

# DIGITAL IMAGE BASED PHOTOLOG SYSTEM

by Nazir Lalani and Joe Breyer

**Abstract.** The County of Ventura Transportation Department recently (in early 2004) acquired a field data collection system to better manage historical, current and future changes to the road network. The objective of this system was to provide an efficient method of building “point-in-time” references to the County's road network that includes compressed digital imagery of signs; markings, signals and all appurtenances on the roadway surface of the County-owned roadway system. The Department has previously logged 35mm color film reels of the roadways at 3- and 4-year intervals between 1980 and 1994 using in-house staff and its own distance measure instrument (DMI). A combination the DMI breaking down and the retirement of the staff person in charge of the analogue system triggered a decision to switch to a digital image based system. This paper and the associated presentation will discuss how the project scope was developed, selection of the most appropriate vendor and lessons learned. Information will be shared about how the Department uses this digital image library in its day-to-day operations.

## INTRODUCTION

The project was originally started in the year 2000 when the County of Ventura Transportation Department, herein after referred to as the Department, issued a Request for Proposals (RFP) developed by in-house staff to a very limited number of firms known to perform this type of work. Only two proposals were received. Agencies with collection systems developed by the two firms submitting proposals were then interviewed and their collection systems reviewed on site at those agencies. The agencies with the most experience were the state Departments of Transportation for Arizona, Connecticut and Pennsylvania. Additional information via mail was also obtained from the Delaware Department of Transportation. An in-house report was prepared summarizing the lessons learned from interviews and site visits.

The benefits of the site visits were to obtain the scopes of work used by these agencies when hiring firms to develop their photolog collection system and a more comprehensive list of firms to whom the RFP could eventually be sent. The type of equipment used to store and view the database was identified. The Connecticut and Arizona Departments of Transportation provided a demonstration of the data collection vehicles, which it acquired to collect image data using its own forces rather than hiring a firm to perform the data collection.

**Figure 1 - Old system limited to 1 user**



Rather than select from the two offers, a critical decision was made to re-solicit after hiring an outside project manager to:

- Assist in the development of a new more comprehensive RFP and help select the most qualified firm to collect a new photolog product and provide a system for accessing/viewing the product.
- Develop a final scope of work for the contract between Ventura County and the firm submitting the successful proposal.
- Manage the delivery/implementation of the new system and to review the quality of data the contractor was required to submit early in the image collection phase of the project.

## REQUEST FOR PROPOSALS

The outside project manager worked with the Department to further refine the County’s needs in light of the revelations that surfaced following the original submittal of proposals. This work included a day of various meetings at County offices to interview the potential users of the system and understand various physical constraints involving workgroup connectivity and communications. Also, the outside project manager gathered existing road inventory information that could convey the size and scope of the roads to be logged by the successful photolog provider.

Figure 2 - RFP Support provided through web

The outside project manager drafted the eventual RFP for submission to over a dozen identified vendors of the required technology. In order to convey the scope of data collection, a web-based GIS service was set up especially for the RFP phase of the project. This enabled the County to display their scope of desired roadways without having to negotiate the signing of waiver forms for the release the voluminous GIS datasets to multiple vendors.

#	Item	Unit Effort	Unit	Quantity	Extended
1	543 Miles of 2-way (1086 log miles) photo-imagery, single camera, bi-directionally acquired, paired, and delivered to County, capable of being viewed in royalty-free viewer provided on each media.		per log mile	1086	
2	Add 2nd camera to provide another 543 miles of 2-way photo-imagery of right side of right-of-way, bi-directionally acquired, and linked to primary camera by position and direction, capable of being viewed in royalty-free viewer provided on each media.		per log mile	1086	
	Add 3rd camera to provide another 543 miles of 2-way				

## PROPOSAL REVIEW AND PROJECT AWARD

The resultant RFP produced 3 completed offers. This was somewhat disconcerting as many firms that showed interest during the response period did not end up submitting. Neither of the firms that submitted on the first RFP bothered to resubmit. The offers did however better fit the

requirements that the Department had defined with the assistance of the outside project manager. The selection of ideal firm to perform the imagery collection resulted in a significantly lower anticipated cost. Therefore, the Department chose to exercise the consultant's alternative proposal options and increased the number of cameras that would be collected to improve the functionality of the delivered product. The Department also chose to add on the option of collecting pavement roughness and rutting data, which was deemed desirable, but was not an essential requirement of the project.

## **NOTICE TO PROCEED**

The project experienced significant delays in arriving at the point where work could commence. The Department had initial desires to keep the imagery from being collected in the rain/fog season, when typically ends in early to mid-June. The combination of the firm's availability, and the County Attorney's requirement to reformat the technical scope of work into a legally comprehensible document delayed the work from commencing until late summer 2003. One important benefit of this delay was that the County used the added time to rectify their GIS shapefile of roads that would be logged with the equipment provided by the Consultant.

## **COMPLETION OF COLLECTION**

**Figure 3 - Collection vehicle with 4 cameras**

The selected firm collected the image data over 2-3 weeks in late October and early November, 2003. As it turned out, a major fire broke out in the eastern part of Ventura County after the 1<sup>st</sup> week of imagery collection, which scorched thousands of acres. Luck (good or bad) would have it that the areas that burned were largely already photographed prior to the burn and the collection vehicle proceeded, for the most part, unencumbered by the fires.



Almost 700,000 JPEG images referenced to the County's GIS system were delivered on a hard drive and a set of DVDs was delivered for mobile users. The County Information Services Department staff, with the aid of the consultant installed the data onto a server that can now be accessed by any staff member needing to view these images at their own workstations.

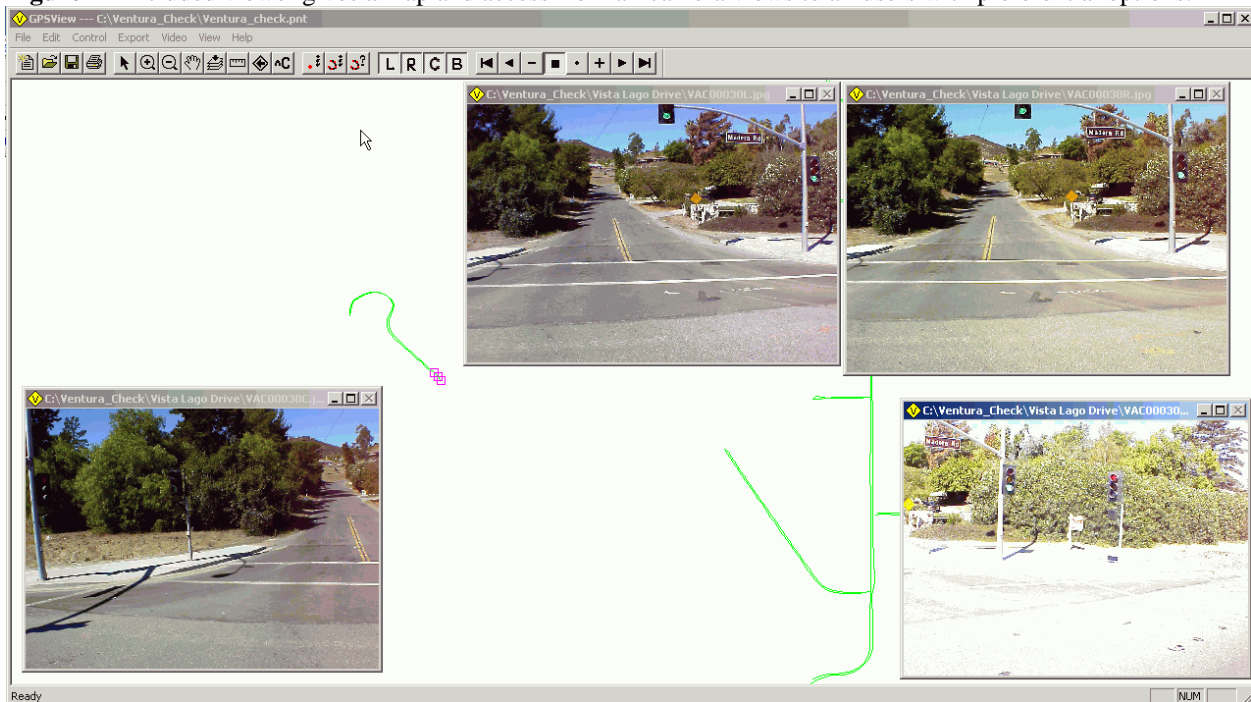
## **DELIVERED IMPLEMENTS**

The delivery of the imagery is considered the "product" of the project. However, a major requirement in the selection of the successful proposal revolved around the "system" included with the delivery of project. The Department accepted delivery of an unrestricted number of

“view only” image viewer licenses that act as individual portals to the image library from separate computer desktops. Ultimately, the County aims to access the imagery through a browser interface over the Intranet and allow future deliveries of imagery to meet an open specification to enable vendor competition.

The Department also has access to one software license that allows for feature extraction from imagery stereopairs. This software will be used to create GIS-based feature inventory databases as necessary. Finally, a spatial file of all of the photolog image points was delivered for use in the County’s web map services.

**Figure 4** - Included viewer gives a map and access from all camera views to all users with preferential options.



## SPECIFIC PHOTOIMAGERY USES

The photolog images are used for the following:

- View field conditions when responding to citizen requests for changes to county maintained roadways.
- Developing preliminary designs for new improvement projects.
- When developing power point presentations for public hearings before elected officials and members of various commissions.
- Documenting existing conditions in the event of a lawsuit arising out of a collision at specific locations on the county road system.
- Many more....

## PROJECT COSTS

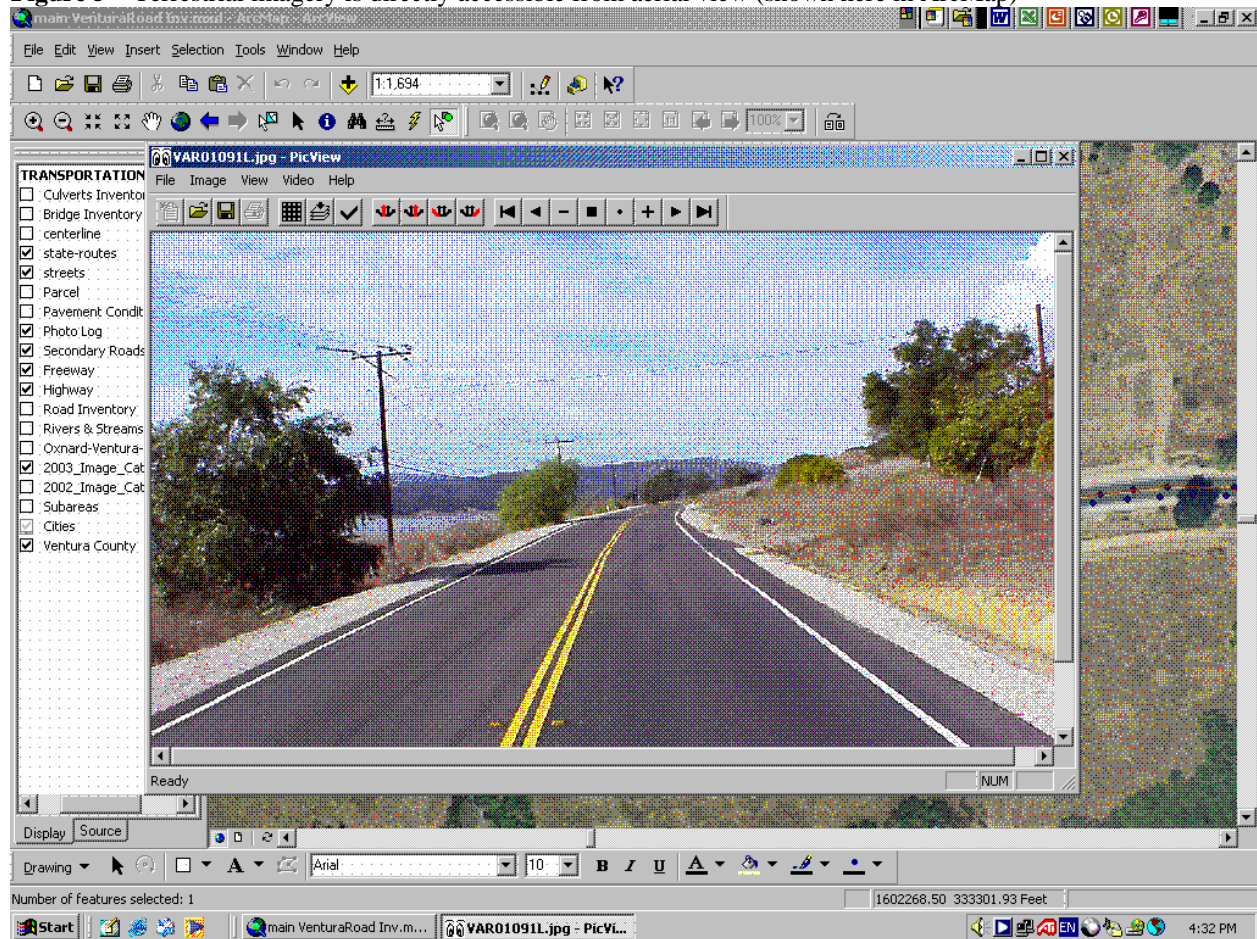
The total cost of the project was approximately \$98,000 for approximately 550 miles (1100 directional miles) of imagery collection. There were two major cost components. The contract to hire the project management consultant was \$25,000. The cost for completing the photolog data collection project was about \$73K. Of this cost, there was only about \$2.5K were one time charges.

The Department spent an additional sum to hire a sub-consultant to collect pavement management data. However, this aspect of the project has not been included in this paper.

## LESSONS LEARNED

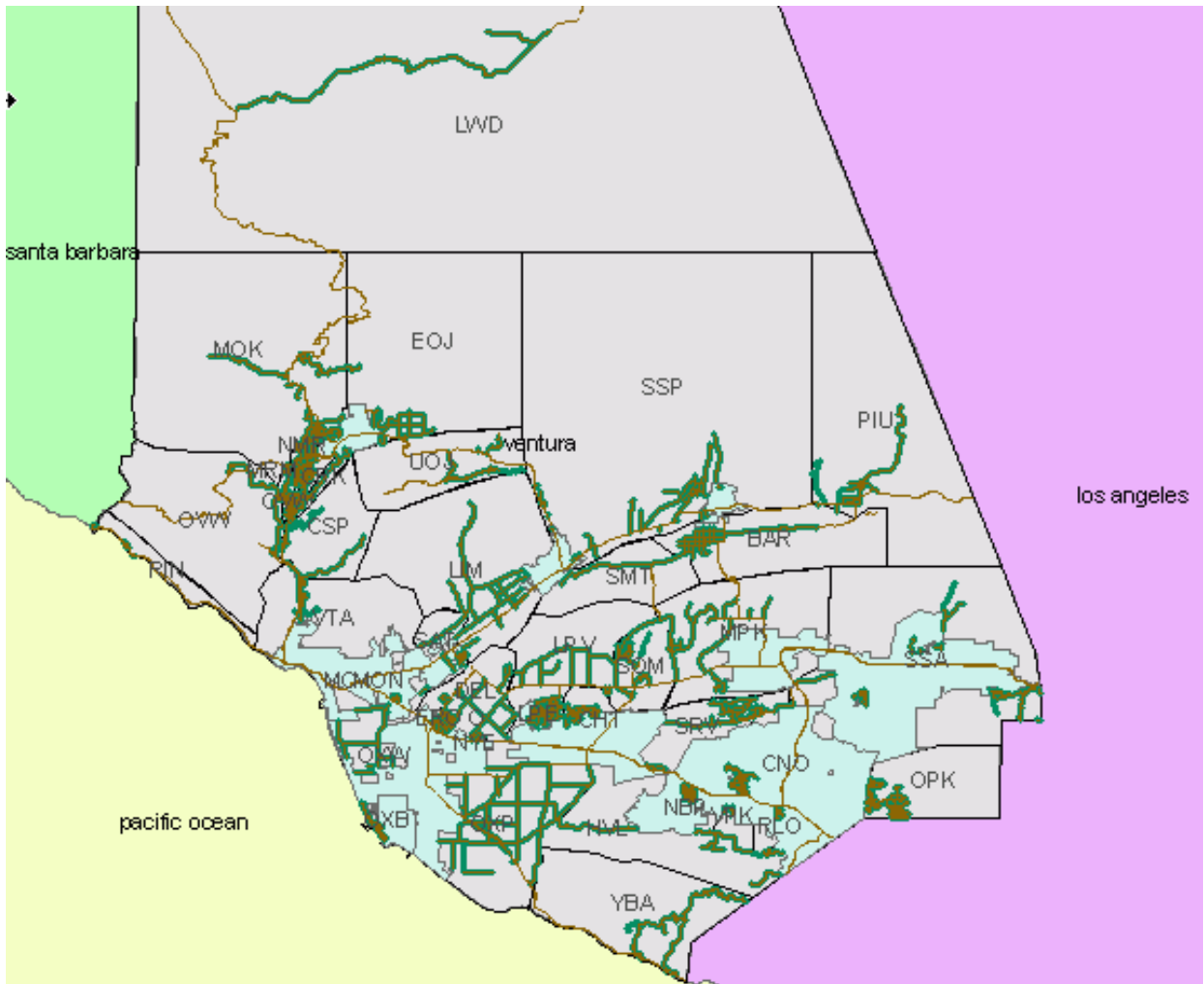
The Department was pleased with its decision to hire an outside firm to provide project management services. The experience of the firm selected to manage the project was critical to avoiding the pitfalls that some agencies have experienced when undertaking a project using this type of technology. The site visits to other agencies with existing photolog systems using digital images tied to GIS referencing helped to develop a comprehensive scope of work, which resulted in the project delivering the type of system the Department needed.

**Figure 5 – Terrestrial imagery is directly accessible from aerial view (shown here in ArcMap)**



The RFP included a request for sample imagery, data, and freeware image viewer. This turned out to be very important in our selection process since it enabled the review panel to better understand the potential deliverables. Primary in this understanding was the knowledge of whether the vendors were aiming to deliver “product” that was simple format and open architecture between the image and the supporting image metadata. This meant that the County would be able to build Intranet applications around the photo-imagery, and satisfy the need for future imagery by inviting multiple vendors to provide future editions of the imagery.

Provision of GIS based inventory of roads to be image-logged is extremely important to the photolog consultant. At the onset of data collection, the County’s GIS shapefile of maintained roads was not as accurate as the tabular database – and hence not the official docket of roads. A parallel effort to update the GIS shapefile from the tabular was ongoing, but unfortunately wasn’t ready at the time the consultant arrived to begin collection. It is therefore very important to have a GIS standard prior to commencement of a project like this. The reality, however, is a catch-22 as many agencies utilized the product of the photolog to create the initial centerline shapefile.



**Figure 6** – Interactive GIS directory of roads to be photolog surveyed was provided over the web to all bidders.

The use of the website to distribute the knowledge of the range and scope of roadways to be traveled was a moderate success. From the quality of the three responses, it didn't seem that the firms submitting the proposals cared very much about the arrangement of roads in order to be competitive in understanding the scheduling and deadheading required. Perhaps more than a few potential bidders failed to respond to the RFP because they weren't enthused about the great number of streets that were a very short run. On a per mile bid, it is a lot more difficult to make money when the travel speed hovers near 30mph and the vehicle spends an inordinate amount of time doing U-turns. In fact, one of the potential bidders that considered, but failed to offer, indicated that they ultimately weren't interested in the project because they had a significant backlog of state DOT clients with long routes, higher speed and therefore a higher production rate.

The ability to sample data before the completion of entire collection process was an important component. Because of problems related to sun glare and varying weather conditions, approximately 0.5% of the images were not of sufficient quality to be useful.

### **ADDITIONAL INFORMATION**

Anyone requiring additional information should contact the authors using the information below.

### **SCOPE OF WORK ATTACHMENT**

The 6-page scope of work for the delivery of the photolog system is attached.

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## SCOPE OF WORK

The scope of work for the digital image based photolog system include the following:

### Section I - Definitions

- a) *Chainage: Distance along the traveled path of the data collection vehicle*
- b) *DMI: Distance measuring instrument, used to calculate chainage*
- c) *ESRI: Environmental Systems Research Institute, makers of GIS software.*
- d) *Shapefile: A format of storing GIS information consisting of a minimum of three self-contained but interlinked files containing geometry, attributes, and spatial index.*
- e) *GIS: Geographic Information System*
- f) *GPS: Global Positioning Satellite*
- g) *JPG: A format of compressed digital imagery*
- h) *Microsoft Access Database: An electronic container of data with stored tables, queries, reports, and software code.*
- i) *Plug-ins: A software component that is installed to provide additional functionality to browser software*
- j) *PDOP: Positional degree of precision*
- k) *Tabular and Spatial Indexes: Databases that provide information relating individual photo images to the conditions under which they were collected. The 'spatial' adjective indicates that position is of the essence and that search capabilities should be enhanced through GIS.*

### Section II - Duties and Deliverables of Consultant

- a) *Base Data Library: The Consultant is responsible for providing deliverables that reference the official road numbering and naming scheme that is already in place to maintain consistency with other County data applications. See "Section V(a). Upon commencement of work, the Consultant will be responsible for acquiring the latest version of the data base library by contacting County staff.*
- b) *Data Collection – Imagery: The Consultant shall be responsible for the capture of detailed color imagery with spatial and tabular indexes on approximately 543 miles of roads in unincorporated areas of the County of Ventura. The spatial extent of the*

roadways to be logged is revealed in the “Base Data Library” referenced above and in Section V. Data and imagery should be obtained and provided as follows:

- Digital image format shall be conventional JPG viewable through contemporary versions of common web browsers without added plug-ins.
- The delivered digital master imagery resolution shall be no less than 1024x768 pixels. Imagery shall be acquired with progressive scan technology.
- Because the County intends to post-process the master imagery to a smaller (perhaps 320x240) JPG format for smaller storage and quicker delivery to users over its Intranet, the Consultant shall provide its PicView software with the capability to enable the County to mass reduce the size of the imagery for thumbnail requirements.
- The principal imagery provided by Consultant shall be a four-camera format with two cameras working in stereo for potential triangulation measurement of features contained. The two side view cameras shall provide a significant peripheral perspective of roadside features to the right and left, including the dividing line on non-divided highway facilities or the left shoulder on median-divided roadways.
- The minimum number of images collected during photo logging shall be 132 per mile per camera in each direction.
- Imagery collection periods shall be dictated by the best possible conditions that will provide adequately lit images of dry pavement without obfuscation by chronically heavy traffic conditions or inclement weather.
- Imagery shall be delivered on 2 copies of a series of DVD media discs. The contents of any media should include all images for a given location including both directions and all camera perspectives. The Consultant shall supply an initial DVD prior to the official submittal to ensure that the DVD-recordable format can be read by the DVD drives available to the County.
- All County-specified roadways shall be driven and images captured in directions of normal traffic flow.
- The data collection process shall operate within all local governing regulatory and advisory speeds to ensure the safety and welfare of all users of the public right-of-way. All traffic laws and rules of safe operation shall be obeyed.
- The data collection vehicle shall maintain no less than 50 feet clear distance behind same direction traffic so that acquired imagery contains a minimal amount of blocked views of the pavement surface and right-of-way caused by other vehicles.
- The data collection vehicle shall display appropriate signing, where legally permitted and safely accomplished, to inform trailing motorists of the function of the vehicle

and give way to backlogged traffic by pulling off of the traveled way in the event that a significant queue of vehicles forms behind.

- The complete set of tabular and spatially indexed imagery shall be accessible through Consultant's ViewOnly viewing software and Feature Extraction software.

All items identified are to be installed and working to County's satisfaction prior to County's acceptance of the work.

- c) *Validation of Imagery:* Prior to embarking on mass collection of the entire set of photo imagery, the Consultant shall deliver initial representative imagery collected on the first day of typical conditions on all cameras to be deployed. This imagery will establish a benchmark quality satisfactory to the County upon which the County will establish a minimum standard of acceptance. Sources of discrepancy, (if any), shall be resolved by the Consultant before the collection of County road system imagery is continued. All delivered imagery is expected to meet County standards established at the onset of imagery collection.
- d) *Data Collection - Metadata:* Photo imagery collection shall incorporate the Base Data Library provided by the County to link stored digital images to official highway log mileage using County naming conventions. Where available, the Consultant shall employ both mile reference markers and cross streets as image collection reference points for associating a linear distance or chainage. Reference markers are only present on longer segments of County roads. The metadata shall be collected in compliance with the following:
  - The Microsoft Access database and an ESRI shapefile of the County street centerlines provided to the Consultant by the County pursuant to Section V(a) do not have the existing reference marker locations catalogued in any GIS file for Consultant use. Therefore each visible milepost marker position shall be “marked” (or gathered) during field collection by acquiring a special positional fix as the photo-log vehicle passes the reference marker in both directions at the Consultant-determined data collection speed.
  - Bi-directional comparisons of the same milepost location that differ by more than 20 feet in projected distance along the centerline are an indication of inattentive data collection practices and shall be corrected. Therefore, the Consultant shall be prepared to anticipate the reference marker value and acquire the next reference marker position/value as the photo-logging progresses. Any errors in reference marker labeling shall be edited/corrected prior to delivering the finished product.
- 3) GPS position of the antenna shall be sub-meter accurate in the horizontal dimension at least 95 percent of the time.

- 4) The Consultant using DMI chainage and offsets from references using the County's GIS centerline file to define the shape of the road shall correct missing GPS points.
- 5) The imagery collection shall be supported with the following metadata stored and delivered in a Microsoft Access (2000 or later) database:
  - a. An indexed value (unique for the year of data collection) representing the image number (i.e. filename minus filename extension).
  - b. The camera position (out of 4 possible cameras) shall be identified
  - c. Image capture rate shall be expressed in frames per mile.
  - d. Date (in Year 2000-compliant format) and time (in HH:MM:SS.S format to the nearest 10<sup>th</sup> of a second) of image capture shall be provided.
  - e. Longitude-latitude (in decimal degrees) and altitude (in feet above Mean Sea Level) positions of the GPS antenna at each image capture shall be provided.
  - f. Name of the inventoried route by "RoadNum" and direction-bound of travel shall be provided.
  - g. Name of the reference crossroad/feature at beginning of current inventory route shall be provided.
  - h. Distance (in miles to 3 decimal places) from the begin route reference measured with a calibrated distance measuring instrument (DMI) shall be provided.
  - i. Positional Degree of Precision (PDOP) of the GPS reading shall be provided.
- e) *GIS Point Shapefile and Imagery Access Scripts*: In order to make the roadway photo imagery accessible to other GIS applications, the Consultant shall provide an ESRI shapefile of the entire library of photo imagery point locations with the final deliverables. The shapefile shall be attributed with image filenames associating each point to the respective image, as well as other metadata stipulated previously. The shapefile shall be projected in feet units using Lambert Conformal Conic NAD27.

Accompanying the shapefile, the Consultant shall also provide an unencrypted ArcView Avenue extension that can be loaded into any ArcView 3.x project file. Also, an ArcGIS extension shall be delivered as a DLL file and as Visual Basic code. Upon loading either extension, the interface shall retrieve a stored variable representing the network path (i.e. hard drive) of the imagery location. The user shall be allowed to alter this path and the new path becomes the stored variable. The extension shall provide a button that will

retrieve and present an image so long as the active theme is the imagery point shapefile and any point is clicked with the button activated.

### Section III – Licenses

- a) *Product Review Software:* The County and all Transportation Department staff shall be authorized to use the Consultant's ViewOnly standard complimentary viewing software to access the above-described metadata with detailed imagery across the County's network, in perpetuity. Consultant shall provide software updates at no cost to the County for a period of two years from the date of delivery.
- b) *PicView Software:* Consultant shall authorize the County to use the PicView software to mass reduce a library of imagery for thumbnail creation provisions, in perpetuity.
- c) *ArcView Extensions:* Consultant shall authorize the County the capability to access to use the ArcView 3.x and ArcGIS 8.x extensions and supporting software code, in perpetuity.
- d) *Feature Extraction Software:* Consultant shall authorize the County to use one license of the Feature Extraction software for field crews and managers to inventory and review signs, pavement markings, signals, and other appurtenances at a shared workstation, in perpetuity.

### Section IV – Services

- a) *Software and Database Installation:* The Consultant shall also provided the following:
  - 1. Installation of View Only software on up to a dozen desktop workstations of Transportation staff in the Public Works agency.
  - 2. Setup and installation of the digital imagery and databases on County-supplied hardware.
  - 3. Setup, installation and training of GIS shapefile and imagery access GIS extensions.
  - 4. Installation of Feature Inventory software on one County-supplied workstation.
- b) *Image Viewing Training:* Training shall be provided for the View Only and Feature Inventory software for up to five County staff:
  - 1. Training shall be based on printed manuals on how to use the viewing software.
  - 2. An electronic file in MS Word format shall also be provided for making additional printed manuals.

3. This documentation should also be available from the user interface as a “Help” option of the viewing software.
  4. Training program offered shall provide enough instruction for County staff to be able to navigate the View Only software and to print images.
  5. Training shall also include a basic orientation in all facets of the Feature Extraction software, and emphasize its primary usefulness relative to the View Only software.
- c) *Telephone Support:* Telephone support shall be provided by Consultant to assist County staff in solving problems during the first one year after the delivery of the digital image based photolog system.

#### Section V – Duties of County of Ventura

- a) *Base Data Library:* The County will provide a Microsoft Access database that details approximately 1214 segments of road that are cataloged with a “RoadNum”, “RoadName”, and “RoadLimits” values that are unique for each segment of road under County inventory. This database is the official source that yielded 542.12 miles of 2-way road as presented in the Request for Proposals. Upon commencement of work, the Consultant will be responsible for acquiring the latest versions by contacting County staff.
- b) *Web GIS Shapefiles and the Web Microsoft Access Database:* The GIS shapefile and database displayed at the [www.venturahighways.com](http://www.venturahighways.com) map website during the RFP stage are currently available for use by the Consultant (total zipped size < 8MB). These sources are not considered to be as up-to-date as the official sources mentioned above.
- c) *Confidentiality and Non-Disclosure Agreement:* The Consultant shall be required to enter into a confidentiality and non-disclosure agreement in order for the County to release any electronic database to the Consultant. All data is provided with the understanding that it can only be used to satisfy the objectives of this project.