



**Quality Assurance/Quality Control  
(QA/QC) Services  
Los Angeles Region Imagery  
Acquisition Consortium (LAR-IAC2)**

**Dewberry & Davis LLC  
David F. Maune, Ph.D., CP, CFM**

January 22, 2009



## Dewberry Tasks to be Completed

1. QA/QC Management Tasks
2. QA/QC of Aerotriangulation (AT) Reports
3. QA/QC of 4 inch pixel digital orthophotos (urban areas)
4. QA/QC of 1 ft pixel digital orthophotos (national forests)
5. QA/QC of updated breaklines/DTMs
6. QA/QC of oblique aerial digital images
7. Full delivery of countywide & SLDS datasets
8. Production of additional data products (resampled, JPEG 2000, SDE export)
9. Mosaic generation (MrSID and ECW)
10. Assistance with production management, optional items



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## Quality Plan

**Dewberry**

Quality Plan for the  
Los Angeles Region  
Imagery Acquisition Consortium 2  
(LAR-IAC2) Project

Version 2.2  
February 13, 2008

### Acceptance Criteria for Digital Orthophotos:

- ❖ Completeness and Aesthetics
- ❖ 1' and 4" GSD
- ❖ Aerotriangulation (AT)
- ❖ Ground Control
- ❖ Digital Surface Model
- ❖ QA/QC Checkpoints



# Imagery Acceptance Criteria

Responsible Company	Tested Characteristic	Measure of Acceptability
A.1	All Scales Orthorectified	
A.1.1	Satellite to the Dewberry to LAR/LAC	Media: OMR External hard drives
A.2	Dewberry to LAR/LAC	Media: DVD
A.3	Satellite	File organization
A.4	Satellite	File name
A.5	Satellite	Geo-TIFF format
A.6	Satellite	Files must open in context
A.7	Satellite	Point definition
A.8	Satellite	Georeferencing
A.9	Satellite	Vertical Datum
A.10	Satellite	Projection
A.11	Satellite	Horizontal Datum
A.12	Satellite	Units
A.13	Satellite	Coordinate system with the index grid
A.14	Satellite	Coordinate system with the index grid
A.15	Satellite	Coverage
A.16	Satellite	Tile grid layout

A.17	Satellite	Mosaics	4 inch and 1 ft. mosaic. Flying and image capture teams should be aware of this. Complies with standard as determined by LA County, to match LAR/LAC mosaics description. More numerous RDC Content Standard.
A.18	Pictometry	Pictometry sensor anomalies	Contractor will work to identify and correct any differences caused by sensor anomalies. Pictometry should be responsible for software associated with sensor anomalies.
A.19	Satellite	Radiometry	Radiometry should be consistent throughout the imagery, on large and small scales. In general, clouds should be visible as shadows and in bright areas of the image and values at or 25% should be missing. < 2 percent of values at or 25% in the extent possible per client's radiometry production. Radiometry target chips (from "Powerup" areas) will be received and approved by the LA County prior to orthorectification production. The chips will provide a guide and expectation of final imagery appearance.
A.20	Satellite	Image Appearance	No image artifacts. Imagery should not appear speckled or pixelated when viewed at completion scale as shown in the "Color" color surfaces are exempt from this requirement.
A.21	Satellite	Color Consistency	Colors should be consistent throughout the extent of the 12 inch product and the 4 inch product. The 12 inch products will be color balanced separately from the 4 inch product. Mosaic boundaries should not produce great visual contrast differences or imagery on either side is not being exempt from this requirement. In some instances, ground differences may be allowed if the correction will cause significant degradation of the image content on either side. Color balancing between tiles should be considered as possible. No image will be accepted without radiometry measurements without prior approval of LA County.
A.22	Satellite	Swims	Normally, swimmers are added manually or broken into DFM as necessary to reflect actual terrain or by image processing when



# Imagery Acceptance Criteria

A.23	Satellite	Wavy features	When DFM correction or image processing will result in reduced horizontal accuracy or misrepresentation of the location or appearance of important features (bridges, roads, etc.), the image will remain uncorrected. No image will be accepted for mosaic without prior approval of LA County.
A.24	Satellite	Mosaic lines	Minimum mosaic line 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 light. Mosaic lines may pass through power transmission towers, cars, trucks and railroad cars.
A.25	Satellite	Building lean within	The maximum displacement of a 10 story building at the edge of a model will be 10 feet (approximately 1 ft per story).
A.26	Satellite	Urban Canyons (epilegms provided by LA County)	Two-way of multi-lane bridge-decks identified by LA County. 3D breaklines are required to ensure consistency of deck surfaces. LA County will provide bridge locations comparable to specific feature specifications.
A.27	Satellite	"Governor's Tree"	Imagery should not cause alarm by giving false impression that a bridge is sagging or that there are serious hazards to public safety. See page 42.
A.28	Satellite	Shadows	DTM
A.29	N/A	Leaf-off	N/A
A.30	Satellite	Urban Canyons (epilegms provided by LA County)	Accepted "Governor's Tree" have been indicated via shapefile and sent to Contractor and Dewberry. Serial case will be made in these areas to reduce building lean and shadows. Flying patterns may need to be adjusted for this including restricting capture time to optimal sun angles.

Acceptance Criteria B: 1-foot GSD	Acceptance Criteria C: 4-inch GSD	Acceptance Criteria D: Aerotriangulation Pictometry Responsibility
B.1	C.1	D.1
B.2	C.2	D.2
B.3	C.3	D.3
B.4	C.4	D.4
B.5	C.5	D.5
B.6	C.6	D.6
B.7	C.7	D.7
B.8	C.8	D.8
B.9	C.9	D.9
B.10	C.10	D.10
B.11	C.11	D.11
B.12	C.12	D.12
B.13	C.13	D.13
B.14	C.14	D.14
B.15	C.15	D.15
B.16	C.16	D.16
B.17	C.17	D.17
B.18	C.18	D.18
B.19	C.19	D.19
B.20	C.20	D.20
B.21	C.21	D.21
B.22	C.22	D.22
B.23	C.23	D.23
B.24	C.24	D.24
B.25	C.25	D.25
B.26	C.26	D.26
B.27	C.27	D.27
B.28	C.28	D.28
B.29	C.29	D.29
B.30	C.30	D.30
B.31	C.31	D.31
B.32	C.32	D.32
B.33	C.33	D.33
B.34	C.34	D.34
B.35	C.35	D.35
B.36	C.36	D.36
B.37	C.37	D.37
B.38	C.38	D.38
B.39	C.39	D.39
B.40	C.40	D.40
B.41	C.41	D.41
B.42	C.42	D.42
B.43	C.43	D.43
B.44	C.44	D.44
B.45	C.45	D.45
B.46	C.46	D.46
B.47	C.47	D.47
B.48	C.48	D.48
B.49	C.49	D.49
B.50	C.50	D.50
B.51	C.51	D.51
B.52	C.52	D.52
B.53	C.53	D.53
B.54	C.54	D.54
B.55	C.55	D.55
B.56	C.56	D.56
B.57	C.57	D.57
B.58	C.58	D.58
B.59	C.59	D.59
B.60	C.60	D.60
B.61	C.61	D.61
B.62	C.62	D.62
B.63	C.63	D.63
B.64	C.64	D.64
B.65	C.65	D.65
B.66	C.66	D.66
B.67	C.67	D.67
B.68	C.68	D.68
B.69	C.69	D.69
B.70	C.70	D.70
B.71	C.71	D.71
B.72	C.72	D.72
B.73	C.73	D.73
B.74	C.74	D.74
B.75	C.75	D.75
B.76	C.76	D.76
B.77	C.77	D.77
B.78	C.78	D.78
B.79	C.79	D.79
B.80	C.80	D.80
B.81	C.81	D.81
B.82	C.82	D.82
B.83	C.83	D.83
B.84	C.84	D.84
B.85	C.85	D.85
B.86	C.86	D.86
B.87	C.87	D.87
B.88	C.88	D.88
B.89	C.89	D.89
B.90	C.90	D.90
B.91	C.91	D.91
B.92	C.92	D.92
B.93	C.93	D.93
B.94	C.94	D.94
B.95	C.95	D.95
B.96	C.96	D.96
B.97	C.97	D.97
B.98	C.98	D.98
B.99	C.99	D.99
B.100	C.100	D.100



# Imagery Acceptance Criteria

D.1	1"=200' map scale AT	Horizontal accuracy against ground control	up to 0.5". Higher RMSE values are subject to review.
D.2	RMSE of control and tie points	RMSE of control and tie points	< 0.5 meters in x and y. Higher RMSE values are subject to review.
D.3	RMSE of survey check points	RMSE of survey check points	Not to exceed 1.2 meters in x and y.
D.4	NAD83/NAVD83 (E, N) of 20m GSD points	NAD83/NAVD83 (E, N) of 20m GSD points	0.5" within 1.75' RMSE for corresponding scale.

F.A.	Breakline locations	Breaklines updated as needed to control bridges, edge of pavement, hydrographic features, ridgelines, and retaining walls as needed for orthorectification, noise in open water.
F.B.	Contouring	No spikes, holes or blunders; no gaps of sufficient size to affect orthorectification, regardless of perspective corner.
F.C.	Breakline Format	ASC generated, lin and pol files.

Tested Characteristic All Scales	Measure of Acceptability
G.1	QA/QC checkpoints must be clearly photo-identifiable on images at map scales evaluated (4-inches).
G.2	Points must be clearly visible and not elevated (on fence posts, fire hydrants, etc.) that cast shadows.
G.3	Documentation
G.4	Terrestrial images
G.5	Survey accuracy and description of survey procedure used

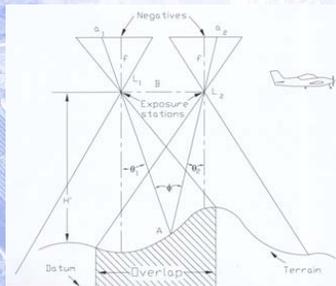


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## Stereo Photography



To correctly map features on the ground in 3D:

1. Need camera calibration to model lens distortions for each camera
2. Need to accurately determine the x/y/z and roll/pitch/yaw of the camera when each photo was taken.
3. This is the primary task of AT (aerial triangulation)

## IMU - Orientation

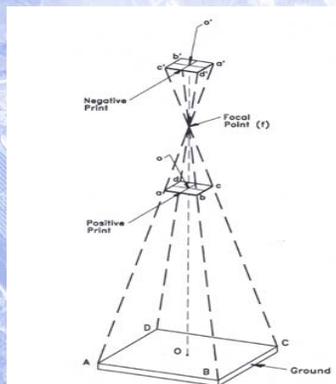


Roll

Pitch

Yaw

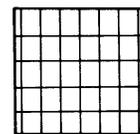
## Vertical Camera Geometry



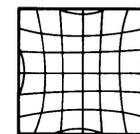
Negative location  
Lens focal point  
Positive location

Points A, B, C, D on the ground pass through the lens focal point to map at a', b', c', d' on the negative, but lines are not straight because of lens distortion and atmospheric refraction

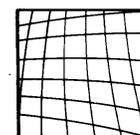
## Camera Calibration



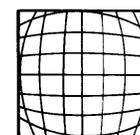
(a)  
Scale Distortion



(c)  
Radial Distortion  
(+ve, Pincushion)

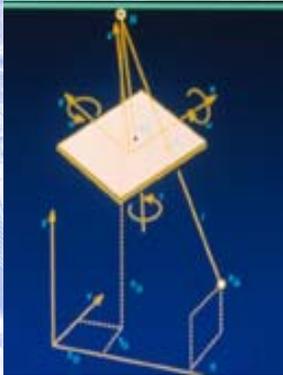


(b)  
Tangential Distortion



(d)  
Radial Distortion  
(-ve, Barrel)

## Exterior Orientation, from Aerial Triangulation

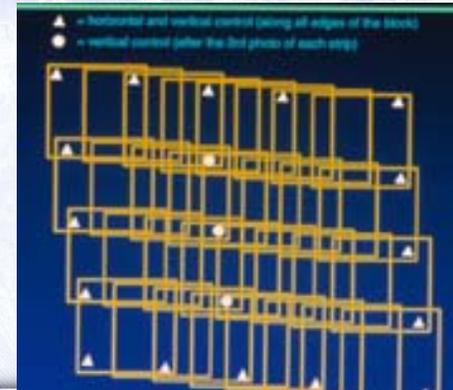


❖ Aerial Triangulation uses survey control, pass/tie points to compute the 3-D position & orientation of the camera for each photo taken:

- x, y, z coordinates in air-space
- roll ( $\omega$ ), pitch ( $\varphi$ ) and yaw ( $\kappa$ )

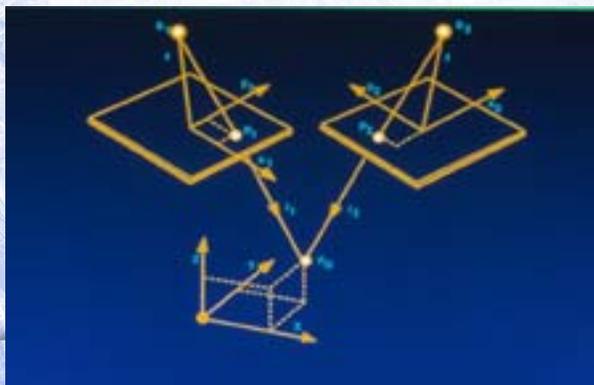
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## Control Points, Pass Points, Tie Points

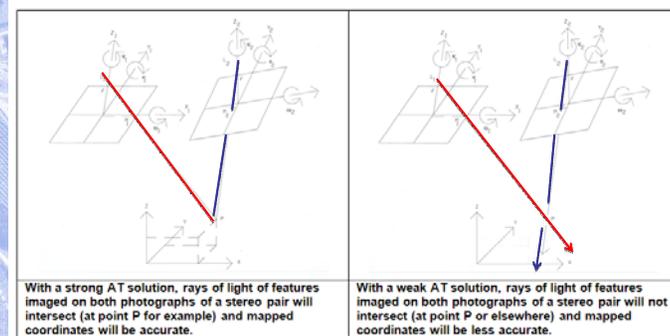


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## Triangulation from Intersecting Light Rays for Control Points, Tie Points, Pass Points



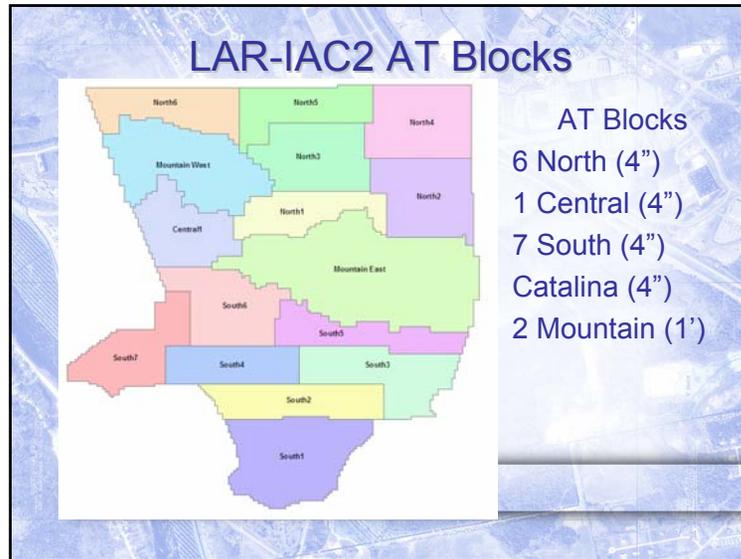
## With and w/o accurate x/y/z $\omega/\varphi/\kappa$



With a strong AT solution, rays of light of features imaged on both photographs of a stereo pair will intersect (at point P for example) and mapped coordinates will be accurate.

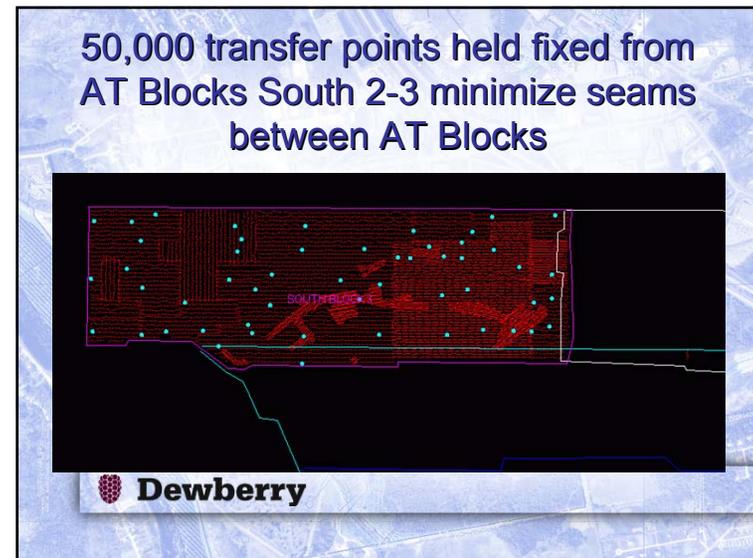
With a weak AT solution, rays of light of features imaged on both photographs of a stereo pair will not intersect (at point P or elsewhere) and mapped coordinates will be less accurate.

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### Massive number of unknowns per AT (6 per image, x/y/z ω/φ/κ; 3 per pass point)

AT Block	Number of Cameras	Number of Flight Lines	Number of Images	Number of Pass Points	Avg. Points per Image	Number of Transfer Points
Catalina	?	226	7,343	4,476,321	610	
South 1	?	405	22,529	5,856,848	260	
South 2	?	410	23,189	6,462,090	279	53,000
South 3	6	336	20,576	10,799,394	525	
South 4	7	506	19,764	12,507,673	633	49,500
South 5	6	427	19,112	13,903,280	727	
South 6	11	477	20,796	6,070,145	292	44,500
South 7	9	386	16,420	5,227,300	318	35,000
Central	11	360	17,729	5,767,011	325	29,500
North 1	?	343	16,971	4,827,422	284	
North 2	?	213	18,934	5,323,094	281	18,850
North 3	?	273	18,448	6,178,246	335	
North 4	6	174	18,577	4,815,413	259	53,600
North 5	?	215	15,147	4,802,997	317	
North 6	6	314	19,414	4,917,191	253	8,850
Mountain W	5	471	6,325	2,368,551	374	
Mountain E	7	938	13,588	4,883,208	359	
<b>Totals</b>			<b>294,862</b>	<b>109,186,184</b>	<b>378</b>	<b>292,800</b>



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## Image Blemishes

Original



Corrected



## Corrected Building Lean

Original



Corrected



## Fails acceptance criterion A.25 for building lean in "downtown area"

447-448



### Gridding Effect – Sanborn unable to correct



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### Color Banding – Sanborn unable to correct



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### Seams on Water – not yet redelivered



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### South 1

AT Block	Tiles	AT Control		Ortho			Ortho Results		DEM		Original % Failure	Resubmission % Failure
		Pictometry	Dewberry	Sanborn	Dewberry	Pass	Fail	Sanborn	Dewberry			
South 1	1020											
South 2	801											
South 3	574										6.9%	
South 4	686											
South 5	711											
South 6	952											
South 7	348											
Central 1	814											
North 1	688											
North 2	3005											
North 3	951											
North 4	811											
North 5	747											
North 6	790											
Cascade	430										0.00%	
Mountain 1	372											
Mountain 2	708											
<b>TOTALS</b>	<b>13919</b>	<b>0</b>	<b>17</b>	<b>0</b>	<b>908</b>	<b>2624</b>	<b>147</b>	<b>0</b>	<b>0</b>			

Of 65 tiles in South 1, still correcting water tiles, geotiff header issues, and one tile for building lean

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## Oblique Imagery Measurement Accuracy

View	North	South	East	West	4-View Average
Targets Visible	186	188	188	188	190
RMSE <sub>r</sub>	2.97 ft	2.70 ft	3.07 ft	2.68 ft	1.25 ft
Accuracy <sub>r</sub>	5.14 ft	4.67 ft	5.31 ft	4.65 ft	2.16 ft
RMSE <sub>v</sub>	1.50 ft	1.16 ft	1.53 ft	1.21 ft	1.22 ft
Accuracy <sub>v</sub>	2.94 ft	2.27 ft	2.99 ft	2.38 ft	2.39 ft

RMSE<sub>r</sub> = Horizontal (radial) Root-Mean-Square-Error

Accuracy<sub>r</sub> = Horizontal (radial) accuracy at 95% confidence level

RMSE<sub>v</sub> = Vertical Root-Mean-Square-Error

Accuracy<sub>v</sub> = Vertical accuracy at 95% confidence level



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