

Unmanned Aircraft Systems

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ABSTRACT

The use of Unmanned Aerial Vehicles (UAV) or Unmanned Aircraft Systems (UAS) has been attracting much attention among geomatics and geospatial professionals recently. The modern UAS although small in size, is big on the amount of data it can collect as well as the amount of ground it can cover in a very short period of time. This technology appears to be poised to make a significant impact on the future of data collection.

The typical UAS consists of an autonomous aircraft with a highly advanced navigation system and a high quality digital camera. The systems are often used in situations where a more traditional form of data collection is either impractical or impossible due factors such as project size, high risk environments, accessibility issues etc. The system will rapidly capture digital images of an area of interest which are subsequently post processed along with flight log files to produce a surprisingly high quality orthomosaic and digital elevation model (DEM). Image resolution and model density are controlled by flight altitude and image overlap, however georeferencing of data can be greatly enhanced through the use of survey quality ground control targets placed pre-flight. These targets will be identified by the user in the image processing software post-flight and will serve to calibrate the orthomosaic and the resulting DEM.

Manitoba Infrastructure and Transportation (MIT) have acquired a UAS and intend to employ this exciting new technology for a number of data collection applications. The following paper represents some background on our investigation into this technology from product research to product acquisition in our ongoing efforts toward the development of a “*BETTER, FASTER, SAFER*” and more cost effective method of data collection.

INTRODUCTION

“Manitoba Infrastructure and Transportation (MIT) is responsible for the development of transportation policy and legislation, and for the management of the province’s vast infrastructure network. To meet these responsibilities, the department delivers a wide range of programs and services that play a critical role in sustaining the contributions of the transportation sector to Manitoba’s economic growth.”

“The department’s water control, drainage and transportation infrastructure management duties cover the construction, maintenance, and operation of 19,000 kilometres of all weather roads, 2,200 kilometres of winter roads, over 21,000 bridges and culverts, 4,700 kilometres of drains, 75 dams, 61 reservoirs, 41 pumping stations, 24 northern airports, and many other components.” [1]

As one might imagine the demand for survey data collection to aid in the design, construction and maintenance processes required to service this magnitude of infrastructure is huge and ever increasing. In addition, designers’ ever-increasing preference in working with three dimensional models and point cloud data is rapidly becoming the standard. As a result, the ability to meet these demands in terms of data collection is becoming more challenging. Point cloud data is currently and most commonly captured via either aerial, mobile or terrestrial LiDAR applications; each of which have their own individual advantages and disadvantages. In general aerial LiDAR surveys will cover a much larger area but are quite expensive in comparison to mobile or terrestrial LiDAR surveys which are usually carried out on a much smaller scale and with a much greater time commitment required for field data collection.

The use of a UAS was looked at as potentially beneficial (on applicable projects) to our efforts in narrowing the gap between the time and cost of data collection, as compared to the volume and quality of the dataset. Our goal is to increase the efficiency, productivity and safety of the data collection process without placing any negative effect on data integrity and to always ensure a true, representative and spatially correct dataset.

BACKGROUND

There are currently several options on the market for UAV/UAS's and depending on the users requirements and budget, there are a number of platforms to choose from. This includes various rotary (helicopter) type to various fixed wing (airplane) type systems with either still image and/or video capture capabilities. Other accessories available on some specific models include a near infra-red camera for agricultural, forest fire, search and rescue applications etc.

At the time of MIT's investigation there existed only one UAS available in the Manitoba market and as a result it became the focus of our research. So at the risk of having this paper seem like an advertisement for a single manufacturer and vendor, the UAS of choice for our investigation was the Gatewing X-100, a recent acquisition of survey equipment manufacturing giant Trimble.

TECHNOLOGY



The Gatewing X-100 (Photos courtesy of Gatewing.com)^[2]

What's in the box?



1. Ground Control Station (GCS)
2. 2.4 GHz Radio pod (for GCS)
3. X-100 Body with eBox and motor

4. Battery Charger
5. Batteries
6. Replacement Parts

X-100 SPECIFICATIONS

Dimensions	100 x 60 x 10 cm
Mass	2.2 kg
Fuselage	Carbon reinforced expanded polypropylene
Top Speed	130 km/h
Cruise Speed	80 km/h
Wind Tolerance	Up to 65 km/h
Flight Endurance	45 minutes
Flight Altitude	100 – 750m ^(*)
Launch Method	Catapult
Landing Method	Belly Landing
Communication Type	2.4GHz Radio
Communication Range	Up to 5.0 km ^(**)
Propulsion	Push prop w/250W electric brushless motor
Battery	11.1V, 8000mAh Lithium-polymer
Payload	Ricoh GR 10MP digital camera
Autopilot	Automatic takeoff and landing Waypoint navigation Autonomous camera triggering Fail safe routines

()Transport Canada regulations state that all UAV's must always be operated at an altitude less than 500 ft (152.40 m) above ground level (AGL).*

*(**)Transport Canada regulations state that UAV's must always be operated within line of sight of the operator.*

WORKFLOW

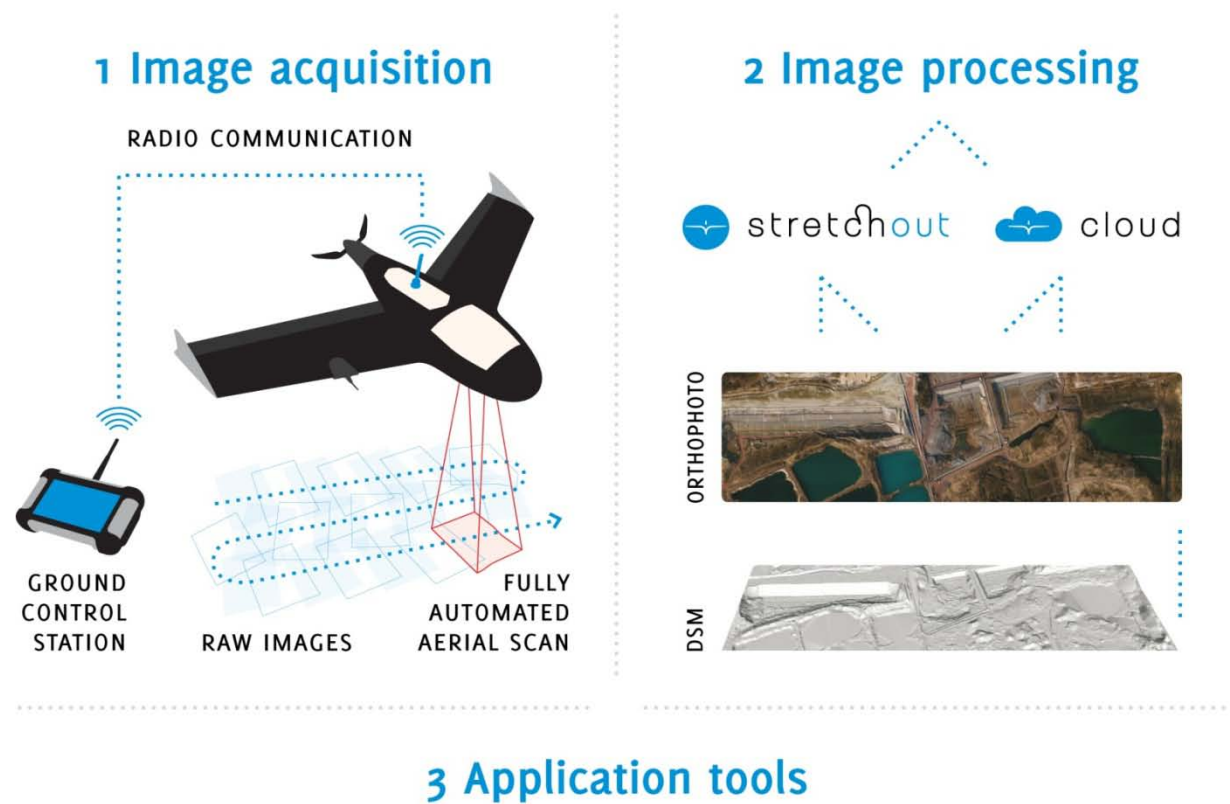
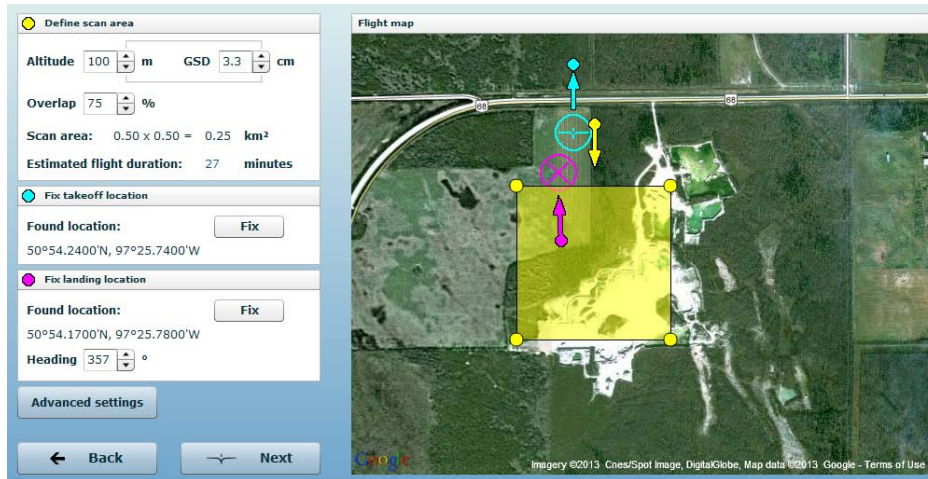


Photo courtesy of Gatewing (www.gatewing.com)^[2]

Workflow can be broken down into 3 main steps:

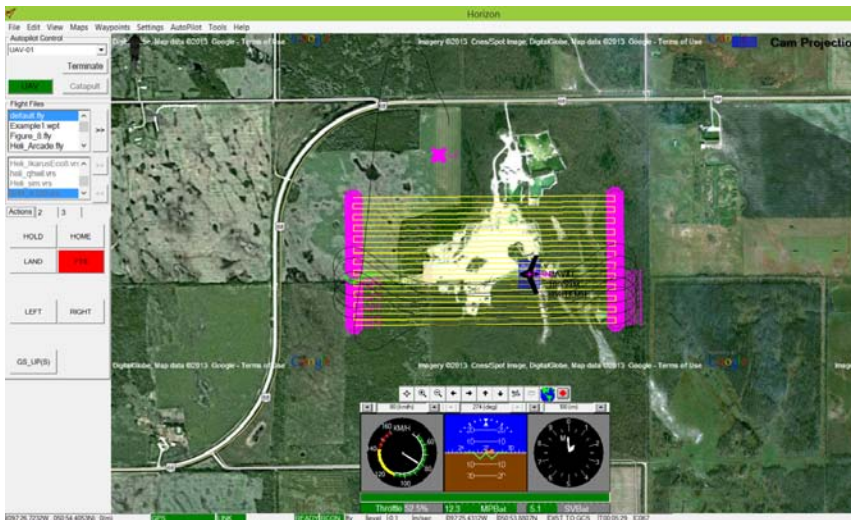
1. Image acquisition using the X-100
2. Image processing to produce an orthomosaic and DEM
3. Import data into the users various application tools (i.e. CAD software)

IMAGE ACQUISITION



A. Setting up of Flight Plan

- i. Select area of interest
- ii. Set wind direction (Yellow Arrow)
- iii. Capture waypoint for launch location and set launch direction (Blue)
- iv. Capture waypoint for landing location and set landing direction (Pink)
- v. Ensure flight time is >45 minutes
- vi. Export flight plan to GCS

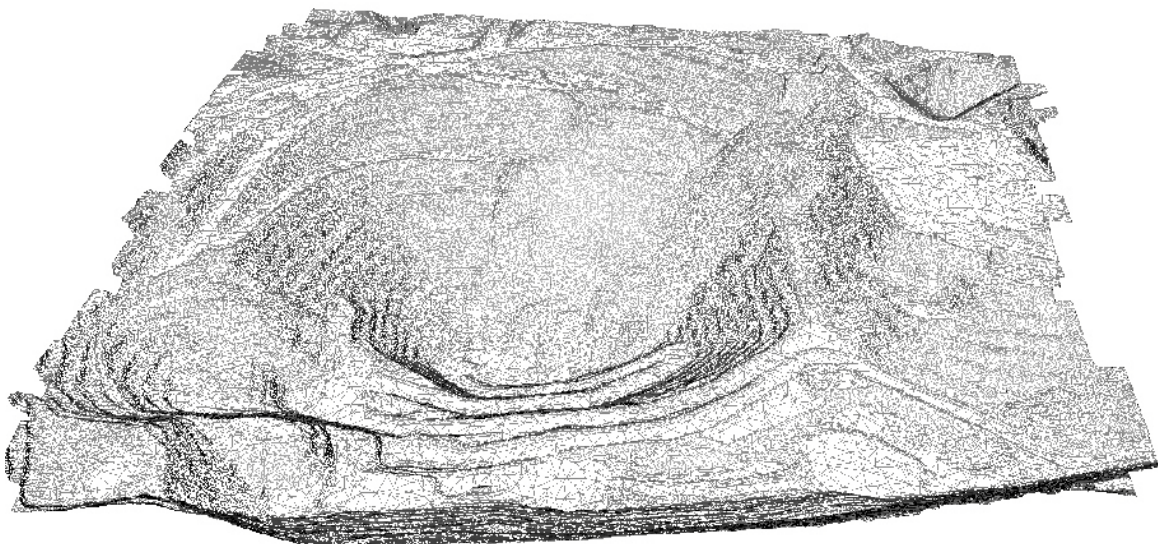


- B. Simulate flight to ensure safe operation
- C. Launch X-100 and carry our flight mission

IMAGE PROCESSING

Image processing involves the processing of flight log files and images. Survey data for ground control targets is also added at this point.

Depending on the processing power of the pc being used, the physical size of the project and the nature of the deliverable(s), full processing times can vary from anywhere between 1 - 2 hours for small sites to 24 hours or more for larger projects. The results however are usually well worth the wait.



Photos courtesy of Gatewing (www.gatewing.com)^[2]

ACCURACY

CATEGORY	ITEM	VALUE
Acquisition	Default flight altitude	150 m
	Overlap	Variable, 75% default forward & side
	Average coverage per flight	1.5 km ² (45 min at 150 m)
	Average number of pictures per km ²	600 (at 150 m)
Orthophoto	Pixel resolution (GSD)	5 cm (at 150 m)
	Planimetric accuracy	Equal to 1 pixel
	Projection	Semi-true or true
	Color	True RGB; no haze
Point cloud	Point spacing	Up to 1 pixel
	Planimetric accuracy (XY plane)	5 cm (at 150 m)
	Height accuracy (Z axis)	10 cm (at 150 m)

Table 1 (from Gatewing Brochure - courtesy of Gatewing - www.gatewing.com)^[3]

The overall “accuracy” of the system is dictated by several factors:

1. Flight Altitude – Higher altitude results in greater distance between pixels in the images and hence a less sharp orthomosaic as well as a less dense DEM.
2. Image Overlap – Higher overlap will improve model quality as it will provide redundancy for ground control target registration as well as to help ensure that there there will be no gaps or holes in the data.
3. Ground Control – Placing enough good survey quality ground control targets around the perimeter as well as within the area of interest will ensure a well calibrated orthomosaic and DEM. Also the coordinates of control targets not used in the registration process can serve as quality control checks on the final model.

APPLICATIONS

MIT sees several practical applications for this technology within our business area:

- Project Planning
 - Alignment studies
 - Project reconnaissance (investigating change)
- Topography surveys
- Stockpile volume calculations
- Geotechnical investigations
- Inventory Mapping
- Flood Inundation Photos
- Investigation into land related issues
 - R/W limits and/or encroachments
 - Landowner property lines
 - Lease property lines (pits, quarries etc)

SPECIAL REQUIREMENTS

1. Successful completion of the manufacturer's 5 day training and certification program is required before users are eligible to use the system.
2. Transport Canada regulations require the submission of an application document before each and every flight mission. No flight is authorized to take place without approval and issuance of a "Special Flight Operations Certificate" (SFOC).
 - Submission document will contain information such as the proposed date of flight, location, flight altitude, coverage area, proximity to obstructions, safety precautions, on site contacts etc.
 - Approvals can take anywhere from 1 – 8 weeks.
 - As UAV technology is relatively new, regulations continue to be developed and modified as the industry evolves.

CONCLUSION

The Gatewing X-100 proved to be a very attractive tool for many reasons. Its ease of use, autonomous operation and relatively low cost make it a great addition to our survey equipment fleet as well as to the level of service we can provide. The amount of ground the system is capable of covering in a very short time coupled with the high quality of the deliverables is quite dramatic. In addition, the risk of injury to staff is greatly diminished as the only requirement for “boots on the ground” is in the placement of ground control targets.

The modern UAS appears to be poised to establish itself in the geomatics and geospatial communities as a viable, dependable and “*BETTER, FASTER, SAFER*” method of data collection.

In closing I suppose one could say that when it comes to the future of data collection, things are looking up!

REFERENCES

- [1] MIT website (www.gov.mb.ca/mit/index.html)
- [2] Images on p. 5, 7, 9 courtesy of Gatewing (www.gatewing.com)
- [3] Table 1, p.10, Gatewing X-100 Brochure, courtesy of Gatewing (www.gatewing.com)