosaic line

Weak AT yields poor orientation of each image to adjoining images



Mismatch of ground features at mosaic line

Dewberry

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.*	$RMSE_x = RMSE_y = 1.0$-ft $RMSE_r = 1.4142*RMSE_x = 1.4142*RMSE_y = 1.41$-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).

Dewberry

Accuracy Testing and Reporting

	A	B	C	D	E	F	G	H	I	J	K
5											
6			QA/QC Points			Orthos measured by Dewberry		Ortho minus surveyed coordinates		Discrepancies Squared as as required for RMSE calculations	
7			California State Plane Zone V FIPS 0405, NAD83		NAVD 88	California State Plane Zone V FIPS 0405, NAD83		California State Plane Zone V FIPS 0405, NAD83			
8	Project	Point	Northing (y)	Easting (x)	Elevation (z)	Northing (y)	Easting (x)	Δy (Northing)	Δx (Easting)	Δy^2 (ft^2)	Δx^2 (ft^2)
9	Area	Number	(US Survey Feet)	(US Survey Feet)	(Feet)	(US Survey Feet)	(US Survey Feet)	(US Survey Feet)	(US Survey Feet)		
10	1	LA107	1740487.9905	6463928.4275	322.8395	1740489.2089	6463928.2891	0.218	-0.138	0.048	0.019
11	1	LA108	1757945.7986	6478942.9446	37.6879	1757945.6986	6478942.9707	-0.199	0.026	0.040	0.001
12	1	LA110	1736983.2778	6498179.1380	20.6476	1736983.7799	6498178.2172	0.502	0.079	0.252	0.006
13	1	LA111	1758833.2498	6500864.5792	67.8855	1758830.8834	6500866.2526	-2.366	1.673	5.600	2.800
14	1	LA116	1731210.4027	6527762.0733	13.0616	1731210.7259	6527762.1410	0.323	0.068	0.104	0.005
15	1	LA117	1755842.1176	6539890.0536	27.6112	1755841.9103	6539890.2650	-0.207	0.211	0.043	0.045
16	1	LA122	1728034.3838	6452053.8265	201.5745	1728034.6916	6452053.8601	0.308	0.034	0.095	0.001
17	1	LA123	1737489.6870	6435447.0261	233.9290	1737489.9830	6435448.7694	0.296	-0.257	0.088	0.066
18	1	LA124	1757524.8057	6445012.8528	96.4721	1757524.7919	6445012.7143	-0.014	-0.139	0.000	0.019
19	1	LA206	1753217.8809	6523862.6628	24.1702	1753218.0854	6523862.7528	0.205	0.090	0.042	0.008
20	1	LA216	1728652.7222	6503989.9073	19.6484	1728653.2982	6503989.0891	0.575	-0.181	0.331	0.033
21	1	LA222	1751316.3322	6497217.5322	20.9404	1751316.3331	6497217.6331	0.000	0.101	0.000	0.010
22	1	LA227	1740450.9200	6532154.2998	28.4758	1740451.2630	6532154.2726	0.343	-0.027	0.118	0.001
23	1	LA228	1748724.1696	6514726.6170	92.7972	1748724.4427	6514726.6231	0.273	0.006	0.075	0.000
24	1	LA229	1742388.0615	6480333.2958	27.7590	1742388.2686	6480333.3200	0.207	0.024	0.043	0.001
25	1	LA283	1757706.5081	6510536.2705	60.3645	1757706.5519	6510536.4059	0.044	0.135	0.002	0.018
26	1	LBC2	1748587.3294	6509030.8018	28.8030	1748587.4407	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			MSE	0.532	0.219
247						RMSEx and RMSEy should = 1.00 ft or less			RMSEyx (ft)	0.729	0.468
248						RMSEr must = 1.41 ft or less			RMSEr (ft)	per NSSDA	0.85
249						ACCURACYr must = 2.5 ft or less at 95% confidence level			ACCURACYr (ft)	per NSSDA	1.98

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.

Dewberry

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_yyyya 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.

Dewberry

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): RasterPixelIsArea
  GeogAngularUnitsGeoKey (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_LambertConfConic_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: 8901/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)
```

Dewberry

Orthophoto Completeness/Usability (2)

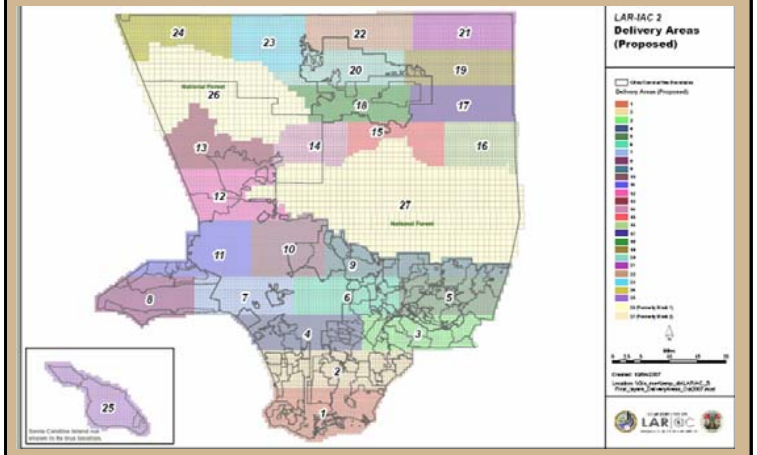
A	Tested Characteristic	Measure of Acceptability
A.8	Georeferencing	For correct pixel size 0.33 ft (4 inch)
A.9	Vertical Datum	NAVD88
A.10	Projection	State Plane – California Zone V
A.11	Horizontal Datum	NAD 83
A.12	Units	U.S. Survey Feet
A.13	24 bit natural color	256 levels of value for each band, 0=black, 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-IAC2 pilot

Dewberry

LAR-IAC Missing Photo Area (MPA) Examples

Dewberry

Delivery Areas



Dewberry

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.

Dewberry

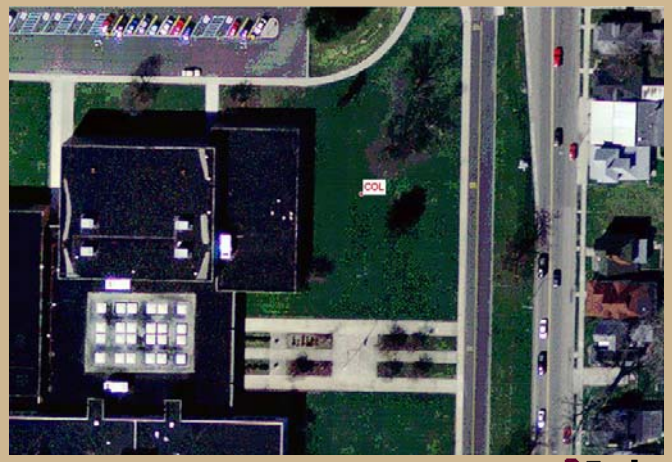
LAR-IAC Ghosting

Dewberry

LAR-IAC Severe Distortion

Dewberry

Pixelation and Speckles (excessive)



Dewberry

Were LAR-IAC "spider webs" legitimate?

Dewberry

LAR-IAC Artifact

Dewberry

Landmark Feature

Dewberry

Color Variations (normal in water)

Dewberry

Color inconsistency + poor seamline

Should this fail for color?

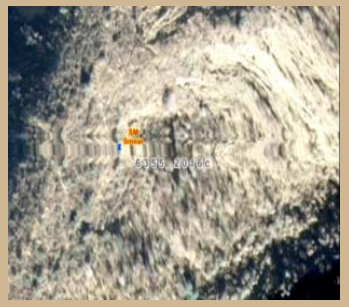
Dewberry

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>.

Dewberry

Smears and Blurry Images

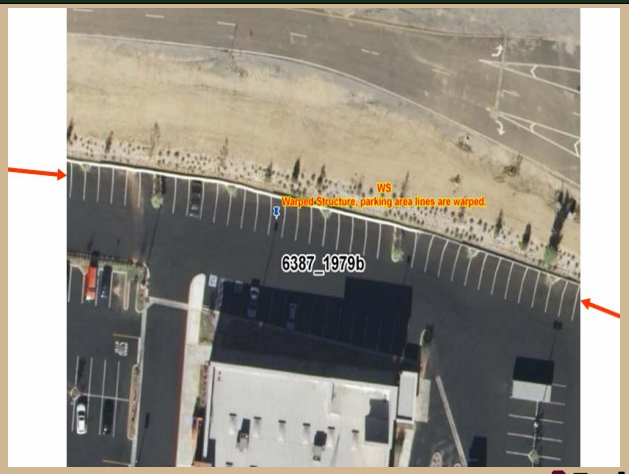


This passed because “middle of nowhere” on steep slope.

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

Dewberry

Fails waviness, poor breakline (arrows)



Dewberry

Fails 3/100 waviness criterion

Dewberry

Passes 3/100 but fails “Governor’s Test”

Dewberry

Orthophoto Aesthetics (3)

A.	Tested Characteristic	Measure of Acceptability
A.24.	Mosaic lines	Minimize 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)
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.

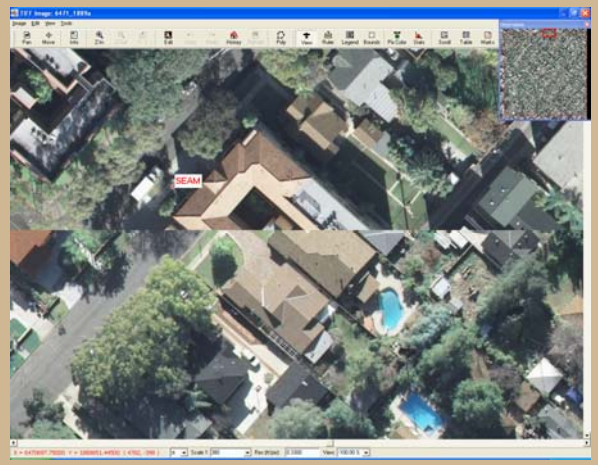
Fails "Governor's Test" (LAR-IAC)

Dewberry

Seamline through building

Dewberry

Major LAR-IAC Seamline Error



Dewberry

This seamline error very hard to see

Dewberry

Minor LAR-IAC Seamline Error

Dewberry

LAR-IAC Multiple Errors

Dewberry

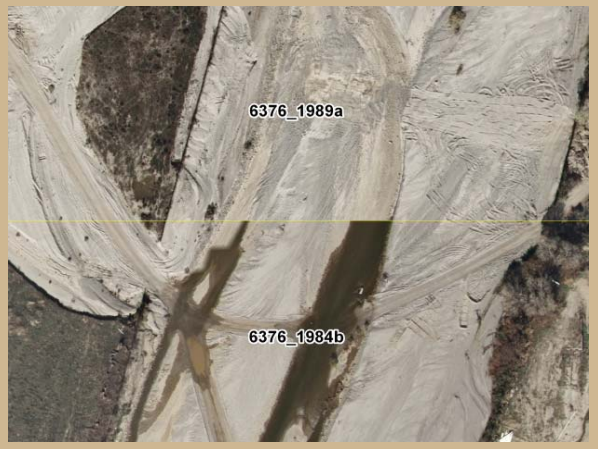
LAR-IAC Warped Bridge

Dewberry

"Hourglass" bridge is always wrong

Dewberry

LAR-IAC: this passed

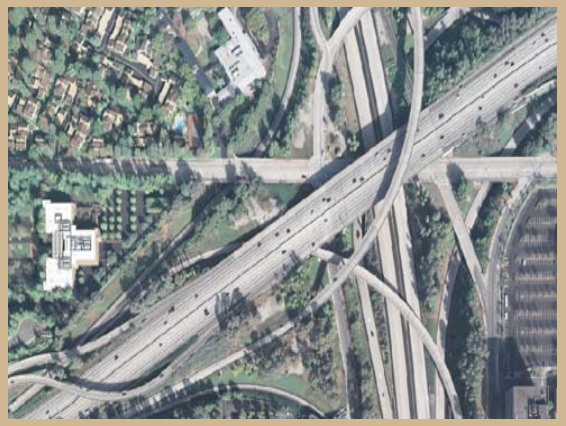


Dewberry

LAR-IAC; this also passed

Dewberry

LAR-IAC Interchanges are critical



Dewberry

LAR-IAC2 Initial Pilot, Excessive Lean

Dewberry

LAR-IAC2 Initial Pilot, Excessive Lean

Dewberry

Orthophoto Aesthetics (4)

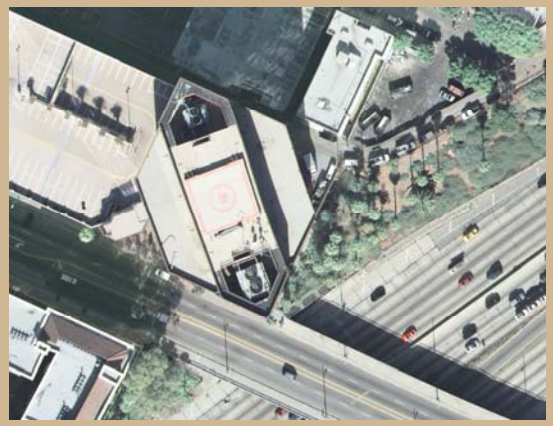
A	Tested Characteristic	Measure of Acceptability
A.28	Shadows	TBD
A.29	Leaf-off	N/A
A.30	Urban Canyon ("Downtown Areas")	Specified "Downtown Areas" have been indicated via shapefile and sent to Contractor and Dewberry. Special care will be made in these areas to reduce building lean and shadows. Flying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

Dewberry

12-bit imagery "tweaked" in shadows

Dewberry

LAR-IAC Good Visibility in Shadows

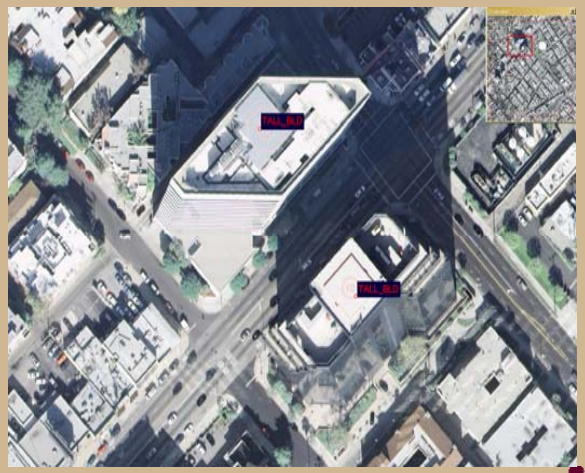


Dewberry

LAR-IAC2 pilot

Dewberry

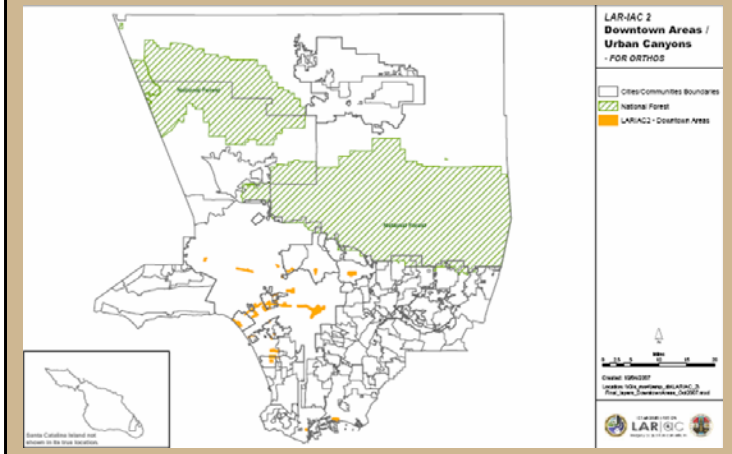
LAR-IAC would have failed "downtown"



But excellent detail in shadows at noon

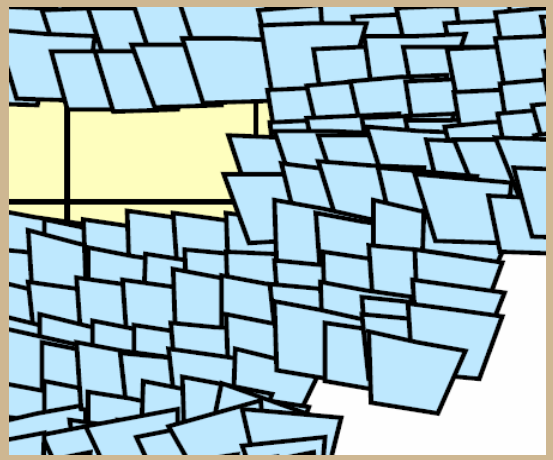
Dewberry

Urban Canyons



Dewberry

Electronic Field Study and Sector Planner



Dewberry

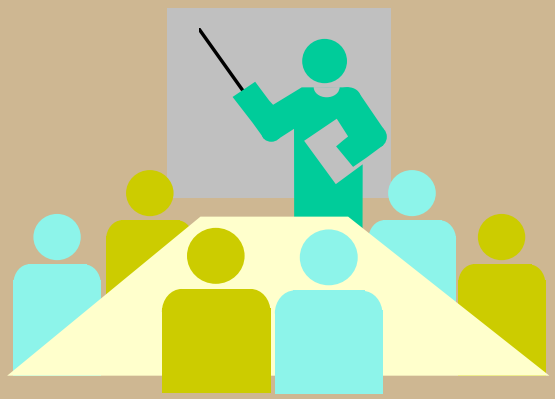
Oblique Imagery Accuracy Statistics

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		202	209	200	199	216
Horizontal Accuracy	$RMSE_x$	1.63	2.09	6.71	7.04	2.24
	$RMSE_y$	6.15	5.36	2.05	1.84	1.86
	$RMSE_r$	6.36	5.76	7.02	7.27	2.91
	$Accuracy_r$	11.02	9.96	12.14	12.59	5.04
Vertical Accuracy	$RMSE_z$	1.37	1.10	1.20	2.29	1.26
	$Accuracy_z$	2.68	2.15	2.34	4.50	2.47

[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.

Dewberry

Questions?



Dewberry