US Surveying and Mapping Education Core Curricula

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ABSTRACT

An understanding or agreement on what constitutes a "core" curriculum for surveying and mapping education is a hotly debated topic in the United States and around the world. ABET, the surveying and mapping accreditation organization of which the American Congress on Surveying and Mapping is a member, provides some guidelines for curricula, these are often very broad. We exam the 14 ABET accredited professional-level surveying programs to analyze the course offerings and determine if there is a *de facto* surveying and mapping core curriculum in existence. Ten courses were taught in at least 7 of the 14 programs studied, but only four courses were common to all 14 surveying programs.

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1. INTRODUCTION

The question sometime arises as to what constitutes a "surveying" education. Current surveying programs are often self-evaluating to see that the courses they offer reflect the most recent and applicable theories and practices and can differ widely from one another. Different niches of surveying education can meet the needs of a variety of students and those who hire them and is encouraged by both ABET, the accrediting authority for many surveying programs, and the American Congress on Surveying and Mapping, which participates in ABET accreditation for surveying programs in the United States.

Although there are a wide variety of current programs, questions often arise as to what is common between them. What courses seem to be the same to all surveying programs? This interest comes from licensing authorities, those trying to start new surveying programs, and the existing surveying programs themselves. There was an attempt to try to define a core surveying curriculum at the North American Surveying and Mapping Teachers Conference held in July 2001, at Penn State University, Wilkes-Barre, but nothing came out of these talks. There was even some reluctance to try to come up with a core curriculum for fear of appearing to "dictate" surveying education.

This paper does not try to dictate or justify what core surveying course should be. Instead, it looks at 15 surveying programs in the U.S. and attempts to map out the courses that appear to be common to all of these programs. The 15 programs selected are all ABET accredited programs, giving them some commonality. These programs were all accredited under either Engineering EAC) or Engineering-related (RAC) criteria. This paper attempts to determine what the *de facto* core curriculum courses are for surveying programs. This is an informal study, using the Internet, and was not followed up by interviews with instructors at the various surveying programs. It also does not include the many non-ABET accredited surveying programs or any of the ABET accredited surveying technology programs.

The information for the courses taught in these programs was obtained from the Internet sites at each university or college. A listing of the Internet addresses appears in the reference section of this article. In trying to determine a core curriculum, only those surveying courses ***required*** for a degree in surveying were counted. Often, additional surveying courses are offered as electives but, since these courses were not required by all students in a particular program, they were not considered in determining core curriculum. To be considered a core curriculum topic, a course needed to appear in at least one-half (7 of 14) of the surveying programs studied.

Courses other than surveying courses were also not considered. Since this paper seeks to define core curriculum surveying courses, other courses required for a degree in a particular

surveying program were not checked. However, in a few instances, the level of mathematics or science required as a prerequisite for a given course are noted.

The surveying courses are listed in tables throughout the paper. Where possible, a listing of both lecture time and lab (practicum or "hands-on") time are given. Several of the surveying programs did not distinguish the hours devoted to each in their Internet listings.

The programs reviewed all operate under the "semester" system except Ohio State University and the Oregon Institute of Technology, which use the "quarter" system. Under the semester system, one credit hour of lecture is equivalent to 15 or 16 hours of actual classroom time. One credit hour of lab is normally equivalent to 45 hours of student time. Texas A & M at Corpus Christi requires only 30 hours of lab per semester credit hour. Under the quarter system, one credit hour of lecture is equivalent to 10 hours of lecture and one credit hour of lab is normally equivalent to 30 ours of student time.

2. ABET CRITERIA

The Accreditation Board for Engineering and Technology (ABET) accredits engineering and technology programs in the United States. Surveying licensing in the United States is done state by state. State licensing boards, in some cases, require graduation from an ABET-accredited program as the first step in the registration process for professional practice.

The two professional level accreditation commissions are the Engineering Accreditation Commission (EAC) and the Applied Science Commission (ASC), formerly known as the Related Accreditation Commission (RAC). The curriculum criteria for surveying and similarly named programs is identical for both commissions:

> The program must demonstrate that graduates have competency in one or more of the following areas: boundary and/or land surveying, geographic and/or land information systems, photogrammetry, mapping, geodesy, remote sensing, and other related areas.

There is a requirement in each commission that one and one-half years of a four-year degree be devoted to topics in these areas. However, there is no current requirement for the actual coursework for an accredited surveying program. Prior to this year, the ASC criteria did specify that a program had to contain a minimum of two semester credits (three quarter credits) in five of the following six topic areas:

- Field surveying instruments and methods
- Photogrammetric mapping and image interpretation and remote sensing
- Surveying calculation and data adjustment
- Geodetic coordinates and astronomy
- Cartographic representation, projections, and map production
- Computer-based multi-purpose cadastre, geographic information systems.

The old criteria also required a minimum of 9 semester credit hours of land boundary topics. However, these criteria will not apply to surveying programs seeking accreditation after the current ASC accreditation cycle.

3. PLANE SURVEYING

All of the programs checked contained required courses in plane surveying. The topics covered in plane surveying ranged from survey instrumentation use to construction staking. The median hours devoted to this seems to be 60 hours of lecture and 90 hours of lab. The smallest amount of time devoted to the topic appears to be a Ohio State, where 50 hours of lecture and 60 hours of lab are required. The largest amount of time seems to be 100 hours of lecture and 240 hours of lab taught at OIT. However, the OIT plane surveying course descriptions show that topics such as surveying astronomy are included in the plane surveying courses. The same is true for the programs at Fresno, Maine, and Pomona. Michigan Tech includes some boundary surveying (Public Land Survey Systems) as a part of their plane surveying course material. It would follow that other programs would have some plane surveying materials within other surveying courses. It is interesting to note that some programs teach curve geometry in the first plane surveying course while others leave curves until a second or later plane surveying course.

It almost all cases, mathematics preparation for plane surveying courses consisted of trigonometry. Students at OIT could start the first plane surveying course without trigonometry, but are required to have it before starting the second plane surveying course. Students at Purdue are required to have preparation in calculus before taking plane surveying.

4. PHOTOGRAMMETRY AND REMOTE SENSING

All of the programs listed have required courses in photogrammetry. Several were missing any reference to remote sensing. Some programs combine photogrammetry and remote sensing into a single course (OIT, Pomona, Purdue). Other programs teach a separate course for remote sensing (Ferris State, Maine, Ohio State, Texas A&M). Many of the programs listed flight or control planning as a part of the topics taught under photogrammetry. Michigan Tech appears to devote the least time to this topic, with only 15 hours of lecture and 45 hours of lab. Fresno appears to devote the most time to photogrammetry, with 60 hours of lecture and 90 hours of lab.

5. SURVEYING COMPUTATION

Courses devoted to surveying computations appeared in all of the programs studied. While some computations must necessarily be taught within other courses, such as plane surveying or photogrammetry, these courses are devoted to a wide variety of computational methods, usually involving computer methods. Although it is not clear from several of the course descriptions, it appears that least-squares adjustments are taught at all of the programs studied. The least amount of time devoted to this topic appears to be 45 lecture hours (Maine, Pomona, Texas A & M) while Penn State devotes the highest amount of lecture time, 135 hours. Michigan Tech teaches 15 hours of lecture and 45 hours of lab on this topic. OIT teaches 80 lecture hours of computations with 180 lab hours, but it appears that many of these

hours may include topics in survey mapping. Many programs appear to have a course devoted to general computation techniques and one or two separate courses devoted to measurement analysis and least-squares adjustment.

6. GEODESY AND GPS

All of the programs contained a course covering geodesy topics. Where once many programs required a course in geodetic surveying, it appears that on Florida, Fresno, and Pomona still do. Most other programs appear to have replaced the geodetic surveying course with a course in satellite positioning (satellite positioning material is shown in the programs at Florida, Fresno, and Pomona as well). Geodetic surveying may still be taught at Penn State in their SUR 441 – Data Analysis and Project Design course listed under Table 3 -Survey Computations Courses.

It appears that a minimum of 45 lecture hours are devoted to geodesy and GPS. Fresno requires the most time devoted to these topics with 120 hours of lecture and 45 hours of lab. Florida and Ferris State have 120 lecture hours (8 semester credits) apiece, but the course descriptions from these two programs are unclear if all of the credit listed is in lecture or if some course time is spent in lab. A median amount of time appears to be 60 hours of lecture and 90 hours of lab. Astronomic surveying appears in the course descriptions of many of the geodesy/geodetic surveying course descriptions. However, astronomic surveying is taught as a part of the plane surveying course at many other programs and as a part of the Cadastral/Boundary surveying course at NMSU.

7. CARTOGRAPHY / MAPPING

Separate courses for cartography or mapping appear in only 8 of the 13 programs studied. Of these, only Ohio State, OIT, and Penn State appear to require work in large-scale mapping. Alaska devotes the most time to this topic with 165 hours of lecture and 45 hours of lab. It appears that cartography/mapping topics are still taught at all the schools, but in many schools the topic seems to have been merged into a GIS/LIS course. Of all the requirements listed under the old ABET RAC criteria, cartography and mapping appear the least in the surveying programs studied.

8. GIS / LIS

A course devoted to GIS or LIS appears in all of the programs except East Tennessee State and Purdue. Purdue does list a course in the catalog, but it is not required for graduation. The two programs devoting the most time to this topic are Maine, with 75 lecture hours and 135 lab hours, and Texas A & M, with 120 lecture hours and 90 lab hours. As noted above, it appears that cartography issues may be covered in several of the GIS / LIS courses.

9. CADASTRAL / BOUNDARY SURVEYING

Courses in cadastral or boundary surveying appear in all of the programs studied except Ohio State. Pomona appears to spend the most time on this topic, with 165 hours of lecture. A median time appears to be 75 hours of lecture. About one-half of the programs do not have

any lab time devoted to the topic. In three of the programs (Fresno, New Mexico State, and Pomona) a separate course in the US Public Lands Survey System (PLSS) is required. As the PLSS is not used in Maine, Pennsylvania, Tennessee or Texas it is not surprising to see that it is not listed under the topics in boundary surveying in the programs in those states. Texas A & M does teach a separate course on Texas boundary surveying. Two of the programs, East Tennessee State and Michigan Tech, require Real Estate law as a part of their boundary surveying coursework.

10. LAND SUBDIVISION

Required courses in land subdivision or land development appear in all of the programs listed except Ohio State and Texas A & M. A median time appears to be 30 hours of lecture with 45 hours of lab. Purdue devotes only 15 hours of lecture, but requires 90 hours of lab. Maine teaches this course early in their curriculum, while most of the other programs appear to wait until the senior year. The topics covered under land subdivision vary as much as any course studied, but this is due to the fact that laws governing the amount of participation surveyors can have in land subdivision varies greatly from state to state. In some states, such as Maine, Pennsylvania, and Indiana, surveyors are allowed to do some civil engineering design, such as storm water drainage. In other states, such as California and New Mexico, surveyors are limited to the survey and preparation of the subdivision plat.

11. SURVEYING PRACTICUM / CAMP

Some sort of surveying practicum or camp is required in 9 of the 14 programs listed. Ohio State, Purdue, and Texas A & M require a survey camp where students are apparently at some remote location doing survey exercises. Purdue requires the most time, with 4 weeks (160 hours). Florida and Ohio State both appear to require some sort of “on the job” course credit. Although the surveying camp and work experience appear to be required at Ohio State, no credit toward graduation is shown. Fresno and New Mexico State require a Senior Project, while Pomona requires a Senior Design course sequence. East Tennessee State requires a 3 semester credit course in Surveying Projects, but the course description is not clear as to whether this is lab or lecture time.

12. PROFESSIONAL ISSUES

The final topic found in many of the programs was a course on professional issues, appearing in 8 of the 14 programs studied. While Maine devotes 15 hours of lecture to this area, Ferris State devotes 90 hours of lecture. Most of the courses seem to cover ethical, liability, and business issues. Again, some of the programs probably cover these issues within other courses, so these issues may appear in more than the 8 programs in which it was found as a separate course.

13. CONCLUSIONS AND FUTURE WORK

It appears that there are ten areas of surveying covered by at least one-half of the 14 ABET accredited professional level surveying programs studied:

- Plane surveying
- Photogrammetry and remote sensing
- Surveying computation
- Geodesy / GPS
- Cartography / mapping
- GIS / LIS
- Cadastral / boundary surveying
- Land subdivision
- Surveying practicum / camp
- Professional issues.

Since the time devoted to each area varies widely, it is easy to conclude that each program is developing slightly different strengths in their graduates.

Plane surveying, photogrammetry, surveying computation, and geodesy were the only topics found in all 14 surveying programs studied. The most hours were devoted to plane surveying topics. Cadastral / boundary surveying was required at 13 of the programs studied. Land subdivision surveying and GIS / LIS existed in 12 of the 14 programs. GPS and practical experience courses appear in 10 of the 14 programs. Cartography / mapping courses and professional issue courses appear at 8 of the 14 programs. Remote sensing was required at only 7 of the 14 programs.

It is possible that although there is not a class devoted to some of the above topic areas within some surveying programs, the topic could be included as part of another surveying topic or taught as part of a non-surveying course.

Future work will include contacting the programs studied for this report to clarify some of the lecture / lab time, perhaps as a part of a formal survey. The study should also be extended to other surveying programs. Technical level surveying programs were not considered for this study, but could be included in future studies. Finally, comparison of US core curriculum courses can be compared against international surveying curricula.

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BIOGRAPHICAL NOTES

Steven Frank is an Associate Professor in the Department of Surveying Engineering at New Mexico State University located in Las Cruces, New Mexico. He received his PhD in Surveying Engineering from the University of Maine, Orono, in 1994. He received a MS in Civil Engineering [Surveying option] in 1991 and a BS in Survey Engineering in 1989 from California State University at Fresno. He has served as President of the New Mexico Professional Surveyors Association and is President of the American Association of Geodetic Surveyors during the year 2002. He has served on the U.S. delegation to FIG since 1999 as Reporter-editor and on Commission 2. His research areas involved professional and educational issues.