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Ground Videography and Data Collection System (GVDCS)

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Abstract

Marketing GIS applications requires up to date information. GVDCS acquires data using a vehicle adapted to support the crew, a computer, GPS, digital cameras and data collection devices. A MapObjects module in the main computer helps navigation while store data from the different sources, associating it with the GPS position. Data processing continue in the office with ArcGIS/ArcObjects based modules for semi-automatic data integration and database updating. The final information is stored in a multi-user geodatabase using ArcSDE. The GVDCS makes GIS data production faster and cheap while meet different data collection requirements like marketing, telecommunication, utilities, and others.

I -Introduction

Brazil census and demographic data is aggregated in clusters or cells of approximately 300 people. Census block data are a good source for GIS marketing studies trying to answer where customers are located.

In Brazil urban planning actions are very limited or concentrated in the more important areas or major cities and frequently very different income people lives together in the same area and even in the same block. For telecomm companies this mean to install the network without knowing if the customer will be there. In this case the existing census block with 300 people and high variance income standard is not enough for an accurate result.

Detailed GIS marketing data aggregated in points are the key for the successes. A good option to have the detail needed can be to qualify each house and building according to the apparently income class standard. Even better is to identify each building and house, making it possible to link then to the company customer database in the map.

Powerful field data collection tools, a very efficient logistic system and innovative desktop tool and methodology was required to meet project requirements regarding time and number of houses.

For decades field data collection tools was a pencil and a paper. Recently new devices like digital cameras, GPS and hand held have been introduced allowing fieldworker to collect more data with great quality. None of these new equipments were able to collect data fast enough.

II - Project Goals

Main goal was to create a system to identify and classify houses and building according to the apparently income class standard, meeting the project requirements for time (12 months) and houses/buildings (3,000,000) to survey.

Standard field data collection systems, like a fieldwork using paper or handheld consumes too much time. The required productivity should be achieved by collecting data faster using cameras from a mobile platform for further in office image analysis. Finally each image should be assigned to an identified building or house.

III - The GVDCS

The Ground Videography and Data Collection System (GVDCS) are designed to be a production line for data about houses/buildings. The complete solution is composed by 4 subsystems:

- 1.Data Acquisition Vehicle Subsystem: Data is collected
- 2.Analysis and Completion Subsystem: Data turns to information
- 3.Fault Field Revision Subsystem: Lack of data is revised
- 4.Logistic Procedures Subsystem: Data is transported

Data flows through each subsystem like steps in a production line or like in a business process. Each Subsystem is composed by a set of tools, software, procedures and a team with a leader responsible for keep data flowing through the GVDCS. One of the most important components of the system is the people involved in the whole processes.

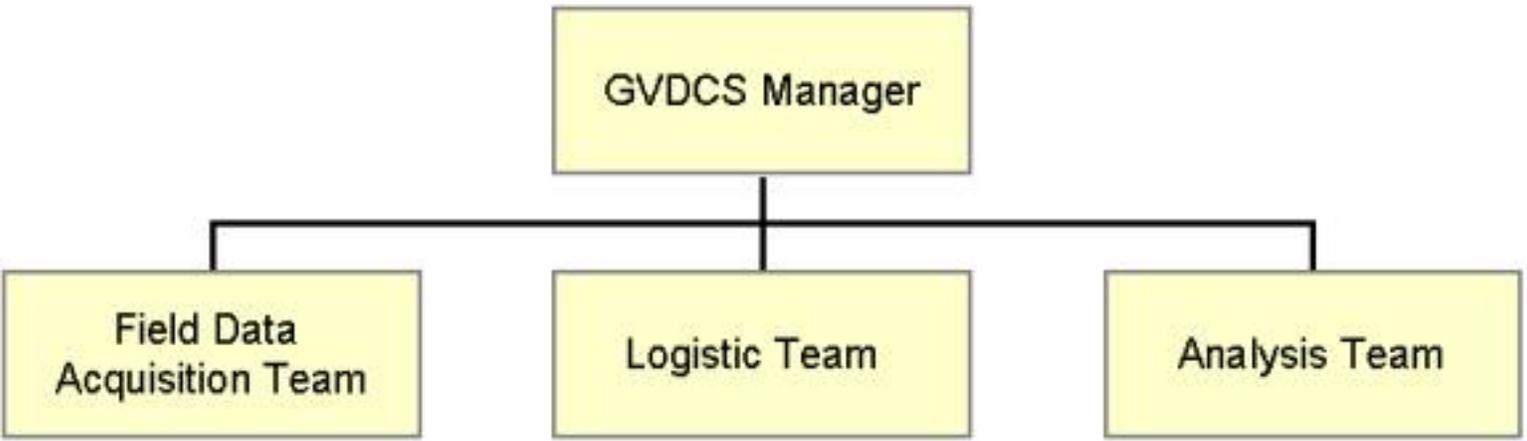


Figure 1: GVDCS Personnel Structure

3.1 -GVDCS Principles

The GVDCS data flow starts with data acquisition at the field. Raw data is a set of GPS points, images and house identification numbers.

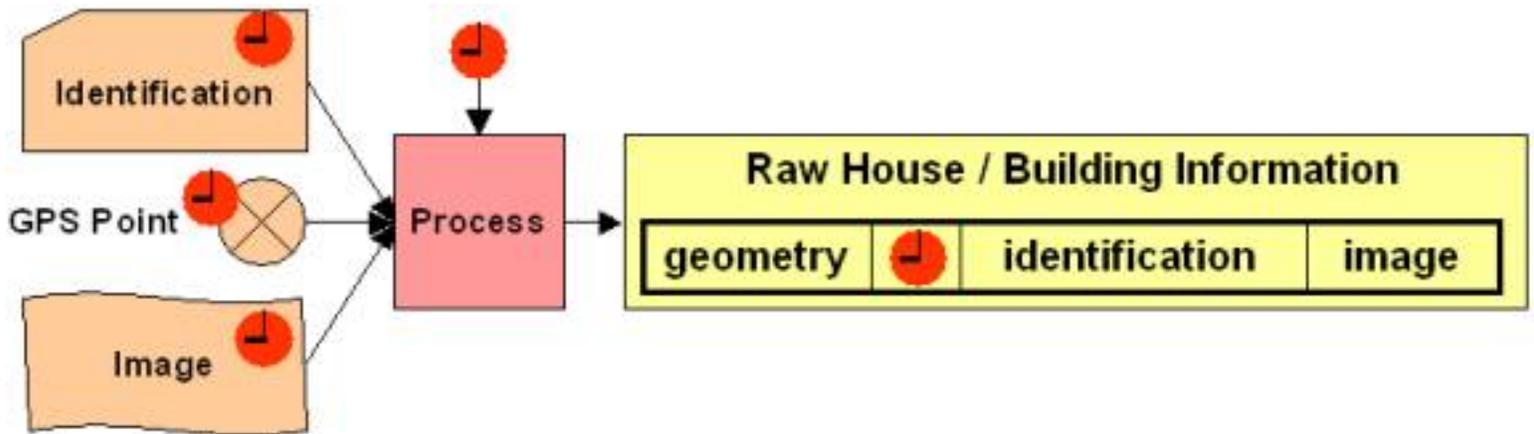


Figure 2: Basic GVDCS Principle

The key for linking together all collected raw data is a common time reference. All collected data is stored with its correspondent time reference for further relationship restore. The final raw information is a point referencing an identified house or building with a related image.

The reference time must be guarantee for all data sources and the GPS UTC information was used to set the time reference to all other capture devices.

The Data Acquisition Vehicle (DAV) course through the streets collects raw data for both street sides simultaneously.

The raw data is sent to the office were an automated process relates all data into a georeferenced house/building point with identification and an associated image.

Finally, the human supervised office analysis corrects the house or building x,y coordinates using an reference map with the correspondent ortho photo and classify the object following known geographic andvisual parameters.

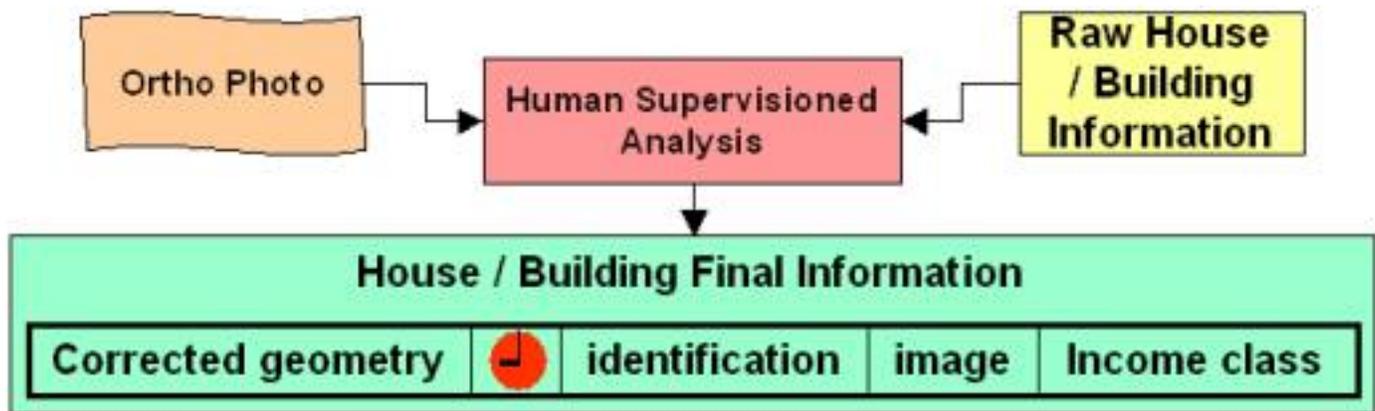


Figure 3: GVDCS Data Completion

3.2 -Data Acquisition Vehicle Subsystem (DAV)

The DAV is a vehicle designed to collect all required raw data in the field as fast as possible, managed by a specially trained crew and equipped with appropriated electronic components for data acquisition. It is the main field tool for GIS data collection.

3.2.1 -DAV Platform

The basic platform for the DAV is the Daimler-Chrysler Sprinter 313 CDI Van. The main vehicle characteristics are:

- Great internal space to support all necessary equipments and crew
- Large window area allowing excellent external visibility in all angles
- Hardness
- Easy to find in most locations in Brazil
- Air conditioning

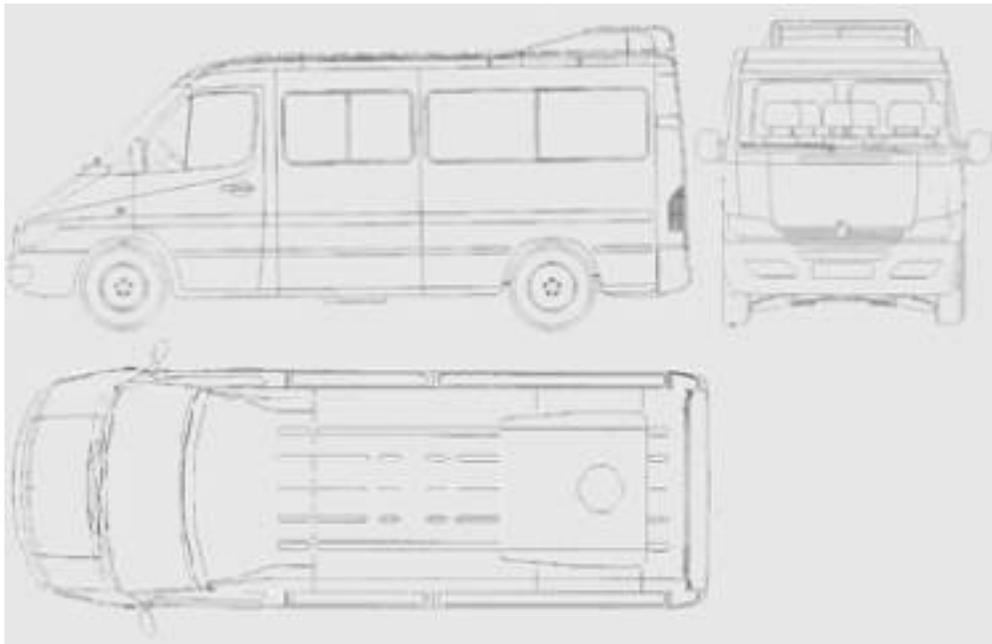


Figure 4: Sprinter 313 CDI Van

3.2.2 -DAV Racks

Internally, the original vehicle seats are removed and just the driver and front passenger seats are left. The vehicle is adapted with specially designed rack to support the crew and the on board equipments.

Leader seat is front faced, located in the middle of the vehicle. The leader has a table to support the GPS receiver and the computer interface. Fieldworkers' seats are located behind leader's seat, positioned at 60° alignment regarding the vehicle longitudinal axis for better external observation. Fieldworkers' seat is equipped with a small side arm table that supports the numeric keypads.

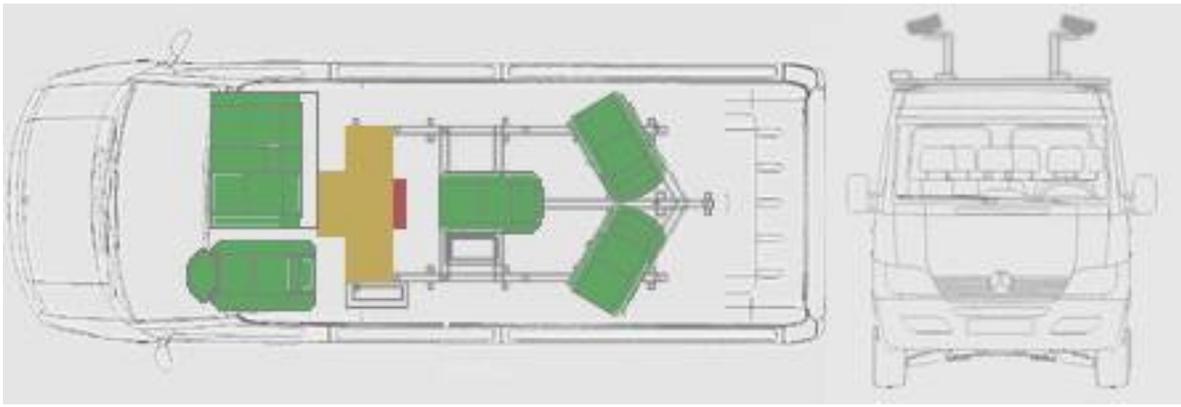


Figure 5: DAV Racks and internal layout

Externally the vehicle received a top mounted rack for CCTV cameras and the GPS antenna support.

3.2.3 -DAV Crew

The driver, a navigator/coordinator and 2 data collectors (fieldworkers) composes the crew in the vehicle, each one with the following missions:

- Fieldworkers: Collect house and building identification in both sides of the street and input it using the numeric keypads
- Leader: Responsible for navigation and coordination, operates the main computer unit, checks the equipment, guide the driver to the desired start point and coordinate all the crew during data acquisition processes.
- Driver: Drive the vehicle to the start point. Drive under coordinator orders during data acquisition processes.

3.2.4 -DAV Electrical Support

The vehicle electrical system is upgraded with one addition 12V 95 Ah automotive battery. No alternator upgrade is required.

An 800W wave inverter that converts 12V DC to 110V AC supplies power for the DAV electronic equipments. The wave inverter is equipped with the required electrical protection (fuse and disconnecter) for all 110V circuit and also works as an UPS.

A standard 8 outlets surge protector does the energy distribution for all electronic equipments

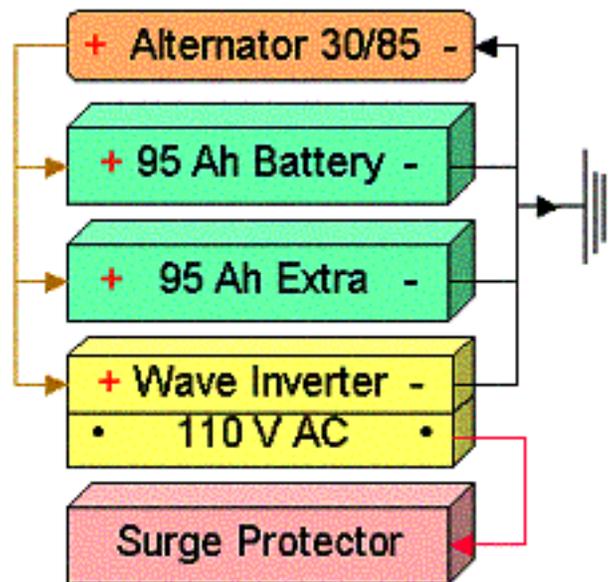


Figure 6: DAV Eletrical System

3.2.5 -DAV System

DAV is equipped with a main computer unit and 3 different raw data sources:

- 1.GPS
- 2.CCTV video cameras
- 3.Numeric keypads

Specially designed software is loaded at the main computer unit for equipment control, mission management and DAV navigation.

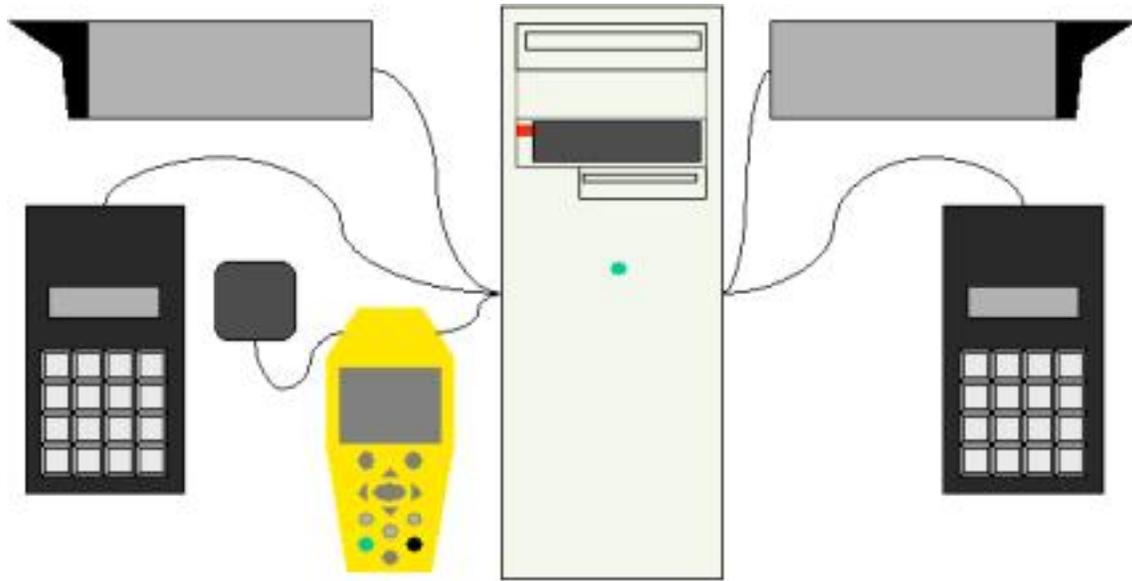


Figure 7: DAV Hardware System Architecture

3.2.5.1 -DAV Main Computer Unit

All acquisition devices are connected to the main computer unit, a desktop computer (Intel based) for data storage and system integration. The main computer unit is a specially modified Intel based computer with the following characteristics:

Model	Dell Precision 910
Processor	933Mhz
Memory	256Mb
Hard Disk	80Gb
Capture Card #1	PixelView Play TV

Capture Card #2	Pinnacle Studio PCTV
Multi-Serial Card	Valley 2s-PCI
Removable HD bay	40Gb Hard Disk

Table 1: Main Computer Unit Specification

The video capture cards purpose are to convert the CCTV RCA signal into digital images that can be read by computer software.

The multi-serial card expands number of serial interfaces from 2 to 4, allowing connection for the GPS and the 2 numeric input keypads.

The removable HD bay offers the fastest and cheapest interface for data transfer and the removable hard disk enables high data volume movable storage.

3.2.5.2 -GPS

A Trimble GeoExplorer® 3 GPS receiver is used to collect georeferenced points. GeoExplorer external antenna and the serial clip with cable are used. The external antenna is fixed in an appropriated holder on the DAV top mounted rack.

The Serial Clip provides the required serial interface to the main computer unit. The supplied DB-9 cable is used to connect the serial clip to the computer. The Serial Clip also provides energy for the GPS Receiver with the provided GeoExplorer 3 power supply. It is modified, as the original one isn't able to supply energy.

The GPS stores all collected points at a 1 second interval and sends raw data through the serial interface. The NMEA data protocol is used to transfer data to the main computer, were all coordinates are also stored. Raw coordinates are used in real time for navigation purposes, fieldwork management and planning.

The GPS UTC is used to keep the computer time up to date.

3.2.5.3 -CCTV Video Cameras

Pair of Wetech WM-9001SCH CCTV Video Cameras is fixed at the top mounted rack. They are positioned horizontally and at 90° alignment regarding the vehicle longitudinal axis. One camera captures the right street image while the seconde camera captures the left street image. An anodized aluminum enclosure protects the CCTV cameras from rain and dust.

The CCTV cameras are equipped with a fixed iris 4mm lens. The Wetech WM-9001SCH provides high horizontal resolution image and high sensitivity. The light compensation feature eliminates the need for the auto-iris lens.

A standard RCA shielded cable connects the CCTV cameras to the capture cards. The cameras has standards 12V DC power supply.

3.2.5.4 -Input Keypads

Pair of Colleter TED 1000 Numeric Serial Keypads is used for house/building identification. They are equipped 16x2 LCD display and 16 keys:10 numeric keys, clear, enter, dot, and 3 programmable function keys.

The keypads are fixed at specially designed arm tables in the fieldworkers' seats. A custom DB-9 cable is used to connect the keypads to the main computer. A 9V DC power supply is required.

The keypad interface is provided by a proprietary DLL provided with the equipment.

3.2.5.5 -DAV System Architecture

The main computer software includes:

- Windows 2000
- Trimble GPS Pathfinder Office
- MSDAC 2.7
- MSComm Control
- ESRI MapObjects Run Time 2.1
- Fath Software VideoCapX Video Capture ActiveX 3.0
- IMG_DAV_Navigator
- MS VB Run Time 6.0

The team leader is the system operator. Most tasks requires the IMG_DAV_Navigator functions, but the leader must also use the Trimble GPS Pathfinder Office software for GPS data transfer to the computer.

3.2.5.6 -DAV SW: IMG_DAV_Navigator

The IMG_DAV_Navigator is the heart at the DAV. It manages the entire system during the 3 operational modes:

- Initialization
- Navigation
- Data acquisition

Initialization mode features are:

- | | |
|--------------------------|------------------------------------|
| ·Start devices interface | · Shutdown devices interface |
| ·Log device status | · Separated device status check |
| ·Crew identification | · Storage location parameter input |

·Device side setup

· System time-UTC synchronization

Navigation mode features are:

·Speed and direction display

· Dynamic Map interface

·Data acquisition management

· Feature identification

· Navigation supervision

Data Acquisition mode features are:

·Start/Stop Acquisition

·Speed and direction display

·Capture side options

·Street name input for further check

ESRI MapObjects ActiveX components are used for map display, GIS data processing and GPS raw coordinates on the fly conversion. Fath Software VideoCapX ActiveX component is used for CCTV image capture and store. The captured image size is 340 x 280 pixels for better storage space use. Colleter proprietary library provides numeric keypad interface.

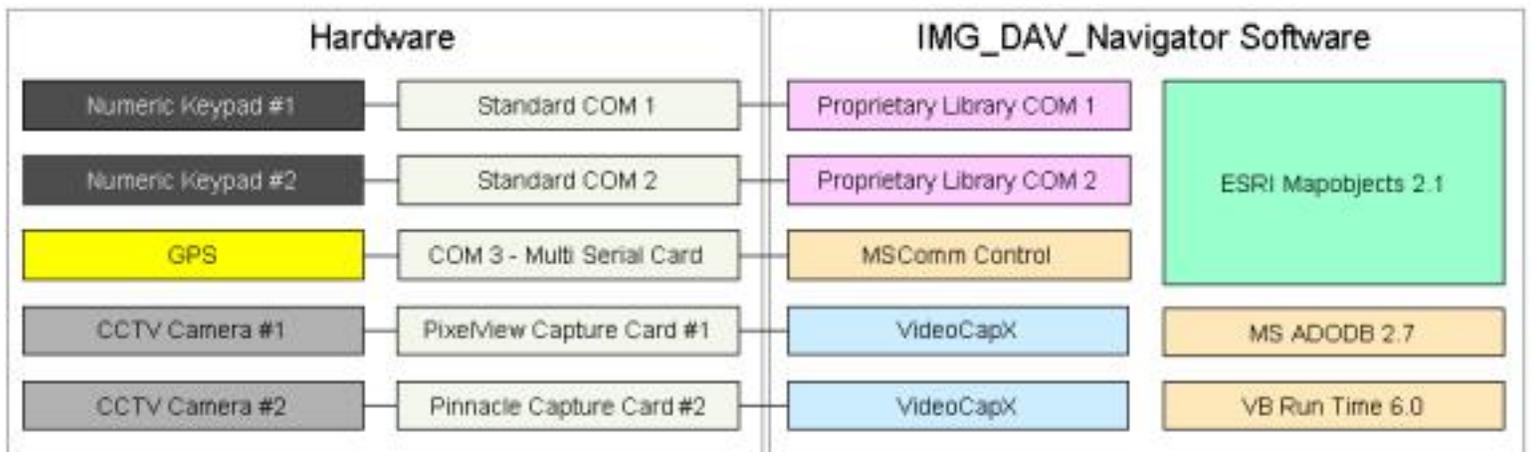


Figure 8: IMG_DAV_Navigator Internal Architecture

All collected raw data is stored in a data package for further in office processing. It includes:

- A Microsoft Access repository with:
 - o Captured images records
 - o Numeric keypad inputs
 - o Surveyed street names
 - o Log activities
 - o Crew identification
- Images directories for each camera
- Raw GPS points as shapefile

Before sending data to the office, the leader must also include the GPS data, transferred to the computer using the GPS Pathfinder Office software.

3.3 -The Analysis and Completion Subsystem

The Analysis and Completion Subsystem (ACS) runs at the office. The ACS process starts after data packages are available to the production team.

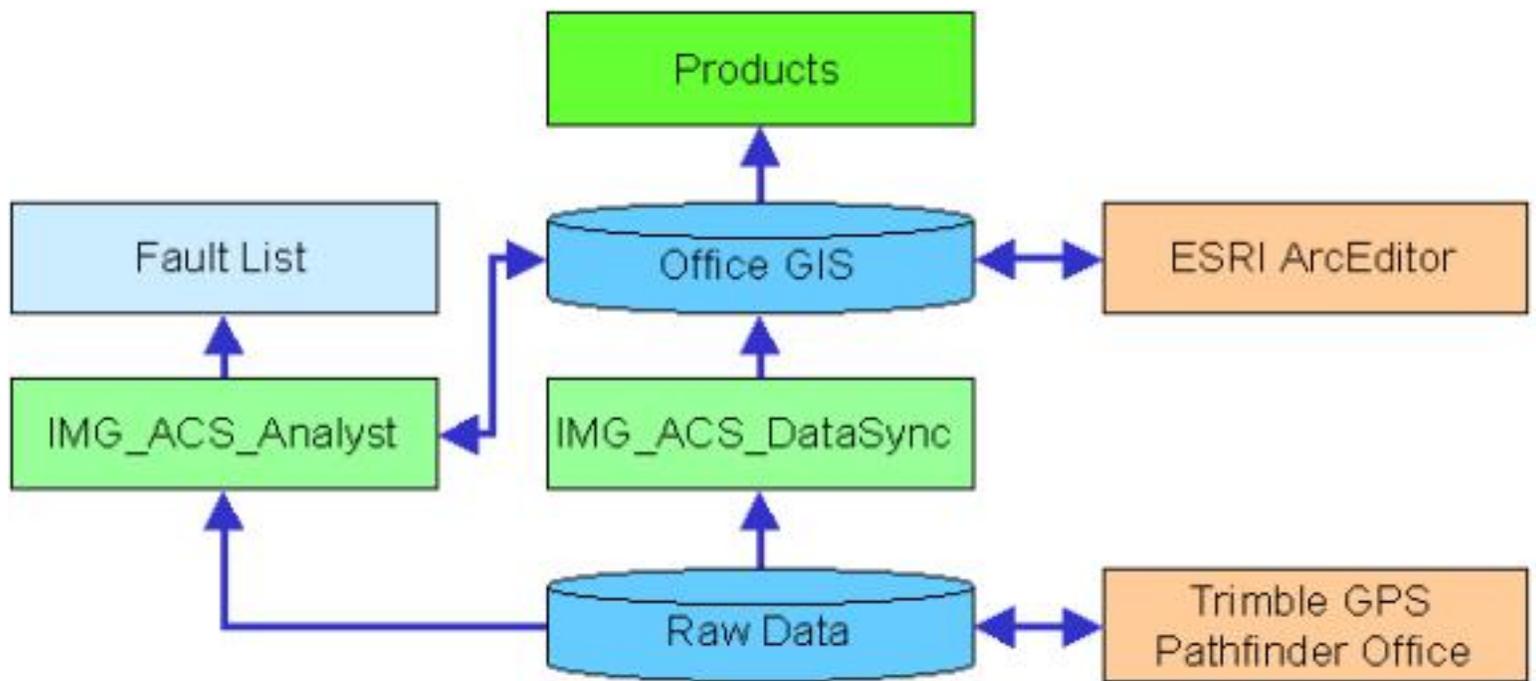


Figure 9: ACS Workflow

Raw GPS points are differentially corrected and converted to the project reference system, using the adequate GPS beacon base reference and the Trimble GPS Pathfinder Office software.

The second step is the IMG_ACS_DataSync process. It reads all numeric keypad inputs, street names surveyed and corrected GPS points, turning the keypad input into a georeferenced point with the street identification, storing it into the an ArcSDE Geodatabase. ESRI ArcObjects provides the core geographic resources for the SW.

The IMG_ACS_Analyst is the ACS main software component. It is a dedicated software that provides high productivity for the house and building classification.

ESRI ArcEditor is used for database maintenance and administration. It is also used for product completion, preparation and revision.

3.3.1 -IMG_ACS_Analyst

IMG_ACS_Analyst provides all necessary data to correct house and building classification. The analyst can better chose the income class standard using the following parameters:

- Build area
- Garden area
- Building quality
- House Location
- Front size
- Garage capacity
- Total parcel area
- Space Organization
- Pool

Data shown to the analyst are:

- Map with features and the ortho photo
- Image collected to the DAV
- House identification point
- House record attributes

The main IMG_ACS_Analyst feature are:

- Map controls
- Graphic house identification
- House point move to the correspondent map coordinates
- Best image finder
- House attributes editing
- Polygon area measure at the map
- Linear measure at the map

Ortho photos and DAV images are stored at the production storage. Each record house record identified at the map and edited is automatic marked as done and saved at the ArcSDE database. ESRI MapObjects 2.1 provides map control and all geographic resources for this application.

High productivity is reached with keyboard shortcut for all available function and automatic mouse click saving function sequences. Specific list boxes values may change using a specific pre programmed function key.

3.4 -Fault Field Revision Subsystem

The Fault Revision Subsystem key components are the ESRI ArcPAD and the custom software IMG_FMS.

The IMG_FMS software reads the Field GIS database and the Fault List sent from the office, identifying lack of information on already surveyed houses and buildings. The correspondent records are loaded into an Compac iPac Pocket PC.

Using a customized ESRI ArcPAD 5.0 project with forms a standalone fieldworker revisits the correspondent sites, checking and collecting lost or missed house/building information.

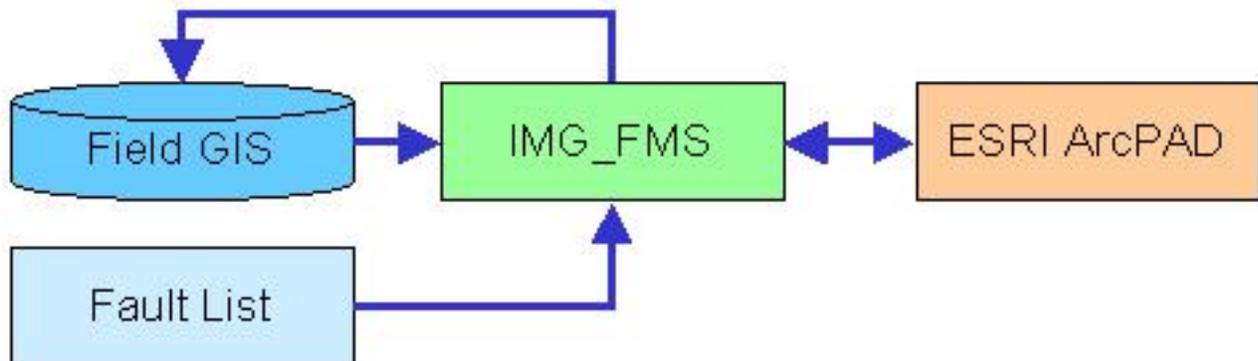


Figure 10: Fault Field Revision Workflow

Back to the field office the same IMG_FMC will read the rechecked data, marking the original records as done and storing the up-to-date information on a plain table. The up-to-date information is sent back to the office were a simple SQL script will update the office GIS with the new attribute values.

3.5 -The Logistic Subsystem

The logistic subsystem must guarantee the continued data flow through the DAV Subsystem, Analysis and Completion Subsystem and Fault Field Revision. It also concerns about the data backups.

The data transfer through subsystems is made using removable 40Gb hard disks.

HD must be quickly processed in the office to be as quick as possible available at the field. HD stored data must be copied to the production storage and backed up to definitive 20 GB DAT tapes.

The DAV internal HD is big enough to store data corresponding to 4 days of work. The DAV internal HD must be cleaned as soon as the office reports the correspondent HD stored data processing. In case the internal HD is full data must be backed up to a new removable HD that must be kept while the the receive report don't arrive and a HD track must be done.

The removable HD must be well package and sent through express courier service.

After the office HD processing some of them may return to field storing a new GIS database version and the fault list for the Fault Field Revision Subsystem. This special HD is identified differently making it easy to track when back to the field.

-5 Compac iPac Packet PC with ArcPAD 5.0

The office infrastructure resources includes:

- a geodatabase server
- a production storage server
- 25 analysts workstations
- 3 logistics and process workstations
- 1 DAT backup unit

DAV acquiring mode speed is 5 km/h that is 5 times faster than a human fieldworker walking continuously and around 10 to 12 times faster than a fieldworker with a Compac iPac operating ArcPAD. The field productivity is very good.

In office analysis is the process bottleneck. A large 25 analysts team is used to work with the data collected by 5 DAV's.

V - Conclusion

All system software evolved in functionality and stability.

All data is digitally captured, stored and maintained during all the processes.

In office analysis uses more classification parameter than on field would use and can be better controlled by a single manager/coordinator.

The DAV uses off the shelf equipments and is very cheap for a reasonably good precision and a very good mass information production line.

The DAV offers a much better fieldworker work environment.

The differential corrected GPS points allow <1-meter precision. But final point coordinate correspond to the visual house location at the ortho photo.

DAV can easily be upgraded or change for other applications like utilities structure and equipment inventory, transit equipment inventory and whatever requires georeferenced images.

The system can become better with well-documented procedures, data protocols and some good intelligent application functions.

Acknowledgment

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