Covering Large Areas in Short Time

A High Resolution Orthomosaic in Brazil

A high resolution orthomosaic was generated for the 800 km2 area of the County of Campinas, Brazil, derived from Ikonos satellite imagery, a Digital Terrain Model (DTM) generated from WorldView-1 satellite imagery, and an implemented geodetic network of 19 points. The final orthomosaic was generated both in normal color and in false color infrared in order to broaden the possible applications to environmental issues. This result represents a very interesting solution to cover large areas in short time and with a lower cost than traditional aerophotogrammetric methods, thus with basically the same quality, allowing for a better assertive planning and sustainable development of the territory.

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Figure 1 – VRT-29 on Ikonos imagery.

1. Introduction

In Brazil, outdated territorial and cartographic data are unfortunately still very common and the planning activities in a fast-paced urban expansion environment represent a rough challenge to urban planners and managers, especially in day-to-day activities. This is also the case for the County of Campinas, where in recent years the population growth has surpassed 1 million inhabitants and is still growing. Also, the Metropolitan Area of Campinas, including 19 other counties, is under great pressure. These boundary conditions make updated cartography and territorial monitoring a constant necessity, because of aggressive planning and management schedules.

In order to deliver to SANASA – the Water Supply and Sanitation Company of the County of Campinas - and to the GIS County of Campinas Administration Project, an updated Cartography and Technical Cooperation Agreement was signed between SANASA and FUNCATE to generate a new orthomosaic of the County of Campinas derived from high res-
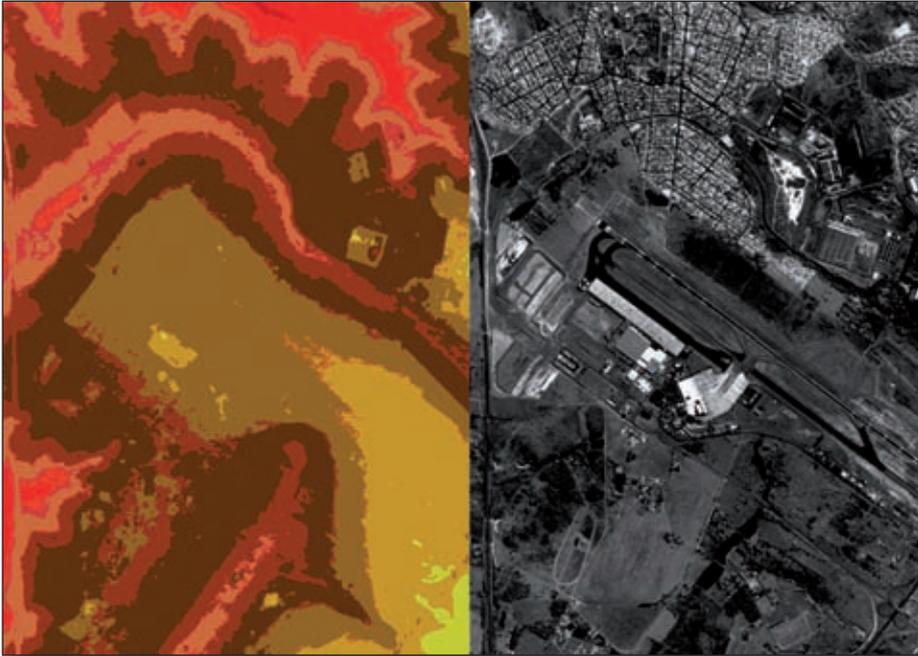
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*Figure 2 – Fragment of the DTM over the Viracopos International Airport (left)
and correspondent WV-1 image (right).*

olution satellite imagery. The decision of using high resolution satellite imagery instead of conventional aerophotogrammetry was due to the short time of approximately 1 year to generate the new cartography and budget limitations.

In partnership with FUNCATE and UWPE, NCDC Imaging was awarded the contract to acquire and process high-resolution satellite imagery to a final scale of 1:2000 NMAS. NCDC is a Native American-owned small business in Colorado Springs that specializes in remote sensing and GIS applications using high resolution imagery, such as mapping and imag-

ing services, land cover classification, natural resource management, sustainability planning and economic development. NCDC has delivered projects to clients including USGS, US Army Corps of Engineers, US Forest Service, Pacific Gas & Electric, Cities of Denver, Seattle, Providence, Sacramento, Albuquerque, and Dallas to name a few.

2. Method
The generation of the Orthomosaic was accomplished using:
- **GEODESY:** A specific geodetic network with 19 well distributed points in accordance to

Brazilian Geodesy standards. The first step in order to ensure the possibility of delivering a final orthomosaic compatible with the scale of 1:2.000 in Brazilian error and accuracy standards was the implementation of a network of geodetic points – ground truth - using well known GPS procedures in accordance to the Brazilian specifications set by the Instituto Brasileiro de Geografia e Estatística (IBGE). A total set of 35 geodetic points were provided by MDATA Engenharia S/S Ltda. From this set, 19 – inside the County of Campinas - were used for the generation of the orthomosaic. The survey delivered the geodetic points in SIRGAS 2000, as this is the new official system that Brazil has adopted in recent years.

- **DIGITAL TERRAIN MODEL:** A high resolution Digital Terrain Model (DTM) derived from World View-1 stereo imagery - collected in two strips during mid 2008 over the 800 km2 of the County of Campinas. The DTM was derived using the well known and validated Rational Polynomial Coefficients (RPC) method.

- **HIGH RESOLUTION SATELLITE IMAGERY:** High resolution color imagery from the Ikonos satellite collected in mid 2008 over the 800 km^2 of the County of Campinas, both in normal color and false color infrared.

- **SOFTWARE:** PCI Geomatics software was used for the project to generate the DTM and orthomosaic imagery.

3. Results
Figure 1 presents the location for VRT-29.
Figure 2 a fragment of the DTM over the Viracopos International Airport and correspon-
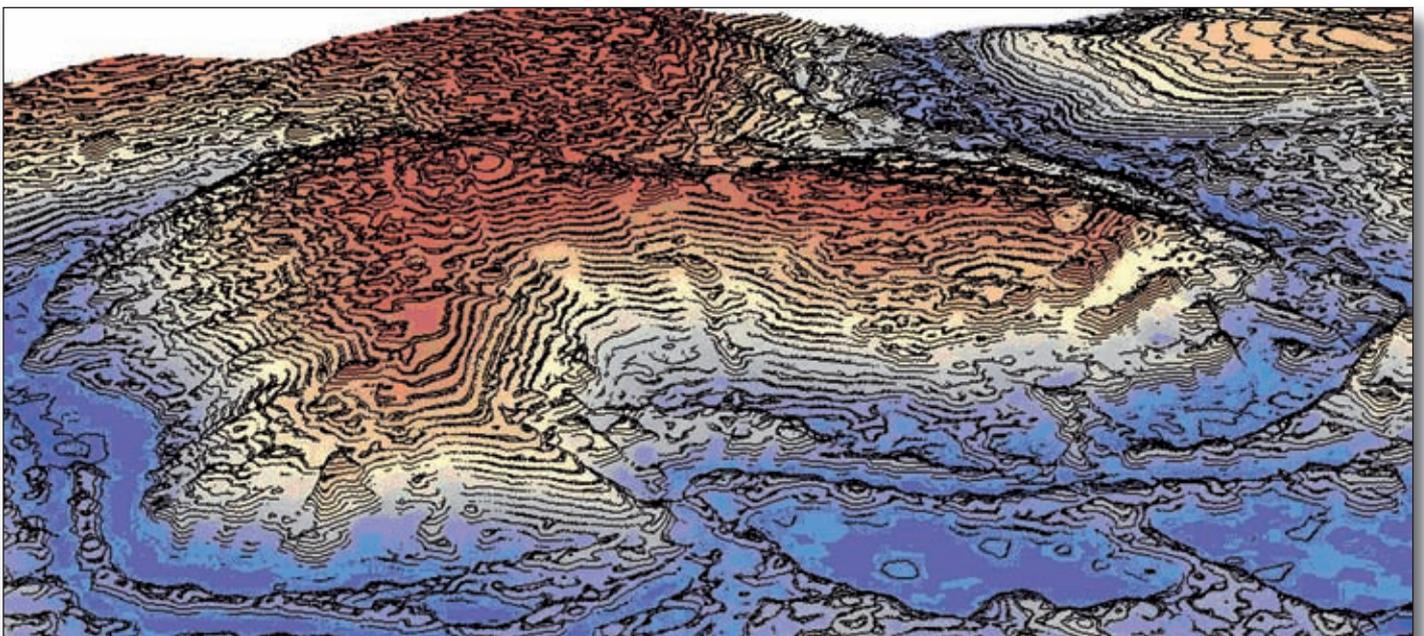

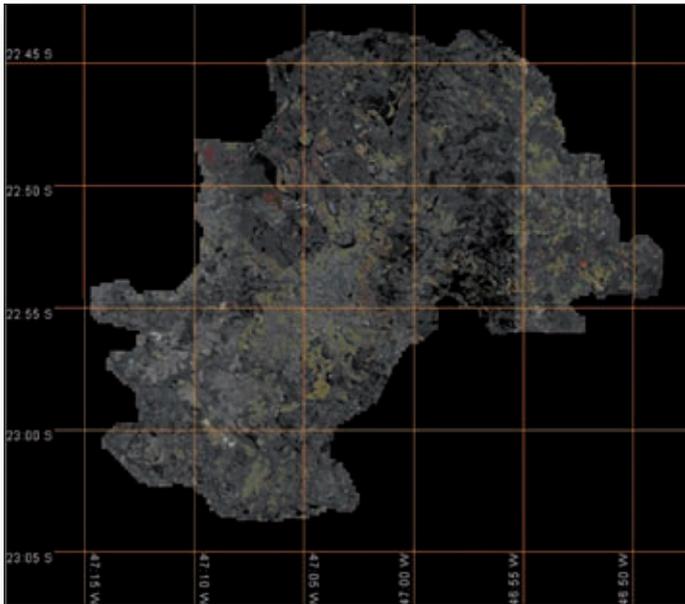*Figure 3 – 3D fragment of the DTM with contour lines.*

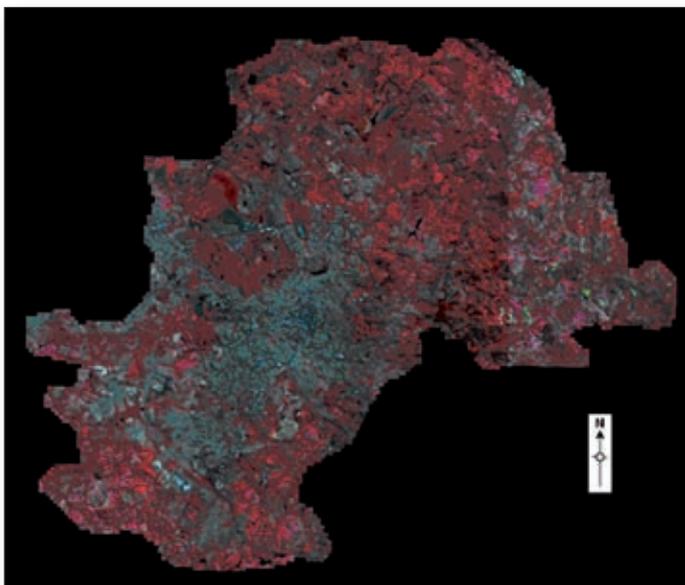*Figure 4 –General overview of the Campinas County Orthomosaic in normal color.*

Figure 5 –General overview of the Campinas County Orthomosaic in false color infrared.
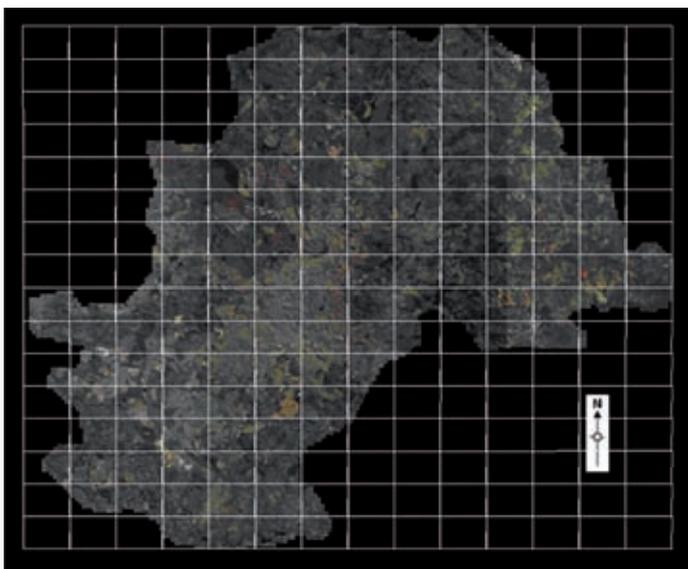

Figure 6 –Tiling of the Campinas County Orthomosaic.

dent WV-1 image, and Figure 3 a 3D fragment of the DTM with contour lines.

General results obtained for the DTM with no ground control at all and verified with 37 independent geodetic points resulted in a root means square (rms) error of 1.0m and final vertical accuracy of 1.7m. A well distributed subset of 23 points resulted in a rms error of 0.6m and final vertical accuracy of 1.0m. Contour lines were derived with a resolution of 1.6m.

A WV-1 orthomosaic was generated as an intermediate product to the final orthomosaic. The final orthomosaic, with the imagery already pansharpened, was then generated using AutoSync, an ERDAS product, collecting hundreds of tie points.

Figure 4 presents the general overview of the final orthomosaic in normal color and Figure 5 in false color infrared. Since the final archive size is of the order of 15 GB the final delivery was also in tiles according to Brazilian Cartography standards. The tiling grid is presented in Figure 6. The final orthomosaic for the County of Campinas presents a high image quality with excellent contrast, as in Figure 7 – normal color – and Figure 8 – False color infrared.

In order to perform the error and accuracy check a set of 80 independent geodetic points was used. The points are from the official County of Campinas Geodetic Network (PMC) and were implemented by well known specialized companies.

Figure 10 presents the distribution of the geodetic points in the County. The points are mostly concentrated in and around the urban areas. This fact does not interfere in the objectives and results since the desired accuracy must be high in the urban areas and is not required in the rural parts of the county where the required result should be close to the scale of 1:5.000.

Final analysis for the rms errors and accuracy was performed comparing the coordinates of the 80 points set and the generated Ikonos orthomosaic in WGS 84 and using the Remote View software environment. Remote View is well known to have an excellent Graphic User Interface (GUI) and not blur the image; and in this work, since the error and accuracy checks are very close to the resolution of the imagery (1 pixel), this was a key issue. Although the Brazilian regulations state that "in practical means" WGS 84 is to be equal to SIR-GAS 2000, it was observed that at this very high resolution level, conversions to and from different software platforms can introduce bias of the order of 0.5 to 1.0m. Therefore, the analysis was performed exploring the Remote View tools at a maximum and allowed for a grouping of the 80 points in 2 categories, i.e. 0.6m rms or lower (Figure 14), and between 0.6m and 1m.

4. Conclusions

The County of Campinas now has an updated high quality orthomosaic – and also a very precise DTM. The final product compatible with the 1:2,000 NMAS scale has proven to be perfectly adequate to the objectives and necessities of the GIS Campinas Project. This GIS is responsible for integrating the new generated cartography to the technical territorial & environmental cadastre of the County and to the databases and applications of all the organizations and secretaries of the County administration.

Besides generating a new territorial reference, the future yearly updating process and monitoring operations will be strongly facilitated and fostered, and possibly at an even faster pace. It is very important to clarify that the urban expansion process in the area is very fast – and most times the velocity of the urban expansion is higher than the pace the county managers can "see" the territory and interfere; in other words: the urban expansion process has more velocity than control, and this is extremely undesirable since it does not allow, among others, to allow for assertive planning

Figure 7 –Fragment final Ikonos orthomosaic – normal color (1:2,000).

Figure 8 –Fragment final Ikonos orthomosaic – false color infrared (1:2,000).

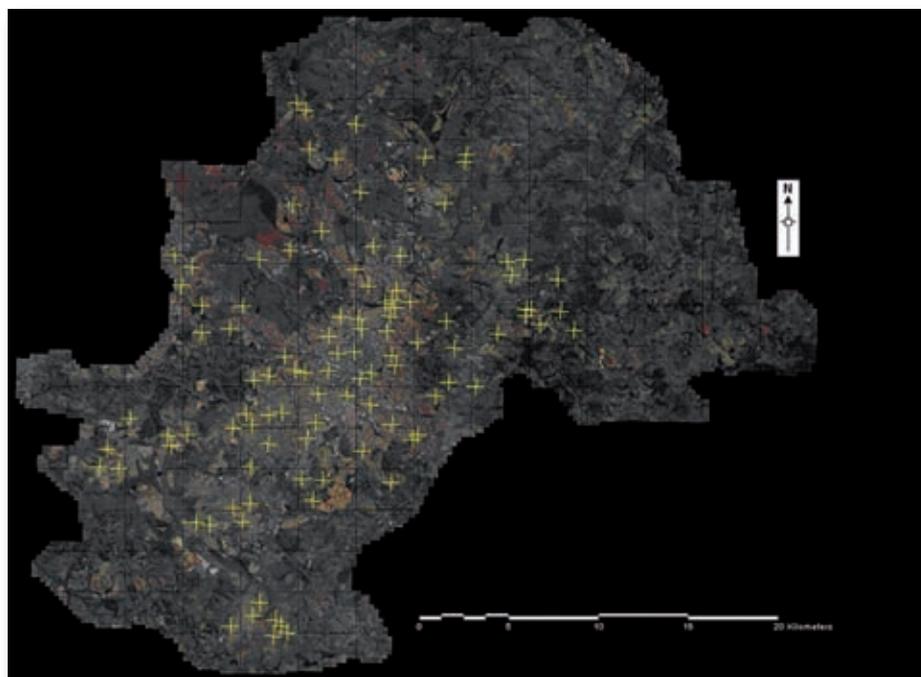*Figure 9 – Fragment final WV-1 orthomosaic – (1:1,000).*

and sustainable development. Hence it has become imperative to have a method of generation of the updated cartography that really brings in a faster speed so that there is more control. Fortunately this Project has proven to deliver this fast, low cost & high quality wanted product.

The result is compatible with the 1:2.000 NMAS scale and Brazilian Standards and represents a very interesting solution to cover large areas in short time and with a lower cost than traditional aerophotogrammetric methods, thus with basically the same quality.

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Figure 10 – Distribution of the independent geodetic points for the error and accuracy check.