

COURSE SYLLABUS SUR 4501/SUR 6502: FOUNDATIONS OF UAS MAPPING

M/W 5th Period + M 8-10th Period
(3 Credits)

Prerequisites

SUR 3103 or Permission of Instructor (non-Geomatics students are encouraged to take this course)

Instructors

Dr. Grenville Barnes gbarnes@ufl.edu (352) 392 4998 **Reed Lab 406B**

Grenville Barnes has been on the Geomatics faculty since 1993 and prior to that taught at Ohio State University for 5 years. He worked as a licensed land surveyor in South Africa before coming to the University of Wisconsin to do a PhD. His research is focused on property rights and systems for legalizing them in developing countries, including using UAS for defining property boundaries.

Co-Instructor

Justin Thomas, PSM LS7106 jthomas88@ufl.edu (352) 392-4996 **Reed Lab 301**

Justin is a Lecturer in the Geomatics Program at the Gainesville Campus. He has a BS in Geomatics from UF and is a Professional Surveyor and Mapper, LS7106, in Florida. Prior to teaching at UF, Justin gained valuable private and public industry experience by working in a Surveying and Engineering firm in Gainesville and then moving on to working in the FDOT District 2 office.

Distance Student Field Project Instructors

Adam Benjamin, PSM abenjamin1@ufl.edu

Adam is a Geomatics Specialist in our Ft. Lauderdale Geomatics (FTL) Program. He has a BS in Mathematics from Elon University and a Masters in Geomatics from UF. In his spare time, he is pursuing a PhD in Geomatics at UF.

Katie Britt k.britt@ufl.edu

Katie is the Plant City Geomatics Program Specialist. She has a BS in Geomatics from UF, an MS in Earth Science from the University of Memphis and is pursuing a PhD from Virginia Tech in Geospatial and Environmental Analysis.

Course Description and Learning Objectives

Foundations of UAS Mapping introduces students to the fundamental components of small unmanned aerial systems (sUAS) and how they function together to produce high resolution, spatially accurate planimetric maps and 3D models of the terrain. These components include GPS/GNSS, inertial systems, lidar, and on-board sensors like cameras. We focus primarily on the application of these technologies, but also cover basic theoretical aspects. We deal with establishing ground control for sUAS imagery so that the products can be referenced to specific geodetic reference frameworks and

integrated with other geo-spatial data. This is the first of the three courses required for the Certificate in Geospatial Measurement and Modeling with sUAS. Students who do not have a geomatics background, such as an introductory surveying class or field experience, are required to get the permission of the instructor before they enroll.

By the end of this course, the student will:

- Understand the foundations of sUAS
- Be able to identify the essential hardware components of sUAS
- Know how to plan, acquire, and adjust GPS/GNSS and total station measurements, and their role in ground control for sUAS mapping
- Understand the fundamentals of onboard GPS/GNSS and inertial measurements, and their role in airborne navigation and control for sUAS
- Understand the fundamental concepts of photogrammetry and lidar
- Be familiar with the standard sUAS mapping workflow
- Be able to analyze and report on the quality of spatial measurements and maps

Method of Instruction

This course is based on the concept of experiential learning or “learning by doing.” Where possible, the material is learned primarily through a series of hands-on field projects. The field data collection component of the project is done in small teams (2-4 students). Analysis of the data and submission of results, however, must be done independently and individually (not as a team). The project deliverables are due at specified dates (*deadlines*) throughout the semester according to a set schedule. These deadlines are not flexible. Students doing their labs through either Ft. Lauderdale or Plant City should communicate with Adam or Katie to determine your lab schedule.

Meeting Times and Places

The class meets weekly on Monday morning (11:45am-12:35pm) in **302 Reed Lab** for a lecture focused on the topic for that week. Distance students can attend these lectures virtually via Adobe Connect at the scheduled time or view the recorded version at a later time. This lecture is used to provide background information on the specific technology and methodology as well as the requirements of the weekly project.

The field data acquisition part of projects occurs on Monday afternoon (3:00-6:00p.m.) for Gainesville students unless equipment constraints or weather dictate otherwise. All field work is done on campus and students should read the project instructions prior to going to the field. Distance students do their projects through our programs at Ft. Lauderdale or Plant City Research and Education Centers (RECs), and need to coordinate with them to schedule project field work. Any student who cannot do their labs in Gainesville, Plant City or Ft. Lauderdale, can only do this course if they have access to the hardware and software involved.

In the Gainesville Wednesday lab session (11:45am-12:35pm), data reduction, analysis, etc., is done independently by each student under the supervision of the Instructors and/or the Teaching Assistant in **402 Reed Lab**. REC students must coordinate the time and

location of these sessions with their respective REC instructors. This lab session is not recorded as each student will be processing their own work (it is not a lecture).

Day	Week Activity (2020)	Mode	Location
Week 1: Jan 6 - 10			
Mon	Topic: Conventional ground control methods Lab: Ground control using total stations (Project 1)	Lecture Field	302 Reed UF campus
Wed	Introduction to UAS and course	Lab	302 Reed
Week 2: Jan 13 - 17			
Mon	Topic: Process total station observations Lab: Ground control using total stations (Project 1)	Lecture Field	302 Reed UF campus
Wed	Processing of ground control observations	Lab	402 Reed
Week 3: Jan 20 – 24			
Mon	<i>MLK Jr. Day – NO CLASS (Jan 20)</i>		
Wed	Complete Processing and writing of Project 1 Report Deliverable: Project 1 Report	Lab	402 Reed
Week 4: Jan 27 – 31			
Mon	Topic: RTK Survey (AB)	Lecture (AB)	302 Reed
Mon	Lab: RTK survey of calibration site points (Project 2)	Field	UF campus
Wed	Topic: Process and analyze RTK observations Deliverable: Project 2 Report	Lab	402 Reed
Week 5: Feb 3 – 7			
Mon	Topic: GPS/GNSS - OPUS	Lecture	302 Reed
Mon	Lab: Acquire static GNSS data for ground control points (Project 3)	Field	UF campus
Wed	Topic: Process differentially corrected GPS baselines using Continuously Operating Reference Stations (CORS) and the Online Positioning User Service (OPUS) Deliverable: Project 3 Report	Lab	402 Reed
Week 6: Feb 10 - 14			
Mon	Topic: GPS/GNSS – static network & mission planning	Lecture	302 Reed
Mon	Lab: Acquire GPS static network data (Project 4)	Field	UF campus
Wed	Topic: Process, analyze locally-referenced GPS network Deliverable: Project 4 Report	Lab	402 Reed
Week 7: Feb 17 – 21			
Mon	Topic: Inertial navigation systems – INS (BW)	Lecture (BW)	302 Reed
Mon	Lab: INS Project (Project 5)	Field	UF campus
Wed	Topic: Analyze INS data Deliverable: Project 5 Report	Lab	402 Reed
Week 8: Feb 24 – 28			
Mon	Topic: UAV Flight Planning	Lecture	302 Reed
Mon	Lab: Flight Planning (Project 6)	Lab	402 Reed
Wed	Topic: Continue flight planning Deliverable: Project 6 Report	Lab	402 Reed

Week 9 Mar 2 - 6 Spring Break			
Week 10: Mar 9 – 13			
Mon	Topic: Lidar/Laser Scanning (BW)	Lecture (BW)	302 Reed
Mon	Lab: Fly UAS and acquire Lidar (Project 7)	Field/Lab	402 Reed
Wed	Topic: Analyze Lidar data Deliverable: Project 7 Report	Lab	402 Reed
Week 11: Mar 16 – 20			
Mon	Topic: Ground Truthing in Forests	Lecture	302 Reed
Mon	Lab: Ground measurements in NATL Forest (Project 8)	Field	NATL
Wed	Topic: Process ground measurements	Lab	402 Reed
Week 12: Mar 23 – 27			
Mon	Topic: Measuring forest parameters in lidar point cloud	Lecture	302 Reed
Mon	Lab: Analyze point cloud data and compare against ground truth measurements (Project 9)	Lab	402 Reed
Wed	Topic: complete analysis Deliverable: Project 8 and 9 Combined Report	Lab	402 Reed
Week 13: Mar 30 – Apr 3			
Mon	Topic: UAS Workflow	Lecture	302 Reed
Mon	Lab: Process UAS-based imagery (Project 10)	Lab	402 Reed
Wed	Topic: Analyze UAS data Deliverable: Project 10 Report	Lab	402 Reed
Week 14: Apr 6 - 10			
Mon	Topic: Processing multispectral image in SFM software	Lecture (AB)	302 Reed
Mon	Lab: Vegetation index analysis (Project 11)	Lab	402 Reed
Wed	Topic: Complete analysis Deliverable: Project 11 Report	Lab	402 Reed
Week 15: Apr 13 – 17			
Mon	Topic: Google Earth	Lecture	302 Reed
Mon	Lab: Evaluate Google Earth spatial quality and means of presenting spatial data (Project 12)	Field	402 Reed
Wed	Topic: Continue analysis of GE Imagery Deliverable: Project 12 Report	Lab	402 Reed
Week 16: Apr 20 - 22			
Mon	Topic: Final student presentations	Present	302 Reed
Mon	Lab: Final student presentation (3-6 pm)	Present	302 Reed
Wed	Topic: Final on-line Quiz (open book)		

Recommended Readings

Ghilani and Wolf (2015). *Elementary Surveying: An Introduction to Geomatics* (14th Edition), Pearson-Prentice Hall, New Jersey

AUVSI (Association for Unmanned Vehicles International): <https://www.auvsi.org/>

Anderson, C. DIY Drones Blog. The leading community for personal UAVs

<http://diydrones.com/profiles/blog/list?user=zlitezlite>

GPS World Staff (2017). GeoCue's GNSS kit for drones provides survey-level accuracy.

<https://www.gpsworld.com/geocues-gnss-kit-for-drones-provides-survey-level-accuracy/>

Campbell, L. and D. Katz (2018). How to Use Ground Control in Drone Surveying.

<https://www.pobonline.com/articles/101529-how-to-use-ground-control-in-drone-surveying>

Communication

The course is managed through the UF's e-Learning system (Canvas - <https://elearning.ufl.edu/>) and all communication and submission of project reports and results should be done through the facilities in that system.

Course Evaluation

Grading is based on project deliverables, on-line quizzes, a final project presentation, and participation and is distributed as follows (ugrad/grad):

Component	UGrad	Grad
a) Project reports and assignments	60%	55%
b) Attendance and participation	10%	5%
c) Peer Review	5%	5%
d) Final project presentation	10%	10%
e) Term Paper	NA	20%
f) Final quiz	15%	5%

Project Reports

Project reports are required for the following Projects:

- Project 1 - Establish Ground Control using total stations
- Project 2 – RTK survey of flight line points
- Project 3 – Observe, process and evaluate GPS/GNSS Static Baselines using CORS/OPUS
- Project 4 – Observe and evaluate GPS/GNSS Static Network
- Project 5 - Evaluate Inertial Navigation System (INS) measurements
- Project 6 - Flight planning
- Project 7 - Observe UAS flight and analyze Lidar data
- Project 8 – Ground truthing in Forest environment (combined with Project 9)
- Project 9 – Measuring forest parameters in lidar point cloud
- Project 10 – Process UAS data to produce orthophoto and 3-D point cloud
- Project 11 – Processing multispectral image in SFM software
- Project 12 – Evaluate spatial quality of Google Earth

A project assignment will be provided each week through the course website. Each student should submit a project report back through the Canvas system before the specified deadline. No reports will be accepted after the deadline.

Report Format: Students are given a report template for each project assignment. Each student *individually* must submit their report using the template provided.

Attendance and Participation

Students are expected to attend all lecture, lab, and field sessions. Ten percent (graduate students 5%) of the grade is dedicated to attendance of Mon and Wed classes (distance students are assessed on the frequency with which they access the course website). More than two unexcused absences will result in a deduction of the student final grade.

Final Presentation and Peer Review

Each student is given 3 minutes (8-10 minutes for graduate students) to present a summary of one of the topics or projects completed during the semester. The presentation should include a brief summary of the objective, methodology, data processing, analysis, results and conclusion(s) reached. Undergraduate students will record this presentation and upload to Canvas. * Each student is required to peer review the presentations of 5 other students according to a specific rubric.

Term Paper (Graduate Students only)

Graduate students are required to write a journal length paper on a topic related to the class. This should include analysis beyond what was done in the assigned project (such as comparisons of different methods from different projects) and should show a thorough understanding of the technology and techniques involved. This should follow the typical format used in Geomatics journals (like [Surveying and Land Information Science](#))

Final Quiz

A final 50 minute quiz will be given on the last Wednesday class of the semester in RLA 402. This quiz covers the concepts and principles associated with the topics covered during the semester. This will be an open book quiz so no proctoring is necessary.

Grade Scale

A	95 -100
A-	90 - 94.99
B+	87 - 89.99
B	83 - 86.99
B-	80 - 82.99
C+	77 - 79.99
C	73 - 76.99
C-	70 - 72.99
D+	67 - 69.99
D	63 - 66.99
D-	60 - 62.99
E	0 - 59.99

Grades and Grade Points

For information on current UF policies for assigning grade points, see <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>

Attendance and Make-Up Work

Requirements for class attendance and make-up exams, assignments and other work are consistent with university policies that can be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>

Distance Students Complaints

Each online distance learning program has a process for, and will make every attempt to resolve, student complaints within its academic and administrative departments at the program level. See <http://distance.ufl.edu/student-complaints> for more details.

Weekly Lecture, Project, and Quiz Schedule

Please note that bad weather and/or other unpredictable factors may cause this schedule to change during the semester. Lectures in 302 Reed will be available live through Adobe Connect and Polycom and will also be recorded for distance students who cannot 'attend' those classes. Lab locations are shown below for Gainesville only (*), but will take place on FTL and PC campuses as well at a time to be scheduled by the instructors at those locations.

*Guest lecture

Online Course Evaluation Process

Student assessment of instruction is an important part of efforts to improve teaching and learning. At the end of the semester, students are expected to provide feedback on the quality of instruction in this course using a standard set of university and college criteria. These evaluations are conducted online at <https://evaluations.ufl.edu>. Evaluations are typically open for students to complete during the last two or three weeks of the semester; students will be notified of the specific open times. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results>.

UF Academic Honesty

As a student at the University of Florida, you have committed yourself to uphold the Honor Code, which includes the following pledge: *"We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honesty and integrity."* You are expected to exhibit behavior consistent with this commitment to the UF academic community, and on all work submitted for credit at the University of Florida, the following pledge is either required or implied: *"On my honor, I have neither given nor received unauthorized aid in doing this assignment."*

It is assumed that you will complete all work independently in each course unless the instructor provides explicit permission for you to collaborate on course tasks (e.g. assignments, papers, quizzes, exams). Furthermore, as part of your obligation to uphold the Honor Code, you should report any condition that facilitates academic misconduct to appropriate personnel. It is your individual responsibility to know and comply with all university policies and procedures regarding academic integrity and the Student Honor

Code. Violations of the Honor Code at the University of Florida will not be tolerated. Violations will be reported to the Dean of Students Office for consideration of disciplinary action. For more information regarding the Student Honor Code, please see: <http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code>.

Software Use

All faculty, staff and students of the university are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against university policies and rules, disciplinary action will be taken as appropriate.

Services for Students with Disabilities

The Disability Resource Center coordinates the needed accommodations of students with disabilities. This includes registering disabilities, recommending academic accommodations within the classroom, accessing special adaptive computer equipment, providing interpretation services and mediating faculty-student disability related issues. Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation 0001 Reid Hall, 352-392-8565, www.dso.ufl.edu/drc/

Campus Helping Resources

Students experiencing crises or personal problems that interfere with their general well-being are encouraged to utilize the university's counseling resources. The Counseling & Wellness Center provides confidential counseling services at no cost for currently enrolled students. Resources are available on campus for students having personal problems or lacking clear career or academic goals, which interfere with their academic performance.

- *University Counseling & Wellness Center, 3190 Radio Road, 352-392-1575, www.counseling.ufl.edu/cwc/*
 - Counseling Services
 - Groups and Workshops
 - Outreach and Consultation
 - Self-Help Library
 - Wellness Coaching
- *Career Resource Center, First Floor JWRU, 392-1601, www.crc.ufl.edu/*

Other Requirements

Cellular phones must be turned off during class. They may be used in field sessions for field work communication pertaining to this course work only.