



Office of Photogrammetry and Preliminary
Investigations

Specifications for Using Unmanned Aerial Systems to Generate High Accuracy Mapping

Presentation to the CSRC - Sacramento
October 6th, 2016

Introduction – John Erickson, CP, PLS

Mapping Branch Chief, Caltrans Office of Photogrammetry and Preliminary Investigations

California PLS in 2013

ASPRS Certified Photogrammetrist since 2004

ASPRS Pacific Southwest Region Director

BS in Cartography, University of Wisconsin – Madison, 1984

32 Years in Photogrammetry and Mapping

Private and Public sector employment - Joined Caltrans in 2005

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Genesis of this Research Project

After helping to organize and attending the American Society for Photogrammetry and Remote Sensing (ASPRS) UAS 2014 and 2015 Symposia, I had some fundamental questions that went unanswered.

I asked vendors and presenters who claimed to do high accuracy mapping from small unmanned aerial systems (sUAS) – How many ground control points and to what accuracy do you need to achieve a certain map accuracy. Which camera works best?

Getting no definitive answers from the best and brightest in the industry, I thought this would be an excellent research project.

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Genesis (continued)

o, I further canvassed my sUAS network of Academics, including TRB AFB80 Committee members, ASPRS UAS committee members, and private sector sUAS endors.

All parties I talked to agreed this type of research project has not been undertaken and is sorely needed.

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Problem Statement

There are many commercially available sUAS for “high accuracy” mapping. The problem is specifications developed for one configuration of a sUAS won’t hold true for a different configuration. For example, cameras used for sUAS mapping range in quality from a GoPro to a multi-thousand dollar medium format digital camera. Camera quality is highly correlated to the resultant accuracy of the mapping products from the sUAS and this is just one of many variables (ground control etc.) that will need specifications.

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Goals

- Provide specifications for sUAS hardware and ground control requirements for high accuracy mapping.
 - Camera Calibration parameters
 - LIDAR system parameters
 - Spatial distribution of the ground control points
 - Flight planning and strip configuration
 - Positional accuracy of the airborne GPS
 - Inertial Measurement Unit (IMU) accuracy requirements

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Expected Benefits

A proven set of specifications for sUAS hardware and ground control requirements.

Although Caltrans is the immediate beneficiary of the proposed research, the resulting standards will be equally well suited for adoption by any organization engaged in the production of photogrammetric maps, and LIDAR derived geospatial products, both in the private and the public sectors.

The specifications will be the basis for a new chapter in the Caltrans Surveys Manual on the use of sUAS in the surveying workflow.

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Tasks

Task 1: Project Management

Task 2: Literature Search

Task 3: Data Simulation

Task 4: Test Flights

Task 5: Data Processing

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Task 1: Project Management

Spans the life of the research project

Quarterly Technical reports

Meetings, budget, schedule etc.

Form a Technical Advisory Panel

Task 1 Deliverables

Preliminary and Final reports

- Will contain specifications for items in Appendix B (discussed later)

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Task 2: Literature Search

An extensive literature search will be carried out to investigate what research and application has been done so far using sUAS imagery and LIDAR.

Task 2 Deliverable

Provide a literature search report outlining existing research and the accuracies and approach used by different users of this technology.

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Task 3: Data Simulation

Use simulated data to determine preliminary specifications for sUAS test flights. Most likely this task will be an iterative process with Task 4 Test Flights and Task 5 Data Processing

Task 3 Deliverable

A report on the simulation study results and a recommended design for the test sUAS flights hardware and ground control specifications.

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Task 4: Test Flights

This task covers all efforts to plan, prepare, conduct, and report on the sUAS test flights and associated work. This is the first proof of concept task.

Some of the steps include:

- Determine with Caltrans the ground cover types to fly over and determine sites that meet these types.
- Contract with vendors to fly the selected sites.
- Place ground control targets.
- Survey ground control targets.
- Scan flight areas with Terrestrial LIDAR for accuracy checking.
- sUAS flights over test area.

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Task 4: Test Flights (continued)

A minimum of four flights are planned but will probably be more.

Task 4 Deliverable

A report on test flights and the ground survey results.

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Task 5: Data Processing

Review and analysis of data obtained from test flights conducted, draw conclusions, and make recommendations. This is the second proof of concept task.

Some of the steps include:

- Adjustment of the ground survey
- Terrestrial LIDAR data processing
- Process flight trajectory
- Aero-triangulation of imagery (Structure From Motion or SFM)
- Ortho-photo generation
- Digital Surface Model (DSM) generation
- LIDAR data processing

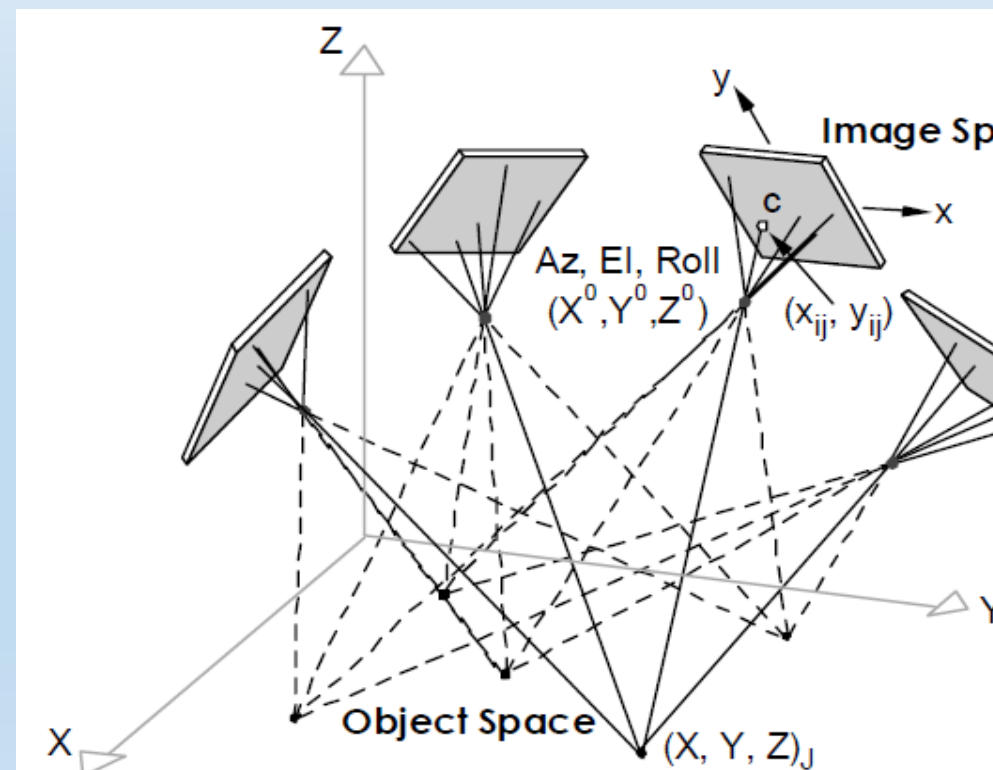
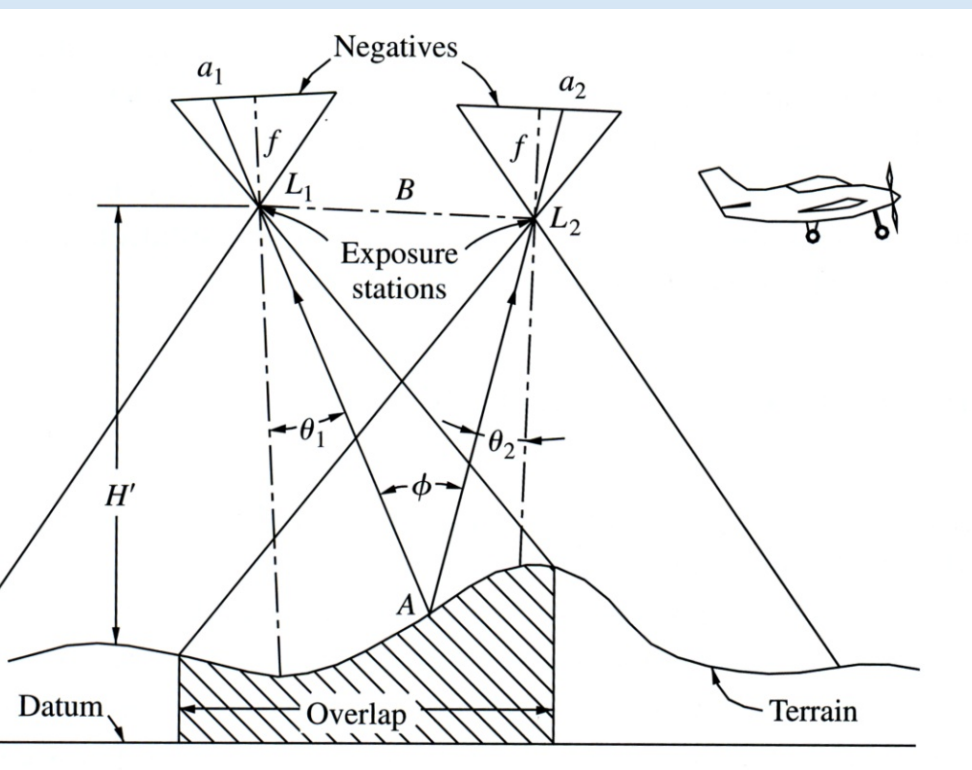
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Task 5: Data Processing (continued)

Task 5 Deliverable

A report on the results achieved by using different commercial software available on the market for each test flight.

Structure from Motion

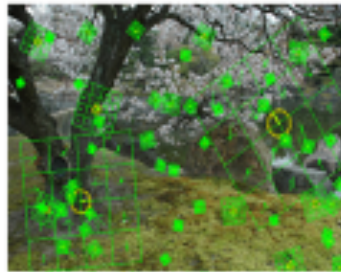


Structure from Motion

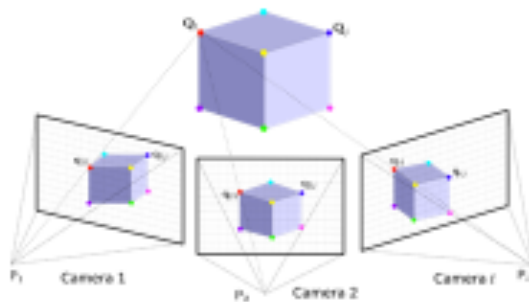


Look Ma!! No GPS or IMU!

Unsorted mess of images →



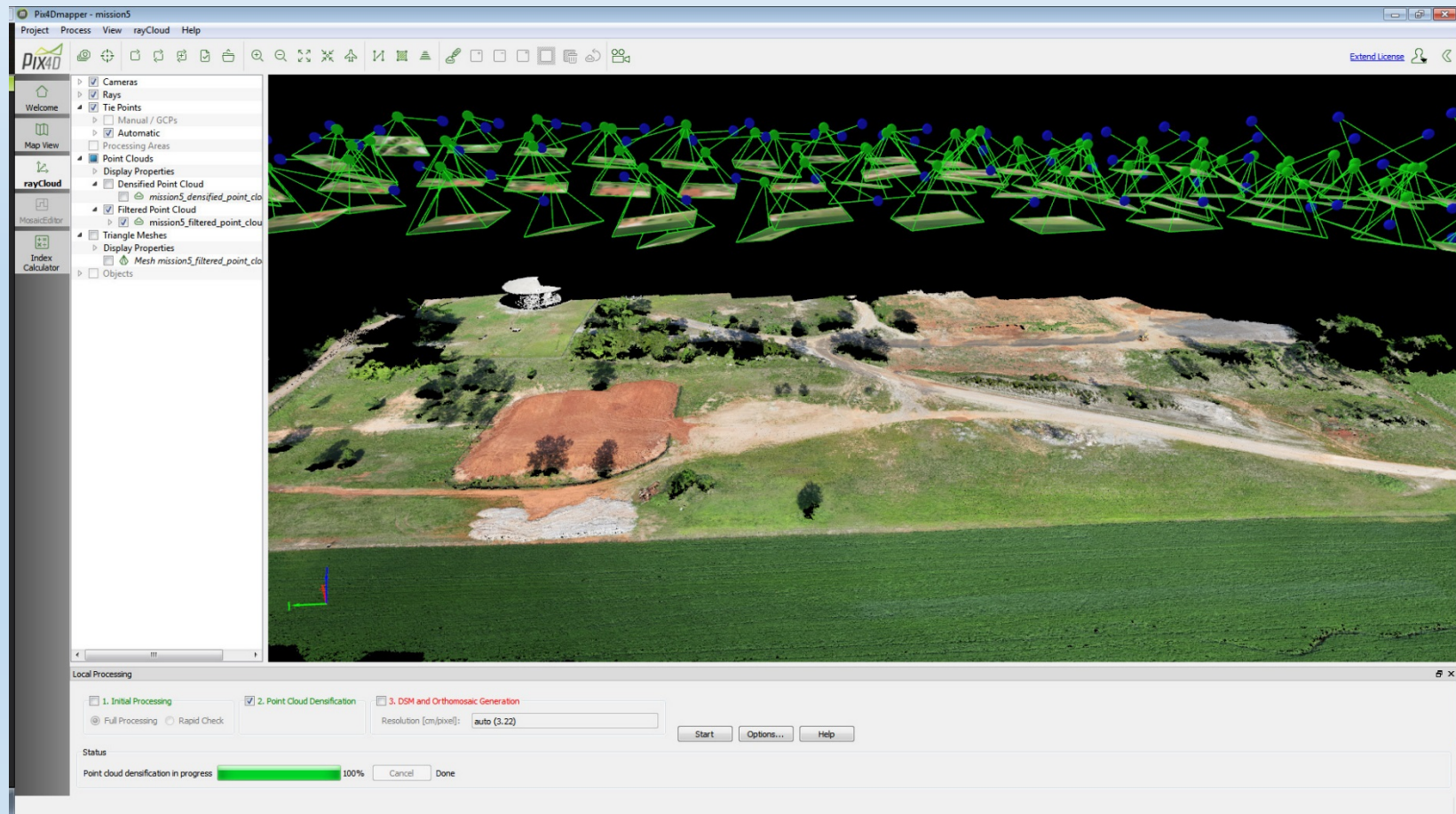
Scale Invariant Feature Transform (SIFT) or Speeded Up Robust Features (SURF)



Structure from Motion (SfM) – e.g. Bundler

→ Camera calibration and Exterior Orientation (EO)
.. . at least relatively

Structure from Motion



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Specifications for Final Report

B.1. Minimum Hardware specifications.

- Camera
- Lenses calibration
- IMU
- Global positioning satellite (GPS) unit
- Camera mount

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Specifications for Final Report (continued)

B.2 Minimum specifications for flight planning

- Camera Calibration
- Imagery Overlap specifications
- Imagery Sidelap specifications
- sUAS flight speed relative to the ground
- Orthogonal flights
- Maximum and minimum area that can be flown economically
- Flying height

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Specifications for Final Report (continued)

B.3 Minimum Ground control specifications

- Ground control target shape and size
- Ground control target placement
- Ground control accuracy requirements

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Specifications for Final Report (continued)

B.4 Minimum specifications for Structure From Motion (SFM) imagery processing

- SFM imagery processing settings
- Image Correlated Digital Surface Model (DSM) specifications
- Horizontal accuracies from DSM using National Standard for Spatial Data Accuracy (NSSDA)
- Vertical accuracies from DSM using NSSDA
- Ortho-photos accuracies using NSSDA

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Specifications for Final Report (continued)

B.5 Minimum specifications for sUAS LIDAR system

- Scan frequency
- Pulse repetition frequency
- GPS/IMU accuracy
- Image intensity
- LIDAR Strip Sidelap
- Potential benefits of integration with camera imagery
- Horizontal accuracies from DSM using National Standard for Spatial Data Accuracy (NSSDA)
- Vertical accuracies from DSM using NSSDA

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Research Contract Information

California State University - Fresno

Principal Investigator: Dr. Riadh Munjy, PhD., PE

34 months (1/1/2017 to 10/31/2019)

Budget \$450,000

Currently being contracted with California State University Fresno

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Caltrans Current and Future Issues

Caltrans use and deployment of UAS – Issue Memorandum

Caltrans Surveys use and deployment of sUAS

- Best Practices, Workflows, Standards, who does what
- FAA Part 107 - Develop sUAS operators in house or contract for services
- Flying over “non-participants”
- Beyond Line of Sight operations
- Vertical accuracy assessment using new ASPRS Positional Accuracy Standards
 - <https://www.asprs.org/pad-division/asprs-positional-accuracy-standards-for-digital-geospatial-data.html>

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Questions?

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