Geomatics Education at the University of Florida: A Case Study of Challenges and Adaptation

Amr Abd-Elrahman, Grenville Barnes, Adam Benjamin, Katherine Britt, Bon Dewitt, Hartwig H. Hochmair, Scot Smith, and Ben Wilkinson

ABSTRACT: In this article, we reflect on more than 40 years of geomatics/surveying education experience at the University of Florida (UF) with a focus on key programmatic changes over the last decade. This includes key challenges faced by the program and subsequent adaptive actions. We summarize continuous efforts made by the UF’s administration, Geomatics program faculty and staff, and collaboration with stakeholders in the state of Florida to address strategic issues faced by the program through the years. In the article, we show that carefully considered expansion to address geographically disadvantaged, “place-bound” student populations and adoption of distance education is one way to address current geomatics education issues (e.g., low enrollment). In addition, diversification of the geomatics education portfolio through degree and certification programs that address industry demand can have a positive impact on increasing both Geomatics program exposure and the level of service to the surveying and mapping profession.

KEYWORDS: geomatics education, geomatics programs, hybrid teaching, curriculum design, enrollment

Introduction

Geomatics has been described as an “…umbrella term being used to describe both a body of knowledge and the scope of professional activities having to do with generation, manipulation, storage and use of spatial data. … geomatics includes traditional disciplines such as surveying, mapping, geodesy, and photogrammetry. It also overlaps with newer disciplines such as remote sensing, imaging, and photogrammetry. It also overlaps with newer disciplines such as remote sensing, imaging, and photogrammetry.” Geomatics includes traditional disciplines such as surveying, mapping, geodesy, and photogrammetry. It also overlaps with newer disciplines such as remote sensing, imaging, and photogrammetry.

Amr Abd-Elrahman, School of Forest Resources and Conservation, Gulf Coast Research and Education Center, University of Florida, 1200 N Park Rd., Plant City, FL 33563. E-mail: <aamr@ufl.edu>. Grenville Barnes, School of Forest Resources and Conservation, University of Florida, 305 Reed Lab, Gainesville, FL 32611. E-mail: <gbarnes@ufl.edu>. Adam Benjamin, Fort Lauderdale Research & Education Center, University of Florida, 3205 College Ave., Ft. Lauderdale, FL 33314. E-mail: <abenjamin1@ufl.edu>. Katherine Britt, Gulf Coast Research and Education Center, University of Florida, 1200 N Park Rd., Plant City, FL 33563. E-mail: <k.britt@ufl.edu>. Bon Dewitt, School of Forest Resources and Conservation, University of Florida, 305 Reed Lab, Gainesville, FL 32611. E-mail: <bon@ufl.edu>. Hartwig H. Hochmair, School of Forest Resources and Conservation, Fort Lauderdale Research & Education Center, University of Florida, 3205 College Ave., Ft. Lauderdale, FL 33314. E-mail: <hhochmair@ufl.edu>. Scot Smith and Ben Wilkinson, School of Forest Resources and Conservation, University of Florida, 305 Reed Lab, Gainesville, FL 32611. E-mails: <sesmith@ufl.edu> and <benew@ufl.edu>.

Information sciences” (Burkholder 2008). At UF, we regard geomatics as “the integrated approach of measurement, analysis, and management of the descriptions and locations of geo-spatial data.” Geospatial data come from many sources, including earth-orbiting satellites, air- and sea-borne sensors, and ground-based instruments. The data are subsequently processed and manipulated with state-of-the-art information technology. Several surveying and mapping degrees started in Central European universities as early as the 1930s to fulfill the needs of cadastral administrations and the reorganization of agricultural practice (Konecny 2002). Since the 1930s and through the 1970s, surveying and mapping education expanded globally across five continents (Aina 2009; Duncan 2004; Konecny 2002; Prendergast et al. 2007; Venugopal et al. 2001). Many of these programs started as surveying and mapping programs and changed their program names later to reflect the rapid technological advances and ever-expanding applications in the field (Mohamed et al. 2011), with “Geomatics” now being one of the most widely used program names.

The Geomatics program at UF was established in 1973, in the College of Engineering, as a Bachelor of Engineering Technology. In 1978, the degree was retitled to a “Bachelor of Land Surveying” and was moved into the civil engineering (CE) department. In 1986, the degree was retitled again to a “Bachelor of Science (BS) in surveying...
changes over the last decade to address geomatics education challenges, and their impact.

Geomatics Education Challenges

Several studies have discussed past and pending geomatics higher education issues (Aina et al. 2014; Barnes 2009; Burkholder 2005; Gillins et al. 2017; Jeffress and Barnes 2010; McDougall et al. 2006; Mohamed et al. 2011; Olsen and Arras 2014). The most challenging problem is the dwindling number of geomatics undergraduate program students in the United States. Although the geomatics profession has been experiencing rapid technological advancements and holds an increasingly invaluable skill set for many applications involving the use of spatially referenced data (Aina et al. 2014; Konecny 2002; Olsen and Arras 2014), enrollment in many geomatics programs across the nation is not meeting expectations. Some programs had suffered declining enrollment, or at best remained steady when at least moderate growth was expected. Another major problem facing geomatics education is the separation between undergraduate and graduate geomatics education (Barnes 2009). Some of the most established U.S. geomatics programs have diminished or eliminated their undergraduate geomatics program, whereas in most cases, graduate education did not experience this trend (Mohamed et al. 2011). Despite relatively stable numbers of graduate degrees being awarded, the associated specializations often do not align with the needs of the remaining undergraduate geomatics programs. Consequently, there is a lack of geomatics teaching faculty/staff with Ph.D. degrees capable of teaching traditional geomatics courses (e.g., specialized field practices/quality control, and boundary/cadastral principles) (Barnes 2009).

We observed signs of a decline in student enrollment associated with the status of the national or regional economy, and, more precisely, with stalls or declines in the construction sector of the economy. Other hypotheses attributed reduced enrollment to decreasing administrative or governmental support (Barnes 2009; McDougall et al. 2006). It should be noted here that during the period from 2004 to 2008, enrollment in the UF undergraduate program increased substantially from about 56 students in 2004 to 76 students in 2007 before it plummeted to 52 students in 2009. We believe the surge in 2007 may have been due to a time lag in interest in geomatics education
associated with the economic boom of 2003-2007. This lag could have been because of students working on finishing the preadmission required courses before being admitted to the program.

**Student Enrollment and Requirements**

Since its establishment until 2006, the two main components of geomatics education at UF have been as follows: (1) the undergraduate program offering a BS in geomatics and (2) the graduate program offering a MS/Ph.D. degree in CE with a concentration in geomatics. In 2006, the program moved to the SFRC, at which point the graduate program’s offering of the MS/Ph.D. degree was accordingly renamed to Forest Resources and Conservation with a concentration in geomatics. At the undergraduate level, ABET presently accredits the undergraduate Geomatics program through the Applied Science accreditation. Although the Geomatics program curriculum and prerequisite courses for admission have gone through several minor revisions over time, the curriculum still requires 60 junior-/senior-level semester credit hours with 30 additional semester credit hours of specific coursework needed at the freshman/sophomore levels. Enrollment and graduation numbers in the undergraduate program have varied over the program’s life span. Figure 1 shows decadal summaries of total graduating student and average enrollment numbers from 1976 to 2015.

At the graduate-level degrees, the geomatics concentration requiring 30 semester credit hours for the MS degree and 90 semester credit hours for the Ph.D. degree have been available since 1988. The concentrations require 12 or 15 semester credit hours of Geomatics-specific coursework, respectively, for the MS and Ph.D. degrees. The program of study is flexible and is guided by the student’s research interest and graduate committee. However, additional department and graduate school requirements exist (e.g., required courses, minimum number of semester credit hours in the concentration, and limits on special topics courses).

![Decadal Summary of Total Graduates and Average Annual Student Enrollment in Bachelor Degrees](image)

*Figure 1. Decadal summary of total BS graduates and average annual enrollment of the UF Geomatics undergraduate program.*
Adaptation and Expansion of UF Geomatics Program

Over the past decade, two major factors shaped the adaptation of the UF Geomatics program. The first was the need to increase the pool of practitioners eligible for the PSM licensure examinations. The second was to diversify the geomatics educational portfolio at UF to cater to specific student and job market needs. Figure 2 summarizes all degree and certificate options now available following several programmatic changes. The following sections detail the decade-long UF Geomatics programmatic changes, with Table 1 providing a summary.

Program Expansion at Three UF Research and Education Centers (REC) across the state of Florida

Before 2004, the UF Geomatics program was located in the CE department within the College of Engineering. Across the United States, Canada, and most of the world, engineering colleges have been the traditional home for geomatics and surveying programs (Mohamed et al. 2011). Financial and administrative pressures within the UF College of Engineering caused the Geomatics program to search for a new academic home that would more fully support programmatic goals (Jeffress and Barnes 2010). In 2004, the UF Geomatics program moved to the SFRC within the College of Agriculture and Life Sciences (CALS). CALS is located within the land grant portion of the UF known as the Institute of Food and Agricultural Science (IFAS). The move to the SFRC and CALS allowed for the use of REC that IFAS has placed around the state to facilitate extension, research, and teaching to the broader state population. REC are located throughout the state and house departments that have ties to local agricultural industries and needs.

In 2007, the association with IFAS allowed the Geomatics program to expand its geographic footprint using the REC to provide place-bound students with access to undergraduate and graduate geomatics education. Through a legislative request pioneered by the geomatics faculty, SFRC administration, and the geomatics industry in the state of Florida, UF acquired funding to extend geomatics education to three of the major population centers in the state of Florida. The funding allowed the establishment of programs at the Gulf Coast REC (Plant City) in the Tampa metro area, the Fort Lauderdale REC ( Davie) in the Miami metro area, and the Mid-Florida REC (Apopka) in the Orlando metro area. Figure 3 shows the location of the Geomatics program’s main campus in Gainesville in relation to the REC. This funding

![Table 1](image)

**Table 1. Summary of graduate and undergraduate degrees, specializations, and certificates.**

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*Surveying and Land Information Science*
included a faculty member and a full-time academic staff member position in addition to funding for establishing geomatics teaching facilities at Plant City and Fort Lauderdale. The Apopka site has only administrative staff and partial computer laboratory support, but receives field laboratory support from the nearby Plant City location. By 2016, 32 percent of the undergraduate geomatics enrollment was through the REC. MS and Ph.D. graduate students are also advised locally by the on-site geomatics faculty members, with 67 percent advised through the REC. Current enrollment and conferred degrees in the last 5 years for both graduate and undergraduate programs are summarized for the past 5 years in Figure 4 between Gainesville and all three REC combined. Certificate students are not associated with REC because they are coded through a separate mechanism.

The introduction of innovative hybrid (distance/live) education methods has become more common across the field as a whole (Elithorp 2015; Raju and Gupta 2012; Wright and DiBiase 2007) and was essential to the successful expansion of both the undergraduate and graduate programs statewide. All four sites (i.e., main campus and the three REC) support both live and distance education. Nontraditional, full-, and part-time geomatics students form a core constituency of the REC student population. Distance education technologies allow for both synchronous learning for full-time students and asynchronous learning through recorded lectures, discussion boards, and chat rooms for place-bound students with busy professional schedules. Several teaching-delivery methods were adopted with a hybrid live/distance delivery style to serve both traditional and nontraditional students. In the hybrid style, live teaching is used at all sites, with the instructor delivering the lecture material in front of attending students. These classes are recorded and made available to all students, including distance students, to watch according to their own schedules. Field and computer laboratories are conducted at their regular class times for on-campus students. The laboratories are offered during the weekends (mainly on Saturdays) or in the evenings for off-campus distance students. Most examinations are conducted on-site either on-campus or at the REC, but PSM are also used as proctors for students who cannot make it to those locations.

Alternative distance education delivery methods are also used for some undergraduate geomatics courses. For example, software packages that facilitate virtual classroom setup (e.g., Adobe Connect software) are used to deliver the course live (online) and make recordings. Some courses in the curriculum also use prerecorded lectures. Because of changes in licensing agreements at the university level, different course management software packages (e.g., Blackboard, Sakai, and Canvas) have been used by the geomatics faculty over the last decade.

The transition to distance education required students to accept taking courses through video conferencing and other distance tools. This adaptation was appreciated by most students, especially off-campus students statewide, who saw this as a unique opportunity to pursue education while place-bound. Meanwhile, main campus students found themselves attending courses given by faculty members at the REC using video conferencing technology. Initially, some main campus students expressed frustration and preference to receive all courses using the traditional live teaching by on-campus faculty. However, efforts to explain the rationale behind the statewide

<table>
<thead>
<tr>
<th>Programmatic Action</th>
<th>Year</th>
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<tbody>
<tr>
<td>Expansion of statewide program to two UF REC in Plant City (Tampa area) and Davie (Miami area)</td>
<td>2007</td>
</tr>
<tr>
<td>Expansion of statewide program to one additional UF REC in Apopka (Orlando area)</td>
<td>2009</td>
</tr>
<tr>
<td>Creation of nonthesis MS degree with a geomatics concentration</td>
<td>2011</td>
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<tr>
<td>Creation of the graduate GA certificate</td>
<td>2013</td>
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<tr>
<td>Establishment of the geomatics undergraduate certificate</td>
<td>2014</td>
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<tr>
<td>Creation of the graduate Mapping with UAS certificate</td>
<td>2016</td>
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<tr>
<td>Creation of the undergraduate GA specialization for the BS in geomatics degree</td>
<td>2016</td>
</tr>
<tr>
<td>Creation of the undergraduate mapping with UAS certificate</td>
<td>2017</td>
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Table 1. Programmatic activities at the UF’s Geomatics program over the last decade (2006-2017).
expansion and the benefit of facilitating geomatics education to students with less favorable circumstances successfully neutralized these feelings as found through course evaluations and through personal communications with students. Other benefits of distance education (e.g., program-wide course management software adoption, ability to replay recorded lectures to review difficult course

Figure 3. University of Florida statewide Geomatics program physical locations.
content, and online discussion forums) helped in reversing this feeling as time progressed. In fact, several main campus students found distance education was the only way to continue the pursuit of their education after accepting jobs while still in the program.

Creation of Undergraduate Certificates

Certificates provide an option for students to take coursework and specialize in an academic area. For those seeking continuing education or additional coursework to fulfill career goals, a full degree program may not be necessary. Certificates allow students to gain skills and training in specific tracks to further their career goals at a lower cost and time commitment than a full degree program. Certificates have the added benefit of providing credits that are transferable to the full degree program should a student decide to change course and pursue a full degree. Two certificate options were created at the undergraduate level, both of which have been developed to meet the needs reflected in regulatory and technological changes. These certificates are the undergraduate geomatics certificate, and the undergraduate mapping with unmanned aerial systems (UAS) certificate that mirrors a graduate-level version. We do not know how many students are concurrently pursuing another degree vis-a-vis only seeking the certificate, because we do not collect and store data on the academic backgrounds of certificate students past the admission process.

There are two options for meeting the educational requirements for PSM licensure in the state of Florida. The first option necessitates the completion of a 4-year degree in surveying and mapping (i.e., geomatics). The second option requires applicants to complete a nongeomatics 4-year degree program with “a minimum of 25 semester hours in surveying and mapping subjects or in any combination of courses in CE, surveying, mapping, mathematics, photogrammetry, forestry, or land law and physical sciences” (§ 472 Florida Statute 2016). The development of the distance undergraduate geomatics certificate program was to serve the needs of applicants trying to satisfy the second licensure option. The certificate began unofficially with 15 geomatics
semester credit hours (five courses) offered to nondegree-seeking students using Geomatics program coursework to meet licensure requirements. Since its unofficial establishment in 2007, two additional elective courses (three credits each) were added to the certificate course options, and the certificate was formalized in 2014. Although the main goal of the certificate was to address the state of Florida’s PSM licensure requirement, the certificate has attracted substantial attention from out-of-state students preparing for national licensure examinations and nonlicense-oriented continuing education students as well. Since its formalization in 2014, 16 geomatics certificates have been awarded.

The geomatics certificate courses are the same as those offered in the undergraduate Geomatics program, meaning the standards for both are the same. Each of the certificate courses is delivered as a distance section of the corresponding undergraduate geomatics course. For delivery of laboratories where equipment is needed, innovative methods are implemented, such as placing distance students with local non-UF mentors and using local surveying companies to provide access to laboratory equipment. As an added benefit, some students transition from participation in the geomatics undergraduate certificate to the full BS in Geomatics undergraduate program after satisfying the necessary prerequisites. Recent technological advances and job market opportunities in the UAS mapping field triggered the development of the newly added (2017) undergraduate mapping with UAS certificate. This certificate includes three courses covering the technical, practical, and regulatory aspects of UAS mapping. The newly added undergraduate UAS certificate also allows for this transition from a certificate student to a degree-seeking student, making both certificates recruitment tools for the undergraduate BS degree program. The 15 semester credit Geomatics certificate, which is open to nondegree-seeking students, consists of courses from the Geomatics core and the Surveying & Mapping specialization, and requires completion of five of seven of these courses.

Creation of Undergraduate Geospatial Analysis (GA) Specialization for the BS in Geomatics Degree

The latest addition to the UF Geomatics program is the introduction of the GA undergraduate specialization for BS degree-seeking students. This new specialization provides geomatics students with the option to choose between (1) a broader set of courses on 3D modeling, analysis, and geographic information systems (GIS) offered in the GA specialization or (2) a more traditional geomatics curriculum provided through the newly named Professional Surveying and Mapping specialization. The GA specialization emphasizes the spatial data analysis aspects of geomatics. A primary objective is to respond to the needs of industry by equipping students with not only rigorous spatial data acquisition and processing education but also theory and tools to analyze the data. In the GA specialization, four of the senior-level courses of the surveying and mapping curriculum (Cadastral Principles, Route Geometrics and Design, Surveying and Mapping Practice, and Subdivision Design) were replaced with courses geared toward data analysis (e.g., GIS analysis) and application (e.g., Geospatial Applications of UAS Mapping). A list of GA specialization elective courses gives students more flexibility in choosing applications closely aligned with their career goals. The new specialization was approved in 2016, and it is therefore too early to report any graduation data. Figure 5 shows the program options in the geomatics undergraduate major. The Surveying & Mapping specialization and the GA specialization share 48 semester credit hours of core geomatics upper division courses, which include subjects such as geomatics, geographic information systems, photogrammetry, and remote sensing. In addition to shared core courses, the Surveying & Mapping specialization requires completion of additional four courses, which are Route Geometrics and Design, Cadastral Principles, Surveying & Mapping Practice, and Subdivision (totaling 12 credits). Likewise, the GA specialization requires completion of a GA course and three electives courses to be picked from four groups of electives, namely, Natural Resources, Analysis, Geospatial Application, or Geomatics (totaling 12 credits).

Expansion of Graduate Program Offerings

Distance education capability used in undergraduate course instruction directly led to graduate program expansion. A 30-credit (semester hour) distance education nonthesis MS degree was established in 2011 (Hochmair et al. 2013) as well as two nine-credit graduate certificates in GA (2013) and Mapping with UAS (2016). The introduction of the nonthesis MS degree led to a significant increase in the number of graduates...
with a concentration in geomatics, as shown in Figure 6. Nonthesis MS degrees are considered terminal degrees, and so students receiving them may not add to the pool of potential faculty members in geomatics.

The graduate certificates are open to UF graduate students in different programs (e.g., CE, agricultural and biological engineering, natural resources, and conservation) as well as continuing education programs, and research shows that opening these courses to nongeomatics majors increases exposure and interest in the discipline (Olsen and Arras 2014). These courses are offered as distance sections parallel to regular course offerings to avoid duplicating teaching effort. The number of students enrolled in the graduate-level GA certificate reached 27 in 2016. The certificates created collaborative research opportunities between geomatics faculty and faculty members in other departments across the university because most UF students taking the certificate courses have research questions with GA components. This experience highlights the role of teaching as a synergetic tool and a way to explore and build diverse research programs. Crossing the gap between traditional geomatics areas (e.g., photogrammetry and measurement science) and evolving applications (e.g., UAS) is key to exploring the geomatics add-on value and visibility across campus.

Geomatics Recruitment

Because the Geomatics program moved to the SFRC, recruitment efforts have been undertaken to address low undergraduate geomatics enrollment concerns. Recruitment campaigns have been conducted by both UF personnel and surveying professionals across the state. Over the past decade, these efforts have included:

1. recruitment programs to increase awareness of the geomatics profession and educational opportunities among students in local high schools and community colleges by regularly participating in events involving potential students such as (1) Florida Future Farmers of America annual meetings; (2) Florida Surveying and Mapping Society (FSMS) annual conferences; (3) Florida Career Construction Days; (4) Earth Day events; (5) GIS Day events; (6) Science, Technology, Engineering, and Mathematics events; (7) 4H events; and (8) Math Awareness Week events among others;

2. outreach through online recruitment campaigns via social media (e.g., Facebook and Twitter) and online advertising portals/tools (e.g., Google AdWords and YouTube);

3. development of short online teaching modules, the so-called Reusable Learning Objects, which were developed by geomatics...
faculty and staff on various geomatics topics. For enhanced visibility in the Web, the corresponding video clips were posted on the Fort Lauderdale Research and Education Center geomatics YouTube channel\(^1\); (4) FSMS-funded multiple PSM to serve as geomatics recruiters across the state.

### Evaluating Program Impact and Adaptations

We believe that the use of distance education within the UF Geomatics program facilitated expansion of education opportunities for place-bound student groups across Florida. This helped the program maintain annual undergraduate student enrollment during the recession, from 2008 to 2012, and to increase enrollment during the postrecession period, although we do not have data to prove it. Distance education facilitates learning opportunities for working students without requiring them to jeopardize current earnings to pursue education in a down economy (Howell et al. 2003; Shachar and Neumann 2010). Distance education certificate options provided employed students opportunities to acquire specific geomatics knowledge and skills. Methods for conducting field laboratories, managing classes, and administering examinations were adopted by the faculty to maintain program rigor. We believe that the certificate programs added undergraduate and graduate students to the UF geomatics student population who were otherwise place-bound. Evidence for this was found through individual communication with the students during and after recruitment into the program. Furthermore, the undergraduate geomatics certificate helped fulfill the needs of industry by providing current unlicensed surveyors and mappers with an educational path to PSM licensure.

The two main concerns facing geomatics teaching in the United States are low undergraduate student enrollment numbers and a disconnect between geomatics undergraduate and graduate education. A decade of programmatic diversification and

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\(^1\)https://www.youtube.com/channel/UCJrKjbiWrr73z3-qrxMGzsUw.

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![Figure 6. UF SFRC geomatics concentration graduates on an annual basis since 2007.](image-url)
recruitment efforts led to an increase in the number of students in the undergraduate UF Geomatics program, whereas the student population at the UF has remained relatively consistent. It also opened the door for many nondegree certificate students to gain access to geomatics education. Dozens of nondegree-seeking students are now enrolled in the undergraduate and graduate geomatics certificates (Figure 7). With their varied professional backgrounds, these students enrich course offerings and expand peer-learning opportunities. Furthermore, they indirectly help to recruit for the degree programs via increased awareness.

Having diverse distance education geomatics programs encourages other departments, such as civil or environmental engineering, to list geomatics courses as electives for their undergraduate and graduate students. It also encourages nongeomatics graduates to take continuous education geomatics courses. Offering more geomatics courses as electives in these programs has mutual benefits. For example, CE students need some of the basic and advanced geomatics curriculum (e.g., basic surveying skills, road geometrics design, hydrographic surveying, and GIS). Meanwhile, interested CE students pursuing geomatics graduate school and academic careers can be important geomatics teaching assistance resources. UF CE does not offer any surveying courses and their students dominate courses such as the route geometrics and design course offered by the Geomatics program.

The UF Geomatics program is one of few U.S. programs offering both undergraduate and graduate degree programs. Adapting to industry needs at the graduate and undergraduate levels through diversification bridges the gap between undergraduate and graduate geomatics education (Barnes 2009). The program offers coursework that fulfills traditional data acquisition, and boundary survey needs as well as advanced data analysis courses in remote sensing and GIS at both undergraduate and graduate levels. This provides an opportunity for employment across the geomatics industry.

Strong support from the surveying industry has been instrumental in achieving robust geomatics education programs. Recruitment and strategic planning support by FSMS, Geomatics alumni, and members of the surveying profession are evident in the success of the UF Geomatics program, especially within the last 10 years. Finally, SFRC and UF administration have had a crucial role in realizing the success of the Geomatics program plans after its transfer to the SFRC. Having administrators become not just resource providers but also partners and genuine believers in the impact that the geomatics profession positively benefited the program.

Figure 7. Certificate enrollment and completions in Spring 2017.
Conclusions

Two challenges facing geomatics education, namely, reduced enrollment and the potential for separation of graduate and undergraduate programs, were introduced, as well as adaptive actions were taken by the Geomatics program at the UF to address these challenges. The expansion of the Geomatics program by adding human and laboratory resources closer to major population centers across Florida was highlighted. The use of distance education and the adoption of statewide teaching efforts were presented. Moreover, the programmatic diversification efforts were shown through introduction of an undergraduate program specialization, creation of multiple undergraduate and graduate certificates, and creation of a nonthesis distance education MS program. Challenges that led to the elimination of long-established undergraduate Geomatics programs in the United States may be able to be confronted through strategic program expansion, adoption of distance education technologies, and programmatic diversification with the support of university administration and the surveying and mapping profession.

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