WOOLPERT

DESIGN | GEOSPATIAL | INFRASTRUCTURE

Geospatial Data Collection Using Unmanned Aerial System (UAS)

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Woolpert, Inc.

ASPRS-EGLR Technical Meeting

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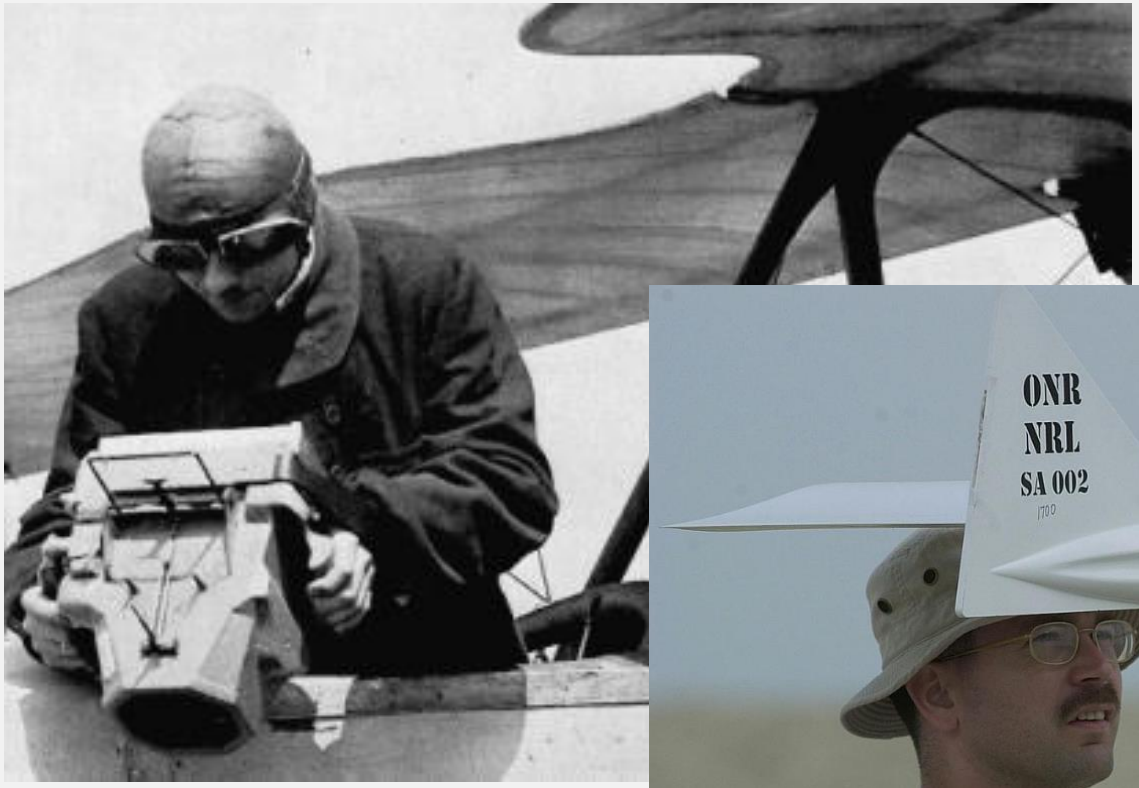
CELEBRATING 100 YEARS

Aerial Sensing Has Come A Long Way!!!



From carrying a camera…

To carrying an entire aerial acquisition system

Image courtesy: http://cryptome.org/2012-info/drone-photos/drone-photos.htm

Not All Drones are lethal…

Image courtesy: http://cryptome.org/2012-info/drone-photos/drone-photos.htm

Drones for surveillance and Mapping…

We call them “Unmanned Aerial System”

Images courtesy: http://cryptome.org/2012-info/drone-photos/drone-photos.htm

The UAS advantages for Geospatial Business

- Ease of data acquisition
- Increased ability to map difficult areas or small projects
- Expeditious data delivery
- Data sets may be acquired at reduced costs when compared to traditional field survey or conventional aerial mission
- It can be metric

Geospatial Market Segment for UAS

+ Mapping and Surveys of corridors
+ Energy Site Mapping
+ Insurance Companies “as is” Plan
+ Engineering, Construction and Forestry
+ Precision Agriculture
+ Environmental Studies
+ Emergency Services
+ Farm Irrigation
+ Site Inspection

Woolpert Strategic Partnership with Altavian

- Woolpert secured a strategic partnership with a leading company in the field of UAS manufacturing
- Woolpert purchased its first UAS in March 2013
- Purchased the Altavian Nova Block III platform
- First flight was achieved in April 2013

Why Altavian?

+ Introduced innovative platform for flexible aerial imagery acquisition
+ Leading manufacturer with geospatial background (owner and founder hold a master degree in photogrammetry);
+ Track record of mapping projects with the US Army
+ US-based operations facilitates fast field support

Woolpert UAS specifications

PLATFORM:

Add system name, model, etc.

IMAGING SENSOR

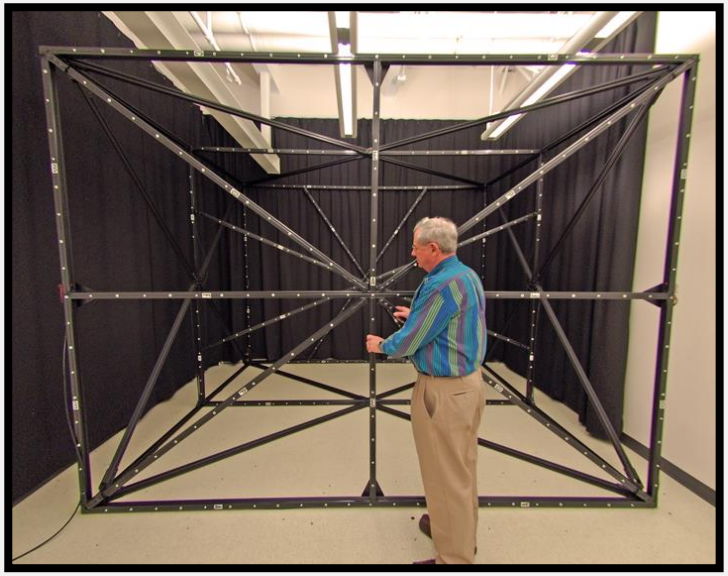
+ Array size: 36.17 mm (H) x 24.11 mm (V)
+ Array size in pixels: 6600 (H) x 4408 (V)
+ Pixel Size: 5.5 µm (H) x 5.5 µm (V)
+ Focal length: 47mm
+ Maximum aperture: f/5.6 - Minimum aperture: f/32
+ Auto-exposure and AGC capability
+ Image exposure via global electronic shutter
+ Flying height: unlimited (fixed focus at infinity)
+ Radiometric resolution: RAW (8, 10, 12 and14 bits) RGB

AUXILARY SYSTEMS

+ IMU: add brand model specs
+ GPS: add brand model specs

Woolpert UAS Characteristics

- Woolpert is working on procedures and modification to convert the UAS to a fully metric mapping system through:
  - System Calibration
    - In-situ and Indoor calibration processes
    - Hardening the hardware and stabilize it
  - Follow pure photogrammetric procedures throughout the entire workflow
  - Automate processing as much as possible



Indoor calibration cage
(Image courtesy, RIT)

Initial Testing

- Processed data over a stock pile site with GSD = 1.5 cm
- Data processed using the following software:
  - Pix4UAV 3D
  - AgiSOFT
  - *EnsoMOSAIC*
  - *MenciAPS*
- All four software packages provide some degree of automation, some of which is completely automated process.
- Some of the packages perform camera self-calibration

Processing Software Evaluation

UAS Software Features	Agisoft	EnsoMOSAIC	Pix4UAV 3D	Menci APS
Ability to import >1000 images (TIF, JPG)		✓	✓	✓
Rapid process mode or image coverage verification tools			✓	✓
Camera calibration	✓[i]	✓+	✓[i]	✓
Image geometric and radiometric pre-processing		✓+		
Automatic AT / bundle adjustment	✓	✓	✓	✓
Quality Control reported results	✓	✓	✓	✓
Export EO for stereo photogrammetric workstation	✓	✓	✓	✓
Automatic DTM/DSM/dense 3D point cloud generation	✓	✓++	✓	✓
Individual image orthorectification		✓	✓	
Automatic Radiometric correction, seamlines, orthomosaic	✓	✓	✓	✓
Seamline editor, orthophoto tiling / Google Earth tile setup	✓[ii]	✓	✓	✓
3D point cloud viewer and orthomosaic correction editor				✓
Main CAD functionalities and common edit commands				✓
Automatic contour line generation		✓+		✓
GPU processing enabled	✓+++			✓
Batch processing or scripting	✓[iii]		✓	✓

[i] Determines initial and refined internal parameters for bundle adjustment.

[ii] Seamline editor not available.

[iii] Supports Python API, using Python 3.2 as scripting engine.

+ Requires additional software and licensing.

++ 3D point cloud with additional licensing and software (EnsoMOSAIC 3D).

+++ Limited number of OpenCL enabled devices supported.

Processing Software Evaluation: Conclusion and Recommendations

Menci APS

+ Menci APS is relatively new, the developers are eager to gain market share, and currently are most willing to implement customer feedback and suggestions to improve their product.
+ During evaluation, required the least amount of processing time, and performed at comparable or higher accuracies.
+ Does not require knowledge in photogrammetry to operate, can be conducted in the field if necessary, but is fresh off the presses and will require continued updates with improvements.

Pix4UAV Desktop 3D

+ Pix4D is the most stable of the UAS specific software packages, but such stability comes at a price in the absence of enhanced functionality or adaptive integration.During evaluation, required the second least amount of processing time, and performed at comparable or higher accuracies.
+ Does not require knowledge in photogrammetry to operate, offers bulk secondary “Pix4UAV Desktop Rapid” licenses for quick turnaround data validation in the field, but to my knowledge is not GPU enabled and offers limited batch processing capacity.

Processing Software Evaluation: Conclusion and Recommendations, cont.

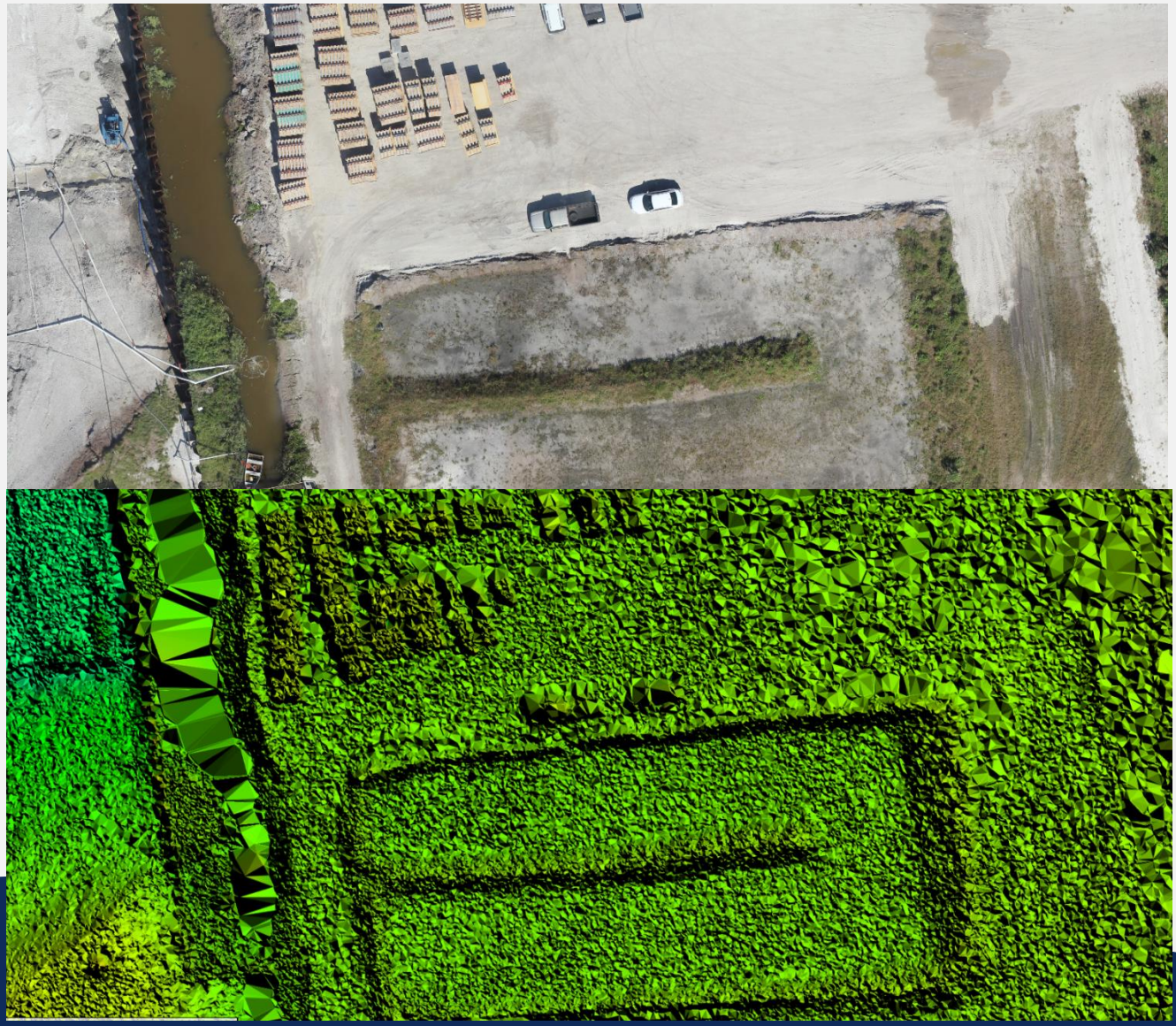
Agisoft

+ Agisoft has the least amount of photogrammetric components, but calculates comprehensive internal camera calibration parameters and offers substantial data export options/formats with batch and scripting capability.
+ During evaluation, required the most processing time and performed at comparable to lower accuracies.
+ Does not require knowledge in photogrammetry to operate, but is deeply ingrained in 3D modeling from still photography that it will require considerable trial and error to derive best practices of use.

EnsoMOSAIC

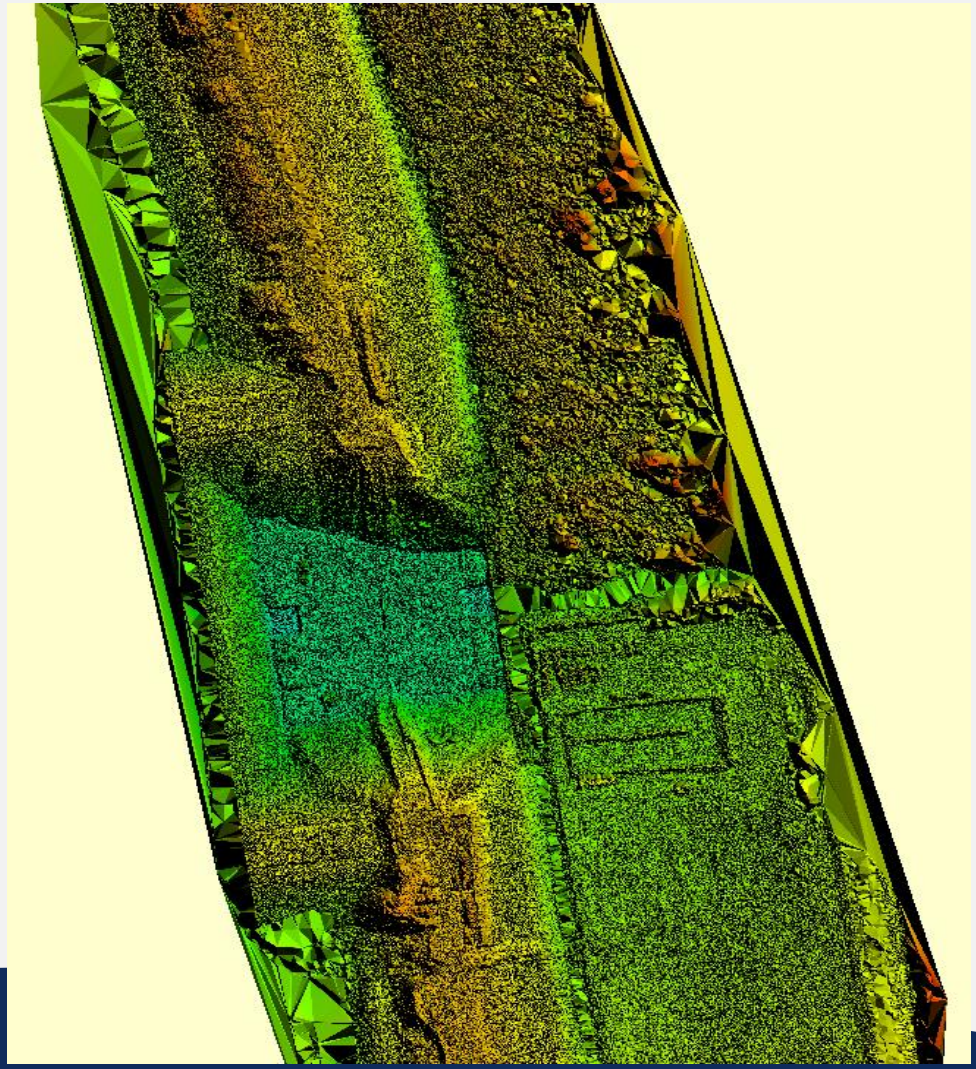
+ EnsoMOSAIC is currently one of the few full photogrammetric software suites optimized for UAS processing, but it is the most expensive package evaluated and shall primarily offer those with current photogrammetric capability an unnecessary level of redundancy.
+ During evaluation, required the second most processing time, the most manual interactive process (setup, parameters, etc.), and performed at comparable to higher accuracies.
+ Requires knowledge in photogrammetry to operate, is not GPU enabled or provide batch/scripting environment, and to my knowledge does not utilize semi-global matching to from dense 3D reconstruction.

Multiple Products System



Ortho Quality (GSD =1.5 cm)

Digital Elevation Model Quality



System Mapping Accuracy

+ Currently, product is meeting class II of ASPRS mapping standard (RMSE = 6 cm for GSD = 1.5 cm) **

+ Objective: To meet ASPRS class I with the new metric system (RMSE = 3 cm for GSD = 1.5 cm)

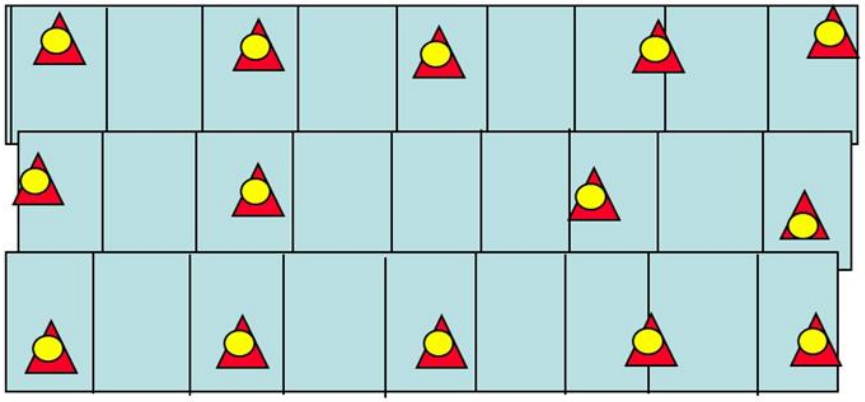
** More testing is need to validate this conclusion

Planned Testing Procedure

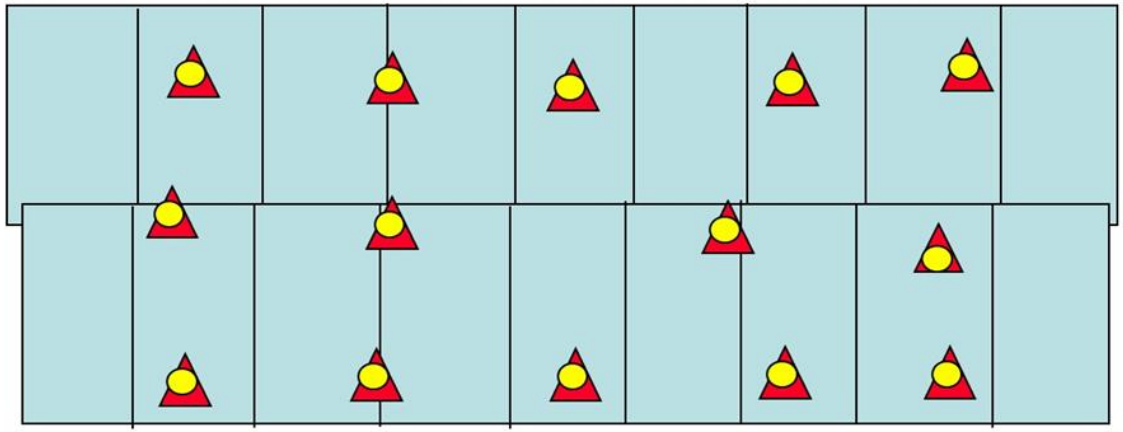
Objective:

+ To ensure that the UAS, aircraft, imaging sensor, and associated systems, function as a fully operational and integrated system;
+ To verify that the UAS adequately meets clients requirements;
+ To perform camera in-situ calibration;
+ To assess and quantify the accuracy and integrity of data derived from the UAS;
+ To assess overall system capabilities and limitations;
+ To assess operational reliability (through atmospheric and altitude changes, over time, etc.).

Design of Calibration Flight



3 Low Altitude Flight Lines (Altitude = 1,000 ft AMT)



2 High Altitude Flight Lines (Altitude = 650 ft AMT)

Sample of Testing Scenarios

TEST NUMBER: L001	ALTITUDE: LOW	CONFIGURATION: E-W or S-N	COVERAGE: FULL	SUBJECT: AT
ORTHO GSD = 2 cm	ORTHO TOTAL FOV= 21 degrees		CONSTRAIN: GPS ONLY	
TEST DESCRIPTION	Report the accuracy of AT generated from all the low altitude imagery using only ABGPS in the solution			
LIMITING HORIZONTAL ACCURACY	RMSE (X or Y) = 0.06 m	90% = 2.17 * 0.06	95% = 2.47*0.06	
LIMITING VERTICAL ACCURACY	RMSE (Z) = 0.06 m	90% = 1.6449 * 0.06	95% = 1.96*0.06	

TEST NUMBER: L002	ALTITUDE: LOW	CONFIGURATION: E-W or S-N	COVERAGE: FULL	SUBJECT: AT
ORTHO GSD = 2 cm	ORTHO TOTAL FOV= 21°		CONSTRAIN: GPS and GCPs	
TEST DESCRIPTION	Report the accuracy of AT generated from all the low altitude imagery using ABGPS and ground GCPs in the solution			
LIMITING HORIZONTAL ACCURACY	RMSE (X or Y) = 0. 02 m	90% = 2.17 * 0.02	95% = 2.47*0.02 =	
LIMITING VERTICAL ACCURACY	RMSE (Z) = 0.02 m	90% = 1.6449 * 0.02	95% = 1.96*0.02 =	

TEST NUMBER: L003	ALTITUDE: LOW	CONFIGURATION: E-W or S-N	COVERAGE: FULL	SUBJECT: Ortho
ORTHO GSD = 2 cm	ORTHO TOTAL FOV= 21 degrees		CONSTRAIN: GPS ONLY	
TEST DESCRIPTION	Report thehorizontal accuracy of the ortho generated from low altitude imagery, AT from ABGPS only, and DEM generated from the imagery and/or lidar.			

Future of UAS in Geospatial Industry

- Once the FAA ease the regulation on flying UASs for commercial and civilian use, The UAS industry will flourish and so as its use for mapping.

- I believe that UAS will gradually replace manned aerial data acquisition and perhaps it will achieve most of this goal (total replacement) in the next fifteen years or so.

- With the increased utilization of UAS and continued automation in data processing, Geospatial data will be more affordable and data collection will be achieved in unprecedented time frame.