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Remote Asset Monitoring and Verification Report - Testing and Proof of Concept

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Afghanistan Irrigation Infrastructure - Remote Asset Monitoring and Verification

Report
Testing of Equipment and Proof of Concept

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Executive Summary

This document is the final Phase 1 Report for this mission. An early version of this report was drafted and delivered[1] – it documented an early assessment that the equipment and software could be used to demonstrate the concept of the mission – and those details are also included/ updated in this document.

The Ricoh 500SE camera was quite easy to operate; it operated very much like many popular commercially available digital cameras with standard controls and guidance symbols. Along with the ruggedized construction, buttons were prominently coloured and larger than normal, which made for easy operation of the unit. The camera has a built-on GPS receiver, which enables the camera to capture and store location information (Latitude and Longitude) with each photo, i.e. in the EXIF headers of the JPEG file.

The 'Gate La' software supplied by the camera manufacturer for transferring photos from camera to PC can have installation issues. If so, the photos stored on the camera can be transferred directly to a PC via the supplied USB cable using Microsoft Windows Explorer. Both methods were used to transfer photos from camera to a laptop PC; so generation of the ultimate GIS outputs - ESRI Shapefiles – is always possible.

The 'List Editor' software supplied by the camera manufacturer was used to create and upload custom memo fields for tagging photos with short descriptions as they were taken with the camera. This provides a slightly more sophisticated data capture approach that might be useful in field operations.

The 'GPS-Photo Link' software supplied by GeoSpatial Experts LLC for producing GIS outputs from the photos and associated GPS position fixes performed well. It installed neatly, and quickly and easily allowed the creation of Shapefiles usable in a GIS, and additional products such as Google Earth KMLs and a copy of each photo watermarked with title, comment, position, date and timestamps. The Ricoh camera also has the independent facility to add date and time watermarks to the original photos.

A template map was drafted in ESRI ArcMap GIS software and the Shapefiles produced from the camera data were successfully added to compose point maps of the areas used in field/test exercise. The digital ArcMap layouts include hotlinks to the processed position-watermarked

[1] (2009-12-17) *Report 1 – Testing and Proof of Concept*. Filename: 'Report 1 - Testing and Proof of Concept - Afghanistan Irrigation Infrastructure.doc'.

copy of each photo and printable JPEG and PDF copies of the point map showing locations and location names from the field exercise were produced. The Google Earth KMLs also provided another useful compilation of the field data from the camera in an easily-viewed presentation.

During Phase 1 testing it was learnt that the camera model purchased by the Kabul EIRP Team is different from the test model being used by the consultant. The Kabul team purchased Nikon Coolpix P6000 cameras. A short test with a sample photo taken with the Nikon camera proved that the concept can also be implemented with this camera and the existing software to produce GIS Shapefiles. It is not known whether the upload of custom memo fields for tagging photos with descriptions as they are taken is possible with the Nikon cameras. However, that is not a totally necessary task for successful implementation/ operation of the concept, as other means of recording such notes are also possible if necessary.

Phase 1 testing also considered the workflow and procedures that would have to be adopted to successfully implement the concept. It is envisaged that there could be three roles for personnel involved: (i) field data capture (ii) processing of camera data (iii) quality control and map production.

Phase 2 of the mission will be used to deliver a training programme in Afghanistan leading to the routine production of GIS Shapefiles, geotagged photos and maps for EIRP monitoring and verification.

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Background and Context

The World Bank is currently engaged in Afghanistan to support the country's irrigation infrastructure and the teams currently involved in supervising the project employ innovative means to collect field data to aid in their ongoing monitoring. Revival of Afghanistan's irrigation systems is key in the fight against poverty. Monitoring of the investment will ultimately aid the long term management of these systems. Given the current security situation, creating a reliable and sustainable means to automate field data collection and transmission to central systems for analysis and monitoring will greatly reduce the need for mission travel to potentially risky areas.

The Bank is interested in using modern geospatial methods to improve current monitoring capacity, through remote asset monitoring and verification of Afghanistan's irrigation infrastructure. Whilst trustworthy verification is desired, simplicity within the process will make it sustainable. This will be accomplished through linking geospatial technology (GIS - Geographic Information Systems and GPS – Global Position Systems) with common technologies such as digital cameras. The consultant is a GIS Specialist hired to test, implement and provide training on the system for field teams in Afghanistan.

Objective

Implement a geospatial data capture methodology for irrigation assets utilizing ruggedized, GPS-equipped cameras to produce monitoring datasets for a GIS.

Purpose

Improve monitoring capacity to support the investment in Afghanistan's irrigation project and further secure the fight against poverty.

Goals of Exercise being reported on

The goals of the Phase 1 were (i) to confirm that the camera and software worked and could be used to deliver the ultimate product - ESRI Shapefiles with integrated photos; (ii) to produce such products and present them in a useful form (iii) to develop a workflow for achieving the objective on the ground and (iv) to develop training materials.

Setup of Equipment and Installation of Software

The equipment, composed of a Ricoh Caplio 500SE[2] Digital Camera (serial number 2310674**7**[3]) and accompanying Caplio software, GPS Photo Link software, 2GB memory card, three battery packs, a battery charger, padded carrying case and strap, and printed documentation for the camera was received on Dec 05, 2009. The camera is ruggedized and has a built-on GPS receiver, which enables the camera to capture and store location information (Latitude and Longitude) with each photo, i.e. in the EXIF headers of the JPEG file.

Charging of Battery Pack

The Powermart DFU004 1800mAh 3.7V rechargeable Lithium-ion battery pack was about 90% charged in 2 hours and 25 minutes; and was fully charged in 2 hours and 45 minutes. Charging therefore took about 30 minutes longer than advised by the battery manufacturer's documentation. The status lights of the battery charger were easy to understand and charging was easy to do. Charging was done on 110v mains supply.

Installation of rechargeable Li-ion battery and Start up of unit

Installing the battery was simple; guidance is stencilled in the camera's battery compartment. The camera started quickly with the push of a single easily identified button on the back, and the initial setup task of specifying the date and time when the camera was first turned on was easily completed.

Installation of Software

Two software packages were supplied and needed to be installed:

- Caplio Software, by the camera manufacturer Ricoh. Includes 'Gate La' utility for downloading photos from camera to PC, and 'List Editor' utility for creating and uploading camera 'memos'.
- GPS Photo Link, by GeoSpatial Experts LLC. For producing GIS products, including ESRI Shapefiles, from downloaded photos on the PC.

The Caplio Software (includes utilities: Gate La version: 4.4.0.0 and List Editor version 2.0) came on a labelled CD/DVD. The software was installed on a laptop in about 10 minutes. But it did not fully work on the first attempt – the software did not recognise the camera when that device was connected to the PC. During the installation the software offered to replace a Windows system driver, with the caveat that should the PC not function properly afterwards, the original systems driver should be used – users may find this a risky choice. As advised by the Camera Manual, the Caplio software was removed and reinstalled. After a second attempt the software

[2] Manufacturer's tab on base of camera incorrectly states the camera model as a Ricoh 500SE-W. The camera model is correctly printed on the front of the unit as Ricoh 500SE.
[3] GPS Photo Link software displays the camera serial number – apparently retrieved from the information embedded in each photo - as 2310674**8.**

did begin working, but the installation seemed to have affected a printer attached to the PC (the printer driver had to be re-installed).

The GPS Photo Link (version: 4.3.7 GIS Pro) software came on a separately encased CD/DVD with the license number and a printed user guide inside the case. The software was installed on a laptop in about 2 minutes; including license activation via the Internet. Free updates will expire on Mar 20, 2010. It worked well and produced the desired ESRI Shapefiles and other outputs.

Testing of Equipment and Software

Start up and Use

On start up the camera's GPS receiver took about 15-20 minutes to acquire its first position fix. This is normal for a GPS receiver on its first start up, and when the camera was switched on at later times the GPS unit acquired position fixes in about a minute or less. So start up of the camera about a minute before taking a photo is useful; to allow the GPS receiver time to acquire a good position fix.

Operating the camera was easy and as normal as with any other popular commercially available point-and-shoot digital camera. Test photos were taken in the southern hinterland region of Guyana at various infrastructure locations along an extent of about 200km. The camera was switched off between test shots and the significant distance (70km+) between some test shots served to test the ability of the GPS receiver to acquire fresh position fixes under a new horizon/ satellite constellation when it had moved a large distance from its last satellite signal reception. The GPS receiver performed well acquiring position fixes in about a minute at its new locations. An additional exercise in the eastern border region of Guyana, again travelling a distance of about 200km, resulted in good performance of the system.

Further successful tests were done in the urban environment of Georgetown, Guyana; in particular incorporating the use of pre-arranged pick-lists of items for push-button attachment of short descriptive 'memos' to each photo with the camera.

Creating and Uploading Camera Memos

The Caplio Software 'List Editor' utility is simple – it allows the creation of five lists and uploading of same to the camera. These may then be used as pick-lists during operation of the camera to apply short descriptive memos to a photo as it is taken with the camera.

SeaDefence	Drainage	Road	Bridge	Condition
None	None	None	None	Good
ConcreteWall	Canal	Concrete	Concrete	MaintenanceNeeded
EarthernWall	Koker	Laterite	Steel	RepairNeeded
Groyne	Pump	Tarmac	Wood	
Mangrove				
NaturalShore				
Other				
RipRap				

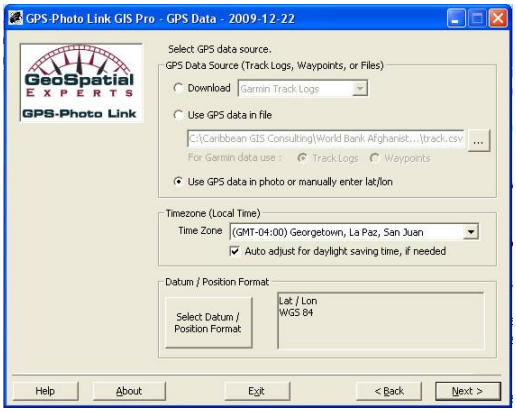
Table 1 Sample Camera Memo List

These data are also stored with the photo, i.e. in the EXIF headers of the JPEG file. A sample memo file, formulated in preparation of recording four types of structures - sea defences, drainage, roads and bridges, and the general condition of the structure, is provided in Table 1.

Downloading Photos from Camera to Laptop PC

The Caplio 'Gate La' utility offers a single click method of transferring photos from camera to PC. In addition, photos could be transferred to the PC using Windows Explorer as Windows recognized the camera when connected to the PC via a USB cable as a USB device. Both ways of downloading photos from camera to PC were used.

Creation of Shapefiles with associated Photos



The GPS-Photo Link software provided an interface that was reasonably easy to understand and use and performed as expected. With the source photos in a defined folder on the laptop the software could be used to process the photos in batch mode. The software helpfully maintained previous settings for succeeding runs, though allowing interactive changes when desired. The software provided several useful outputs in addition to the desired ESRI Shapefile; including creating a position-watermarked copy of each photo (see samples below), an HTML page viewable in any browser that summarised all the processed photos and associated information, a comma-delimited text file of photo positions and associated information and a Google Earth KML of the positions and the photos. These provide very useful complementary products.

Figure 1 Field photo watermarked with location and other information after processing

Figure 2 Location of above field photo centered in Google Map

Figure 3 Field photo watermarked with location and other information after processing

Figure 4 Location of above field photo centered in Google Map

Creation of Shapefiles from Nikon Coolpix P6000 sample Photo

The Kabul EIRP Team has purchased Nikon Coolpix P6000 cameras for execution of this concept project. A sample photo taken with this model camera was requested from the EIRP Team and received. It was also easily processed with the GPS-Photo Link software.

Figure 5 Field photo provided by Kabul EIRP Team watermarked with location and other information after processing

Figure 6 Location of above field photo centered in Google Map

Utilizing the ESRI Shapefile

A template map was drafted in ESRI ArcMap GIS software and the Shapefile produced from the camera data was successfully added to compose an initial point map of the area used in the field exercise. The digital ArcMap layout includes hotlinks to the processed position-watermarked copy of each photo (see below).

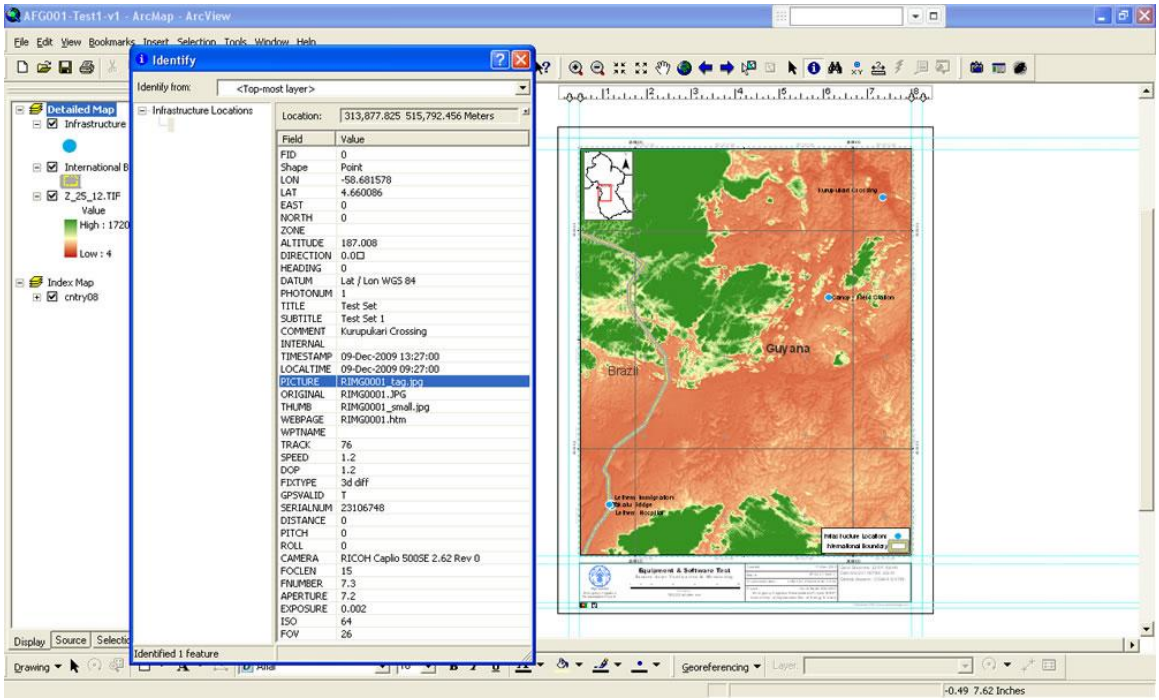


Figure 7 Screenshot of ArcMap GIS showing hotlink to Photo and other information related to a location

Printable (300dpi) JPEG and PDF copies of the point map showing locations and location names from the field exercise were produced using ArcGIS. The JPEG version is shown on page 5 (Fig. 8) and is also attached to this report as a separate file; the PDF version is also attached.

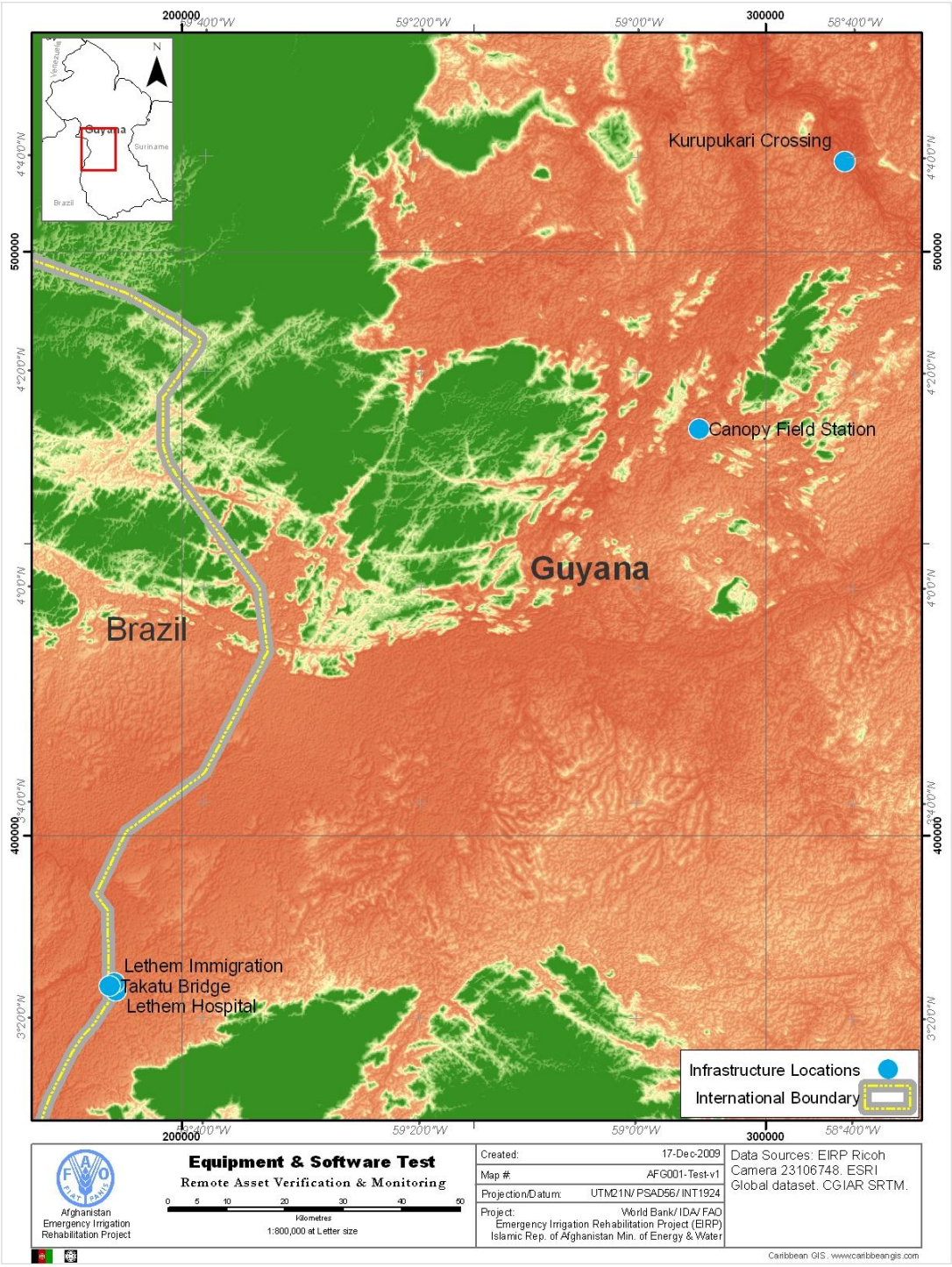


Figure 8 Map of area showing Infrastructure Testing Locations and Location Names. The camera data are the source for the point locations. This Map Layout is a draft and has not yet been approved by the FAO or the World Bank.

Recommendations

The equipment and software can be used to implement a remote asset monitoring and verification for the EIRP. It is envisaged that there could be three roles for personnel involved:

i. Field data capture

The role will entail operation of the camera to successfully capture photos of the EIRP asset with georeferences, and field notes if necessary, and delivery of the camera or the memory card, and any field notes, for processing of the collected data. The person(s) fulfilling this role should be competent in carrying out simple routines and will be trained to:

(i) Charge the camera battery and load same into the camera
(ii) Operate the camera, recognising when the GPS receiver has acquired a georeference (listen for the loud beep and look for the appropriate icon on the camera display), to take photos of EIRP assets
(iii) Remove/ replace the memory card if necessary
(iv) Make associated written field notes, if necessary, and with the aid of a simple form
(v) Organise delivery of the camera or the memory card, and any field notes, for processing of the collected data

ii. Processing of camera data

The role will entail processing of camera data into Shapefiles and other complementary data products (text file, watermarked photos, HTML page and KML file). The person fulfilling this role should be computer literate and will be trained to:

(i) Maintain an organised directory structure on a PC
(ii) Download field photos from the camera/ memory card to a PC using either the Caplio Gate La utility software or Windows Explorer
(iii) Operate the GPS-Photo Link software to batch process the camera data into ESRI Shapefile and other data products (text file, watermarked photos, HTML page and KML file)
(iv) Perform sample checks to confirm which camera has been used to acquire the data and dates of field observations and that processing has occurred correctly – by examining the text file watermarked photos, HTML file, and if possible, the associated KML
(v) Transfer field notes, if supplied, from hardcopy to a digital format such as a Microsoft Excel spreadsheet
(vi) Clear the camera/ memory card and return of same to personnel conducting field data capture
(vii) Note inconsistencies between what might have been expected from the field and what data was actually received (e.g. spelling of place names, apparent

dates of field data capture) and alert downstream or upstream personnel with written notes

(viii) Make backup copies of downloaded and processed data

iii. Map production

The role will entail production of maps from the downloaded camera data in ArcGIS software and routine transmission of map and other products to EIRP administration. The person fulfilling this role is ideally skilled in basic GIS and will be trained to:

(i) Load the Shapefile into an existing ArcGIS ArcMap layout (a map template), modify the layout to reflect the new data set (e.g. insert a correct map Title, date and reference number), and save as a new permanent layout.
(ii) Append additional field notes, if necessary, to the Shapefile in ArcGIS
(iii) Correct minor inconsistencies, e.g. spelling of place names
(iv) Produce a map(s) of the data in hardcopy, JPEG and PDF formats
(v) Perform sample checks to confirm which camera has been used to acquire the data by examining the text file, watermarked photos, HTML file and the associated KML
(vi) Compare with existing GIS basedata or previously acquired camera/ field data and alert EIRP administration of developments/ concurrence with expectations/ inconsistencies with written notes
(vii) Package the Shapefile, map products, other complementary data products and notes and organise delivery of same to EIRP administration

The other complementary products from processing the camera data (text file, watermarked photos, HTML file and the associated KML; in addition to the desired ESRI Shapefile), are simple and produced with no additional effort. They can also be easily transmitted via email to upstream and downstream offices and viewed with any internet browser and free Google Earth. Together they provide additional confidence in the verification process. It is recommended that their routine use be incorporated into achieving the purpose of this project.

The comma-delimited text file of photo positions provides a backup of the location information. It may be both examined using readily available software such as Microsoft Excel (see sample below) and imported into other GIS or database packages. Importantly, this also contains a record of the camera serial number alongside the georeferences and dates of the photos – and so provides a means of tracking deployment and usage of the cameras.

Lon	Lat	Altitude	Direction	Heading	Datum	PhotoNur	Title	SubTitle	Comment	Internal	TimeStamp
-58.6816	4.660086	187.008	0.0°	0	Lat / Lon WGS 84	1	Test Set	Test Set 1	Kurupukari Crossing		12/9/2009 13:27
-58.9056	4.245108	314.961	0.0°	0	Lat / Lon WGS 84	2	Test Set	Test Set 1	Canopy Field Station		12/9/2009 15:57
-59.801	3.373511	341.207	0.0°	0	Lat / Lon WGS 84	3	Test Set	Test Set 1	Lethem Hospital		12/10/2009 13:32
-59.8042	3.385758	298.556	0.0°	0	Lat / Lon WGS 84	4	Test Set	Test Set 1	Lethem Immigration		12/10/2009 14:44
-59.8109	3.380722	383.858	0.0°	0	Lat / Lon WGS 84	5	Test Set	Test Set 1	Takatu Bridge		12/10/2009 14:53

Figure 9 Comma-delimited text information extracted from camera data - viewable in Microsoft Excel

The position-watermarked copy of each photo provides a referable archive that can be quickly viewed using software preinstalled on every PC and used to illustrate word-processed reports. In the sample below, the three upper elements (essentially captions) imprinted on the processed photo are user-entered; the three lower elements – Latitude and Longitude georeferences, elevation as estimated by the GPS receiver and data and time – are created from the camera data. The photos by themselves will therefore allow even non-technical personnel to independently spot-check or raise informed queries about EIRP assets.

The HTML page and Google Earth KML file also provide other useful summaries of the field data from the camera in an easily-viewed presentation (the HTML page needs any browser and the KML file needs free Google Earth software to be viewed; see screenshot below). Again, in addition to providing convenient summaries for technical personnel, the HTML page or KML file by itself will allow even non-technical personnel to independently spot-check or raise informed queries about EIRP assets.

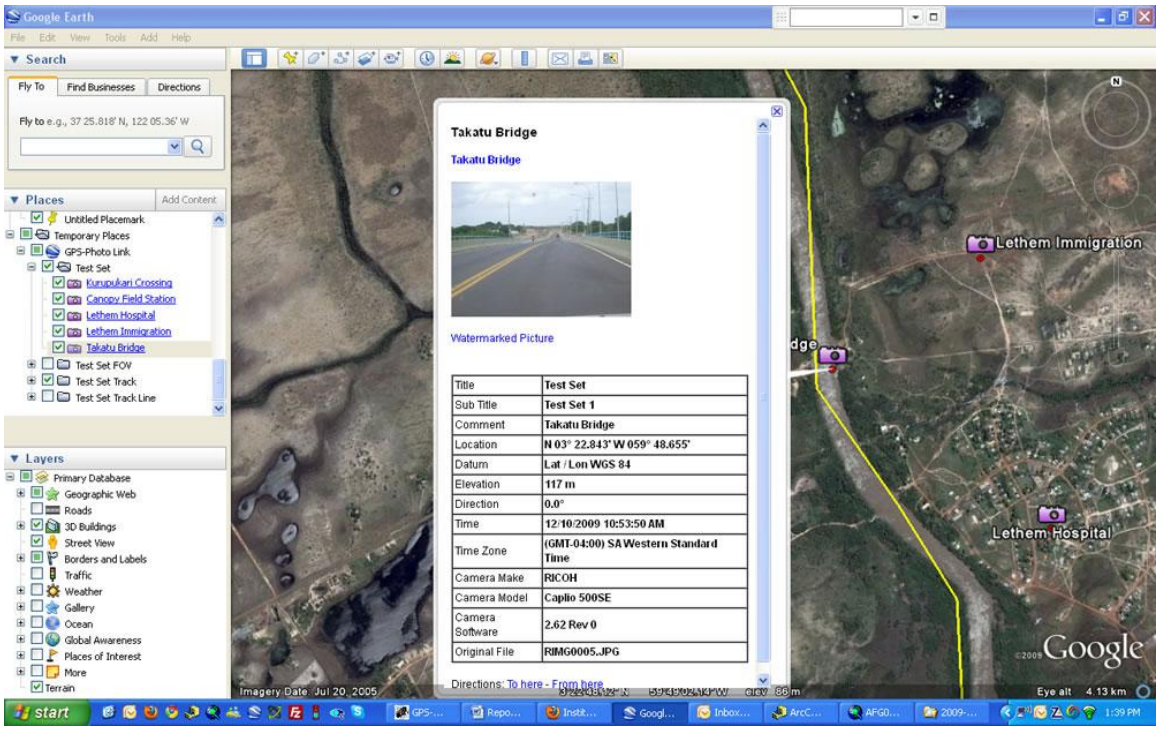


Figure 10 Screenshot of Google Earth KML extracted from camera data

Annex 1 – Results, Deliverables and Execution of the ToR

Results

The results to be achieved by the consultant are divided into two sets:

A. Proof of concept development for field testing the device and data collection.
   - This task will include testing of the hardware, software and development of a training program.

   This task will be carried out offsite by the consultant. The Bank will provide the hardware and software for development of the pilot will be tested. Once the consultant receives the equipment a workflow will be developed and tested for setting up and managing a data dictionary, acquiring photographs and associating them with other information including georeferences, downloading the data from the cameras and production of spatial datasets. The data dictionary, and attributes and presentation of the output spatial datasets will be defined in consultation with the Bank's Team Leader and/or their staff in Afghanistan to reflect the infrastructure assets and attributes to be monitored. The training programme (the second set of tasks) will also be planned during the consultations. Internet communication will be used for these consultations.

   The spatial datasets produced are expected to be in the form of ESRI Shapefiles or geodatabases. ESRI Shapefiles are a *de facto* global standard for spatial data and accessible with many other GIS software if necessary. The consultant is also expected to explore and report on options for importing and viewing the data in Open Source GIS software and evaluate their capability.

B. Implementation of the training program in the field to generate the desired GIS monitoring datasets

   Consultations via the internet with the Bank's Team Leader and/or their staff in Afghanistan will be used to (i) identify the trainees (ii) finalize training content and a training schedule and (iii) list location(s) and overall duration for the training program. The system will be presented to the task teams, for initial feedback, prior to consultant arriving in Afghanistan and meet with the task teams to present using actual field data. The training program will be delivered on-site in Afghanistan. Some time will be set aside to observe and further guide trainees in the actual use of the new equipment and methodology in the field through to the production and transmission of actual monitoring datasets on-site.

The methodology for generation of the spatial monitoring datasets will also include the adoption of specific nomenclature for files, data fields, etc., specification of the format of time and date records, specification of basic, necessary metadata, recommendations for data transmission and archiving, and recommendations for formal map output(s).

Deliverables

- A test report demonstrating the acquisition of photos with georeferences and other data and creation of GIS datasets
- Use hardware and vendor provided software to process the acquired photos and represent in desktop GIS software.
- A short training program on the acquisition of photos with georeferences and other data and the creation of GIS datasets for teams monitoring implementation of irrigation infrastructure in Afghanistan
- Delivery of the training program to personnel in Afghanistan and task teams.
- Final report with recommendations.

Execution of ToR

The above deliverables will be delivered in two stages:

- Stage 1 – Testing and demonstration of the hardware and software, and creation of a training programme. This would be done at headquarters and is expected to take three weeks (21 days). It will include discussions with the Bank Team Leader and other relevant personnel in Afghanistan.

- Stage 2 – Delivery of the training programme. This would be done on-site in Afghanistan and is expected to take two weeks (14 days).