

# **ADVANCING GEOSPATIAL SCIENCE EDUCATION THROUGH MARYLAND STATE DEPARTMENT OF EDUCATION'S DIVISION OF CAREER AND COLLEGE READINESS HOMELAND SECURITY AND EMERGENCY PREPAREDNESS PROGRAM**

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## **ABSTRACT**

As the Maryland State Department of Education's (MSDE's) Postsecondary Affiliate for the Career and Technology Education (CTE) program in Homeland Security and Emergency Preparedness (HSEP), the Mid-Atlantic Center for Emergency Management (MACEM) at Frederick Community College (FCC) has successfully completed development of an Information/Communications Technology pathway within the HSEP program. The pathway is built on a Geographic Information System (GIS) curriculum designed to introduce high school students to industry-leading geospatial technology and software, and the role they play within the fields of Homeland Security and Emergency Management. The creation of the Information/Communications Technology pathway included the development of course outlines, course guides, and individual lesson plans that culminate with the student's ability to take the newly released, industry-recognized, Esri ArcGIS Desktop Entry certification examination, which is part of the Esri Certification Program.

While the pathway is built around the Esri ArcGIS Desktop Suite of software, including training modules from the Esri Virtual Campus and textbooks published by Esri Press, it also exposes students to a wide variety of proprietary and open-source geospatial platforms, tools, and data formats. This includes the Maryland iMap GIS Portal, Department of Homeland Security (DHS) Homeland Infrastructure Foundation-Level Data (HIFLD) Portal, and OpenStreetMap. The Federal Emergency Management Agency's (FEMA's) Independent Study (IS) course, IS-922: Applications of GIS for Emergency Management, is also integrated into the pathway, allowing students to earn a certificate of course completion through the FEMA Emergency Management Institute (EMI).

This paper intends to detail MSDE's innovative Information/Communications Technology pathway and its development on an industry-recognized standard, which will prepare the next generation for the geospatial challenges that lie ahead. It will also identify key considerations for geospatial education at the secondary level and the challenges that are associated with designing a curriculum that will remain relevant in a technology-based discipline that is rapidly evolving.

**KEYWORDS:** education, K-12 Stem, Geographic Information System (GIS), Emergency Management, Homeland Security, Esri

## **INTRODUCTION**

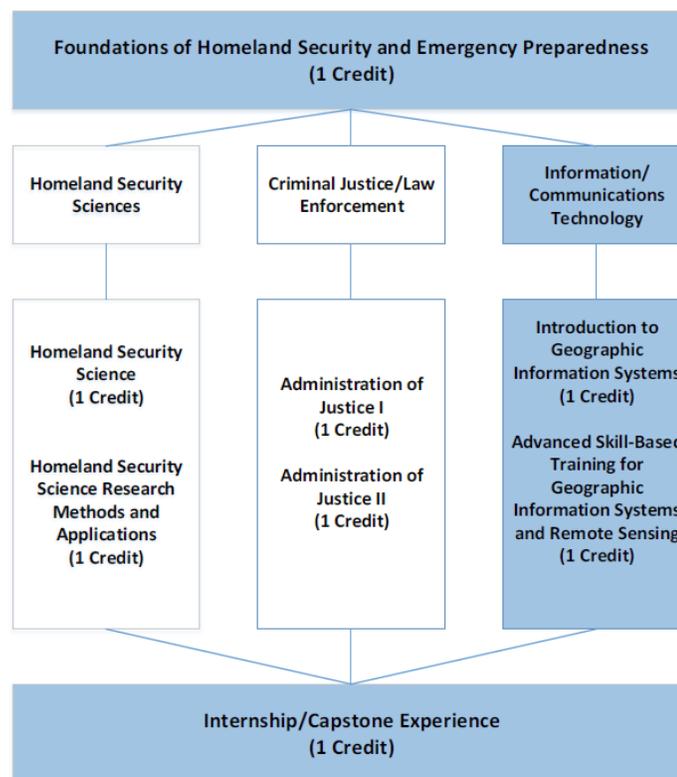
The MSDE CTE programs of study are statewide model programs designed to prepare high school students for the 21st century's global economy and its rapidly changing workforce needs. All CTE programs are aligned to established academic and technical skill standards to ensure student preparation for college and careers. Upon completion of a Maryland CTE program of study, students have the option to earn college credits and/or industry credentials such as certifications and licenses.

Through a Carl D. Perkins Grant fund, the MACEM is the approved Maryland Affiliate for the CTE program in HSEP. The HSEP program prepares students for industry certification and college credit in one of three pathways: Homeland Security Sciences, Criminal Justice and Law Enforcement, and Information/Communications Technology.

In the fall of 2015, at the direction of MSDE, a summit was held to review existing (STARS) curriculum requirements in the HSEP Information/Communications Technology pathway and make recommendations on the program content and future development. The meeting was attended by GIS teachers, CTE administrators and staff, industry GIS Subject Matter Experts, and the MACEM staff. The meeting consisted of a review and discussion of the following topics:

- Current industry-recognized certifications and the HSEP requirements
- Characteristics of a quality curriculum
- Pros & cons of the STARS curriculum, resources, and process (capstone)
- Potential use of the new Esri ArcGIS Desktop Entry-level certification

At the conclusion of the summit, the group consensus was that the MACEM should pursue researching the new Esri ArcGIS Desktop Entry-level certification and the development of course materials to support the process. The results of the summit and subsequent findings were presented to the MSDE CTE HSEP Advisory Committee in the spring of 2016, and development of a new curriculum based on the Esri ArcGIS Desktop Entry-level certification was started.



**Figure 1.**

The new curriculum (Figure 1) was completed and presented to MSDE CTE administrators and the HSEP GIS instructors at the MACEM's Summer Institute, a week-long training program established for HSEP instructors' professional development, in July 2016. Several HSEP program administrators adopted the revised Information/Communications Technology pathway for the 2016/2017 school year and are currently transitioning the program. It is also anticipated that additional HSEP programs will make the transition for the 2017/2018 school year. As part of the grant, the MACEM currently provides support to administrators and instructors adopting the new curriculum.

## **CURRICULUM DEVELOPMENT**

The HSEP GIS Technology courses were developed to cover a broad range of topics related to geospatial techniques, technology, and software, with an emphasis on how these are leveraged within the context of the fields of Emergency Management and Homeland Security. The two courses, HSEP GIS I (Introduction to Geographic Information Systems) and HSEP GIS II (Advanced Topics in Geographic Information Systems), were designed to be taken sequentially, with HSEP GIS II building on and expanding upon the fundamental concepts that were covered in HSEP GIS I. Each course is broken up into six units, each of which covers a fundamental topic area and consists of between three to six lessons. In total, HSEP GIS I consists of 31 lessons, while HSEP GIS II consists of 24, plus a final "capstone" project.

The GIS Technology track is intended to provide students with exposure to a variety of geospatial software packages and tools. While both proprietary and open-source software and tools are introduced to students throughout HSEP GIS I and II, Esri's ArcGIS Suite is the primary platform that is used. As the industry-leading geospatial software provider, Esri's ArcGIS Suite of products includes desktop, mobile, server, and cloud/Web-based applications. While ArcMap and ArcCatalog from the ArcGIS for Desktop Suite are the primary Esri applications that are used throughout the GIS pathway, students are also introduced to other Esri software, such as ArcGIS Online and ArcGIS Pro, as well as other geospatial tools and platforms such as GoogleEarth and OpenStreetMap. The Esri Training portal also plays a key role in the GIS pathway, as students complete several Web-based training courses that focus on specific tools and technical areas.

Several Web-based training courses are integrated into the GIS track, including FEMA's IS-922 course, Applications of GIS for Emergency Management, which is offered as an online course through FEMA's EMI. While this course is not overly technical in nature, it provides students with a broader perspective of how GIS and geospatial applications are used within the industry. Covering topics such as the history of GIS, spatial queries, and industry-specific tools such as HAZUS-MH, this course is made up of six units that are incorporated throughout HSEP GIS II. Upon completion of all six units, students are able to take a brief exam in order to earn a Certificate of Completion from the FEMA EMI. The Penn State Geospatial Revolution video series, produced by Penn State Public Broadcasting, is used in several HSEP GIS I lessons as the centerpiece of the engagement section. Each of the parts of this 4-part series covers a different application of geospatial technology and is made up of multiple chapters, which allows for short video clips to be integrated into lessons. These videos are used during the introductory section of many lessons, preceding a discussion or group activity that encourages students to evaluate how geospatial technology is used in and positively affects their lives. Additionally, an Educator's Edition DVD set is available for teachers, which includes the video episodes and other learning materials that are designed to accompany the videos.

Course guides were developed for each course to provide instructors with a "road map" for teaching each course. Each course guide provides a high-level overview of the CTE and HSEP programs, a course overview that outlines the units and primary learning objectives for each, and key instructor resources (textbooks, websites, videos, data sources, etc.). In addition, each course guide provides a lesson guide, which provides more detailed information about the topic areas, learning objectives, resources, and assignments/activities associated with each lesson in the unit.

Lesson plans are provided to the instructor for each of the 55 total lessons in HSEP GIS I and II, which provide guidance on the content, key focal areas, resources, and recommended method(s) for assessment in each lesson. The lesson plan format is based on the 5E Instructional Model developed by the Biological Sciences Curriculum Study and consists of five key components identified as:

1. Engagement
2. Exploration
3. Explanation
4. Elaboration
5. Evaluation

The Engagement area is focused on capturing students' interest and encouraging participation, which is frequently achieved by using an article, video clip, or demonstration focused on a relevant or timely topic, followed by a group discussion or individual exercise. Here, the primary focal areas for the lesson are established, which leads into Exploration, where group or individual exercises are used to allow the students to become familiar with the subject matter through a "hands on" activity. This will commonly be a technical, guided exercise administered through one of the primary textbooks. Following Exploration, the Explanation area serves to provide more detail and background on the topic at hand. The Elaboration area is used to expand upon the topics, tools, or techniques that were introduced in prior sections, which may consist of a custom-developed technical exercise focused on the same tools or techniques, but tailored to Emergency Management or Homeland Security through the use of custom data or scenarios. Finally, Evaluation is the instructor's assessment of each student's understanding of the subject matter. Evaluation generally takes place at the end of each lesson through a quiz, examination, or graded exercise but may also occur throughout the lesson, depending on the structure and organization of the lesson. Due to the fact that the time allocated to each lesson may vary based on the school system, school, or instructor, there is no standard timeframe that each lesson is designed for. Rather, each of the five sections have a "recommended" timeline, ranging from 5 minutes to 1 hour, depending on the demands and complexity of the activity, but are included only as a general guide for instructors. Similarly, the structure and content of the lesson plans are provided only for guidance and are expected to be customized by each instructor to be specific to his or her available time, resources, and class size, as well as the technical level of the students.

Each course uses two textbooks, a primary text that is used as a workbook with guided technical exercises and a supplemental textbook that focuses more generally on geospatial concepts or ideas. For HSEP GIS I, the primary textbook is *Getting to Know ArcGIS*, which is published by Esri Press. This is paired with *GIS for Homeland Security*, which is also published by Esri Press and contains a collection of case studies and career profiles that are related to GIS applications within the Homeland Security realm. HSEP GIS II uses *Discovering GIS and ArcGIS* from Macmillan Learning as the primary workbook, along with *The ArcGIS Book*, which presents innovative uses of geospatial technology with interactive links and activities. While both *Getting to Know ArcGIS* and *Discovering GIS and ArcGIS* come with data DVDs that contain all spatial data required for students to complete the guided exercises, instructors are provided a variety of open-source data resources for acquiring geospatial data for substitution into guided exercises, or for the development of customized technical exercises. This is encouraged when feasible, for a number of reasons. First, local geography helps engage students, so if exercises involve data that is pertinent and relevant to students, they are more likely to become engaged in the exercise. There is an optional textbook from Esri Press, *A to Z GIS: An illustrated dictionary of geographic information systems*, that instructors may wish to use for both courses and as a study aid for the Esri ArcGIS Desktop Entry examination. *A to Z GIS* provides definitions, diagrams, and figures for approximately 1,800 GIS-related terms.

HSEP GIS I consists of six units, with a focus on introducing students to the geospatial industry, applications of GIS software, and the ArcGIS for Desktop Suite. The topics covered in these six units include:

- Unit 1: Introduction to GIS
- Unit 2: Getting Familiar with GIS
- Unit 3: Introduction to Esri ArcGIS Suite
- Unit 4: Exploring Spatial Data
- Unit 5: Data Management and Visualization
- Unit 6: Data Queries and Statistics

In HSEP GIS I, students learn about key resources for open data and data acquisition fundamentals, with an introduction to key data resources such as DHS's HIFLD, State of Maryland's iMap, and FEMA's GIS Data feeds, among others. In addition to providing students with an overview of the wide variety of open-source GIS data, this

also provides instructors with access to data that they can use to tailor their technical exercises to Homeland Security and Emergency Management. The OpenStreetMap platform is also used in HSEP GIS I, which introduces students to the concept of volunteered geographic information and provides opportunities for students to create their own data and interact with data developed by other citizen mappers.

HSEP GIS II builds on the foundational geospatial concepts and technical skills that are developed during HSEP GIS I, expanding to more technically advanced topics and techniques:

- Unit 1: Map Design and Cartography
- Unit 2: Spatial and Statistical Analysis
- Unit 3: Geodatabase Concepts
- Unit 4: 3D Data and Visualization
- Unit 5: Geoprocessing Tools and Models
- Unit 6: Certification Exam Review/Final Project

HSEP GIS II concludes with a capstone GIS project, which should encapsulate the knowledge students have gained throughout both HSEP GIS I and II. While some ideas and themes for capstone projects are provided in the accompanying lesson plan, the hope is that students are encouraged to pursue topics and technical areas that they are interested in and passionate about.

The Esri Technical Certification Program offers Esri software users opportunities to earn industry-recognized certifications in three primary areas: Desktop, Developer, and Enterprise. Within these three areas, certifications are offered at three levels: Professional, Associate, and Entry, which is the newest addition to the Esri Technical Certification Program and a key goal for students in the GIS pathway. The Entry-level certification is offered only in the Desktop area and is recommended for ArcGIS for Desktop users with 2 years or less of experience. The Esri ArcGIS Desktop Entry examination is a specific version of the ArcGIS for Desktop platform (10.3, 10.4, and 10.5) and consists of 95 multiple choice/multiple select questions covering six primary focus areas, which must be completed within a 2-hour time limit. Students who do not pass the Esri ArcGIS Desktop Entry examination on their first attempt are eligible to retake the examination; however, subsequent attempts are subject to additional testing fees, and availability is dependent upon the school and school system.

## CHALLENGES

Given that the geospatial market is one that is rapidly changing, with new trends and developing technologies being used in the industry, it is crucial that the HSEP GIS curriculum is updated to ensure relevancy. To that end, the MACEM team, in cooperation with industry leaders, intends to deliver ongoing support and provide maintenance to the curriculum as part of its continued support to the HSEP program. Updates to the curriculum will primarily be made to account for changes to key software packages, including the ArcGIS Suite, or other technologies that directly impact the primary objectives of the curriculum. The number of modifications to the curriculum will be kept to a minimum to reduce impacts and potential disruptions to teachers and their classes.

It is the intention of the MACEM team to ensure that key industry trends are being properly addressed within these courses. These may not only be specific to the geospatial and GIS industry but also to Homeland Security and Emergency Management. For example, topics such as Unmanned Aerial Vehicles and Big Data have major implications within both of these areas. This curriculum was developed in a way to leave a great deal of flexibility in terms of the specific activities and technical exercises that are used for each lesson. This allows teachers to address emerging technologies and use current events and news in their instruction.

The advancement of the ArcGIS Suite will provide challenges for the maintenance of the curriculum. The current iterations of HSEP GIS I and II were developed specifically for ArcGIS for Desktop version 10.3 and 10.4; however, as of February 2017, version 10.5 has been released. While the nature of changes between versions 10.4 and 10.5 are relatively minor within the context of these courses, it will be critical to monitor the impact of Esri's updates to the ArcGIS platform and evaluate the need for changes to course content. With updates to the ArcGIS Desktop Suite will also come updates to the Esri ArcGIS Desktop Entry examination, as these tests are designed to be specific to one version of ArcGIS Desktop software. Not every update to the ArcGIS Desktop Suite results in

new examination versions being offered; rather, the Esri Certification Team evaluates the need for new examinations at each release based on the nature of changes to the platform. For example, the ArcGIS Desktop examinations at the Associate and Desktop levels are currently being offered for versions 10.3 and 10.5 (Beta), while the Entry level examination is offered for versions 10.3, 10.4, and 10.5 (Beta).

## LOOKING FORWARD

GIS touches myriad HSEP career paths and will only become more valuable as its potential is unpacked and applied in the HSEP industry. It is envisioned that the HSEP Information/Communications Technology pathway will have continued growth and will become a strong partner in meeting industry growth needs for Cartographers, Forensic Analysts, and Emergency Managers, to name a few key positions, as projected by the Bureau of Labor Statistics through 2024. Employers in the industry are looking for skills and experience. At this phase in the growth of GIS, it is hard to find a good combination of both; therefore, this curriculum will give the HSEP students a head start in their career path planning and recognition within the industry coming out of high school. U.S. Department of Labor, Employment & Training Administration's High Growth Job Training Initiative identified 14 sectors, one of which was Geospatial Technology, that fit within the following criteria: They are projected to add substantial numbers of new jobs to the economy or affect the growth of other industries, or they are existing or emerging businesses being transformed by technology and innovation requiring new skill sets for workers.

GIS, as with other modern technologies, is constantly evolving; therefore, the HSEP program will require a process in place to monitor industry progress and recommend revisions to the current program design in order to keep it up-to-date in the fast paced world of technology advancement. Since the development of the curriculum, mid-year 2016, ArcGIS for Desktop versions 10.4 and 10.5 have been released and directly attest to this need. GIS inputs and outputs, such as data collection platforms and software, and data analysis suites also operate at high rates of enhancement as well. As the Postsecondary Affiliate for the CTE program in HSEP, the MACEM will monitor technological and industry changes affecting GIS and make recommendations for curriculum and/or software changes. This active approach is intended to keep necessary changes to the program both minimal and current through an annual update.

MSDE students are measured on their success by the state to ensure both individual and program success. One of the state's core indicators of performance for career and technical education students at the secondary level is student attainment of career and technical skill proficiencies, including student achievement on technical assessments that are aligned with industry-recognized standards. The newly created HSEP Information/Communications Technology pathway not only meets this goal but, depending on the individual student's achievement in the program, also could exceed it and meet one of the postsecondary level core performance indicators by the student attainment of an industry-recognized credential, a certificate, or a degree upon successful completion of the Esri ArcGIS Desktop Entry-level certification examination.

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