THE MOTHER OF INVENTION: PART ONE

C. JASON SMITH DESCRIBES ASSEMBLING A LOW-COST AERIAL SURVEY SYSTEM IN THE ALASKAN WILDERNESS

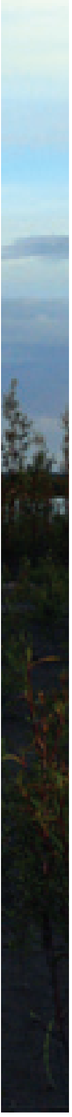
The story of how an ingenious survey team assembled a low-cost, high-definition 3D aerial survey system using a leased helicopter, an off-the-shelf digital camera, and Topcon's new PI-3000 software.

Hanging out of a helicopter with a five pound camera and gyroscope contraption in hand is not the usual modus operandi for a surveyor, but that is what survey manager Eric Stahlke found himself doing in May 2007. In this first part of a two part story Stahlke and his survey team from Alaska's Tanana Chiefs' Conference are trying to solve a problem that has plagued them for years: how to conduct low-cost, three-dimensional aerial surveys for isolated native villages where most of the surveying work is difficult and pro-bono. There was only one problem: no one had ever done it before.

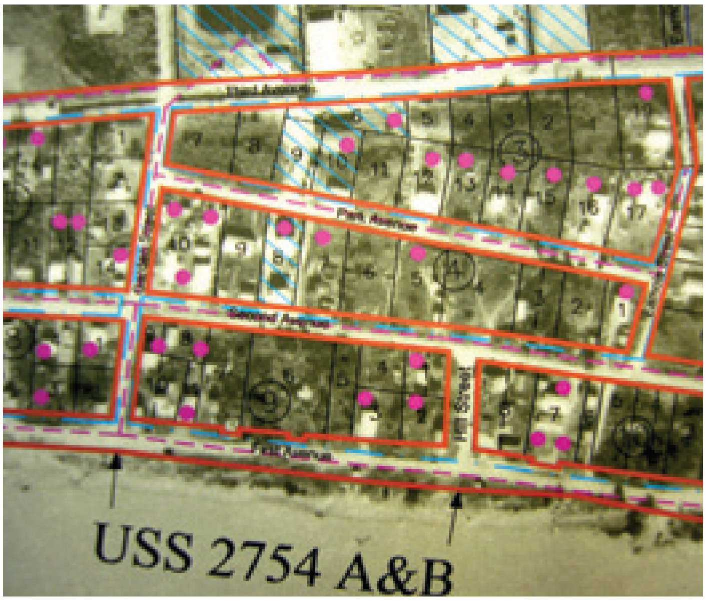
Founded in 1962, Tanana Chiefs' Conference (www.tananachiefs.org) is a non-profit corporation based in Fairbanks, Alaska. The conference is a partnership of 42 member Athabascan Indian villages located in an area of 235,000 square miles in the Alaskan interior. The primary function of the corporation is to administer health and social services assistance to the outlying villages. Most of the professionals, outside the administrative units, are doctors, dentists, and social workers.

Surveying pro bono

The primary work of the Tanana Chief's surveyors is the surveying of the boundaries of Tribal lands. But as they work in the Alaskan bush,



Eric Stahlke with the PI-1000



Tanana's existing city ortho photography

The Robinson R44 Raven helicopter

Shooting stereo pairs from the R44 helicopter

the teams generally base in one of the local villages where they are often called on to survey subdivisions for new housing and solve local boundary disputes. Surveys in the Alaskan interior are prohibitively expensive for most residents. Calling in a survey crew generally entails chartering a flight into areas with few, if any, roads and local budgets simply cannot bear the burden of such an expense. Therefore much of the work Stahlke's team does is pro bono: "As travel to the villages is the greatest single expense in the performance of a boundary survey, and as our crews happen to be in the area doing other boundary work for a client with deeper pockets, we can usually find some time to work in a few local survey requests."

Practical need

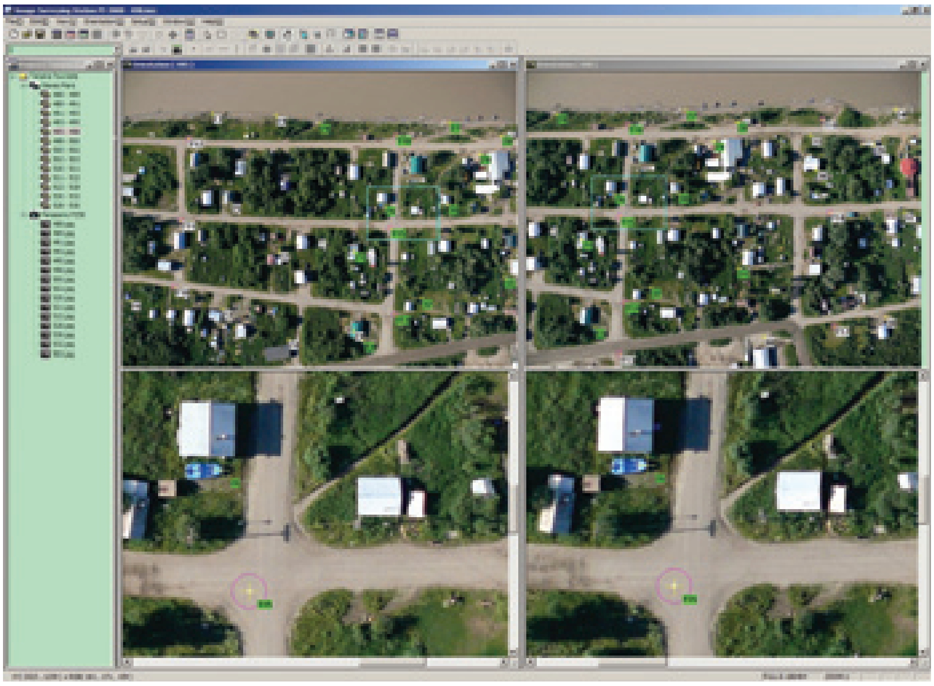
There are few places more challenging to survey than in the Alaskan bush. One of the difficulties with this work is that much of the monumentation from the original government surveys—conducted primarily between 1920 and 1960—hn lost. For the Athabascan people of the Alaskan interior, property lines have traditionally been more a matter of practical need than legal ownership. As Stahlke describes it, "the Athabascan culture is not one that abides fences. People are used to sharing both their food and their land. In a culture that recycles nearly everything, any open space not taken up by buildings is often filled with old trucks, snow mobiles, and dog yards."

Actual boundaries?

The dog yards are just one example of how the Athabascans tend to think of property along occupational lines—how much space is needed for their possessions—rather than along actual surveyed property lines. Even streets and utilities may wander off the original right-of-way lines and across personal property. "As long as land remains in original ownership," Stahlke relates, "this system works without too many problems. But if anyone wants to sell a home, or borrow money on a home, or sell their lot, a boundary survey is required by lending companies the same as if these properties were located in a big city." Occasionally residents will approach the surveyors complaining that a neighbor is encroaching on their property, though, as Stahlke says, "few people have a clue where the actual boundary is."

Disappearing markers

To make matters worse, the monumentation markers have a tendency to disappear: "In a typical village," Stahlke said, "your garden variety lot corner is either located under a pile of used equipment, in the middle of a dog



Example of a PI-3000 measure screen

yard, under a building, or is missing completely." Sometimes villagers build dog pens or pile snowmobile carcasses on top of them. Missing monumentation pushes the cost of the surveys even higher. In many villages so few of the original survey corners remain in place that it may take two or three days just to recover enough control to re-establish lost boundaries. All things considered, the typical boundary survey in these villages can run upwards of $20,000 in an area where the average annual income is around $15,000.

Cost effective solutions

Though traditional survey methods worked, they were time consuming, particularly for pro bono work (sandwiched between larger projects) that needed to be completed as efficiently as possible. Considering the difficulties of the village surveys, Eric Stahlke realized that what was really needed was the ability to conduct detailed cost-effective aerial surveys on site. High-quality ortho rectified images could be merged with vector information showing controlled lot and block lines and most boundary disputes could be solved immediately. But, how was this going to be accomplished?

Solutions and problems

Alaska fosters a practical problem-solving mentality that comes from living in a climate of extremes. Far away from supply centers or in many cases roads, finding solutions to seemingly insurmountable problems can be literally a matter of life and death. But in this case each potential solution to the problem all seemed to lead to another insurmountable problem. Traditional aerial surveys were out of the question as the one pixel per half meter upper limit for true color photography was considerably less than the two to three centimeters per pixel they wanted. Which is not to mention the cost, $15,000 per village, nor the fact that ortho-rectified images would not be available for several months. Nevertheless, the surveys needed to be done and a more efficient method needed to be found. What they did have was a helicopter—a Robinson R44 Raven leased every summer for work in remote areas: work supported by a homemade barge-houseboat.

Producing something new

His team did not want to find simply another method for producing GIS-style depiction of approximate boundary line locations. "Our goal is to produce something new," Stahlke said**,** "an aerial survey plat that approaches the accuracy of an actual boundary survey plat." If they could use the helicopter, the photos could be taken at a much lower altitude, allowing for much more detailed photos. Traditional aerial cameras employ the use of a large format 23 cm x 23 cm image plate and need a lens with an aperture that will capture enough light for the exposure. Because of this limitation, the best shutter speed is 1/500 of a second or faster. At that speed the forward motion of low-flying, fixed-wing aircraft inevitably impacts the resulting image. A helicopter, on the other hand, can hover in place eliminating the distortion due to motion and improving resolution. And, Stahlke thought, why spend $500,000 on a top end digital aerial camera designed for airplanes when a $1,000, 10 megapixel, off-the-shelf camera might work just as well, or better, at a lower altitude?

Answering the questions

The team settled on the Lumix DMC-FZ50 due to its buffer speed of 2 photos per second, 10 megapixel image quality, focus and aperture locks, and variable zoom function. Since aerial photography cameras use an external gyro stabilizer to isolate the camera from aircraft vibration, and they rightly expected the vibration to be severe, they also ordered a gyro stabilizer. "There were a number of other questions that had to be answered besides what kind of camera to buy. For example, what would be the best focal length, what was the optimum aperture setting, at what height above ground should we fly? Also, how much ground coverage could be expected at different focal lengths and at different altitudes, and what size

Making aerial targets

Testing the target sizes

ground targets should be used? While there are formulas that can be used to calculate all the above parameters, for us it seemed more intuitive to answer these questions by common sense combined with trial and error."

Finding the right software package

By far, the most difficult problem aside from money was the computer programming to quickly convert digital mages into a precision ortho rectified mosaic. The software packages used by photogrammetrists run upwards of $50,000, well beyond their budget. Stahlke set about familiarizing himself with helicopter aerial photography. His diligence finally paid off. While reading an article titled "Mapping small areas using a low-cost close range photogrammetric software package with aerial photography" (*The Photogrammetric Record* 20.122), he stumbled across reference to a program, Topcon's PI-3000, that seemed ideal to solve the imaging problem. Best of all, the program would run on a conventional laptop so, if it worked, the team could complete the images on-site. Stahlke got on the phone to Topcon distributors and was put in contact with the managing director of TerraDat Geophysics, Nick Russill, based in the U.K. Russill said, "My initial reaction was that here was an excellent opportunity for a novel application of PI-3000. I knew from my experience with low-altitude kite photography that the results would be impressive." The PI-3000 software package was soon in the mail.

Leaning out the door…

With only a few days left before the supply boat for the interior would leave it was time to test the camera. Team members cut up some makeshift circular targets of varying diameters and scattered them on the tarmac in front of the hanger at Quicksilver Air at the airport in Fairbanks. Since they did not have the remote control or special mount for an aerial camera, they improvised. Stahlke: "We removed a rear door from the helicopter and I flopped down in the back seat and hooked into the airframe with a safety strap. The technique was simple: lean out the door as far as possible, point the camera straight down and start taking pictures. We flew the target sight over and over again, from different altitudes and using different focal lengths on the variable zoom lens. This took about a half hour, which was about all my body could take, as handling the gyro stabilizer with one hand uses more muscles than one can imagine."

Ready for the next step

From the resulting images they were able to determine the optimal resolution and target size. They were ready for the next step - practical application. But, as the PI-3000 had yet to arrive, they were facing the possibility of having to install the program and learn how to use it all onsite. Just hours before they were to head up-river for the summer, Topcon's Russill emailed Stahlke that he's willing to change his travel schedule and join them for the first test. As an expert on the software (and a professional photographer), Russill's presence would greatly reduce the learning-curve of attempting to use the software cold. Stahlke readily accepted Russill's offer and made plans to fly him and the PI-3000 out to the first site on the helicopter upon his arrival.

To be continued next month…

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The Team

Eric Stahlke, LS, CFedS, survey manager
Nick Russill, managing director of TerraDat Geophysics (Topcon)
Albert Macica, LS, Project Manager
Todd Jantzi, Party Chief/ACAD Tech
Alvin Dayton, Survey Tech
Charlie Yatlin, Survey Tech/Trainee
Colin Debler, Survey Tech/Trainee
Ralph Woodford, Cook

The Equipment

Topcon PI-3000 software and laptop
6 dual frequency GPS/GLONASS receivers
AutoCAD Land Desktop 2005
Canon EOS 5D with calibrated 28mm lens
CF Memory and firewire reader
Lumix DMC-FZ50 with variable zoom calibrated lens
Kenyon Labs gyro stabilizer for camera
White neoprene disks 0.50m diameter (can be seen from 1250ft.)
Robinson R44 Raven II Helicopter

The Topcon PI-3000

"Topcon PI-3000 Image Modeler Software puts the power of photogrammetry into the hands of an everyday surveyor. The ease of use and variety of applications for this software is revolutionary. We know that there are many surveying and mapping projects that are too large for traditional land occupied measurements and there are some that are too small to have an aerial company hired. PI-3000 fits perfectly into these projects. Beyond a fly over application like this, there are applications such as stock pile volumes, archaeological sites, forensics, and architectural modeling projects that can benefit from the use of PI-3000." Scott Langbein, Topcon.