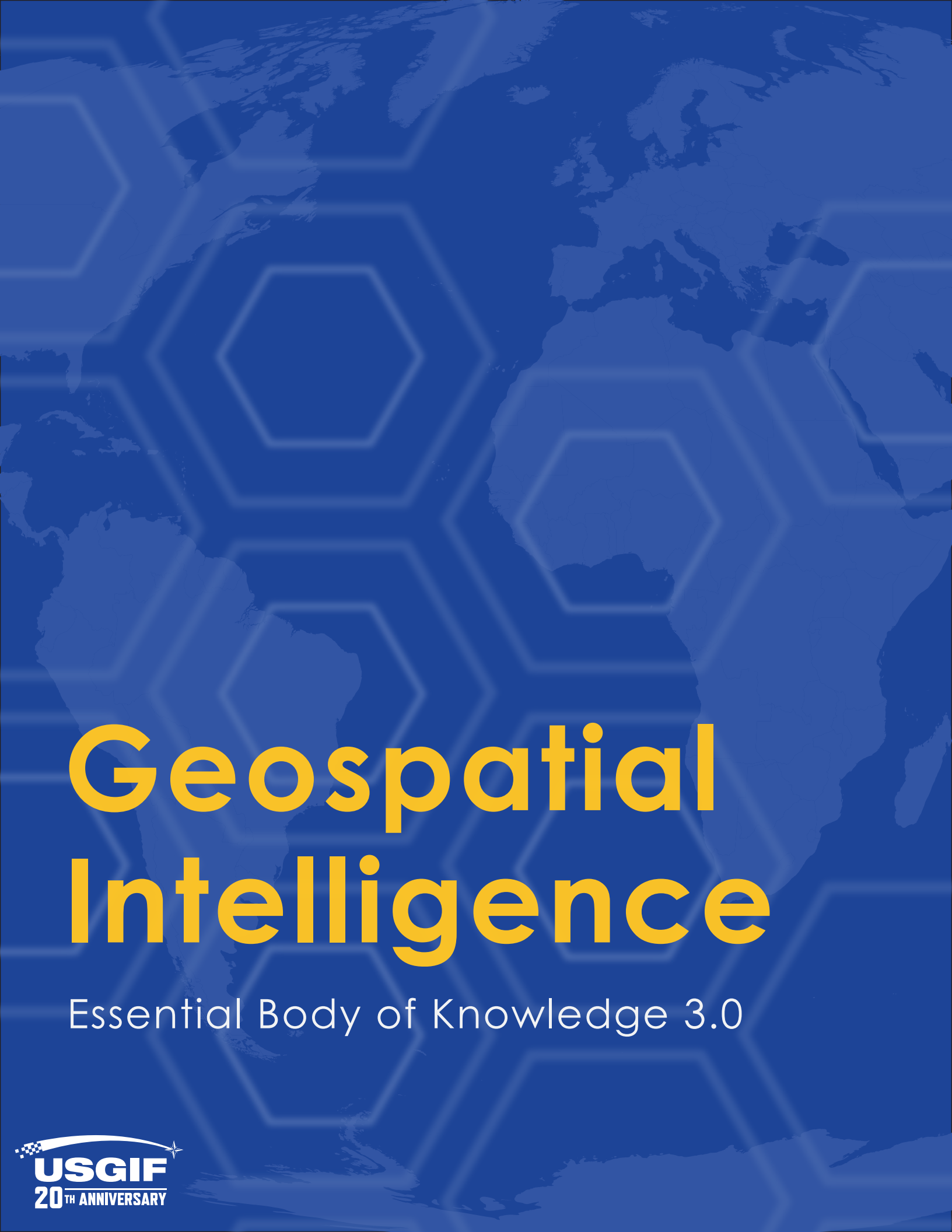

# Geospatial Intelligence

## Essential Body of Knowledge 3.0

USGIF 20TH ANNIVERSARY

# GEOSPATIAL INTELLIGENCE ESSENTIAL BODY OF KNOWLEDGE[1]

The United States Geospatial Intelligence Foundation

## Table of Contents



[1] VERSION 3.0/2024

# OVERVIEW

The United States Geospatial Intelligence Foundation (USGIF) Essential Body of Knowledge (EBK) describes the geospatial intelligence (GEOINT) discipline and represents the essential knowledge, skills, and abilities required for a GEOINT professional to be successful. This document nests learning objectives within subtopics that address proficiencies from prerequisite to mastery. USGIF developed the first GEOINT EBK for the GEOINT discipline in 2014, providing context and standards necessary to succeed in the field. In 2019, USGIF significantly revamped the content into a "2.0" version that reflected evolution in the discipline and provided additional value to the community's stakeholders. This 3.0 version now reflects the continued growth in GEOINT tradecraft and the current reality of the GEOINT field, as informed by input from members of the GEOINT community across industry, academia, and government.

The EBK represents our community's perspective on the knowledge and skills necessary for the next generation of GEOINT professionals, researchers, practitioners, and decision-makers to be successful. We see this as a tool for all members of the GEOINT community. Academic stakeholders utilize it as a framework to develop curriculum, assess student skills at each proficiency level using the learning objectives, and provide students with a robust resource to inform their course choice and studies. Employers may use the EBK to determine the appropriate knowledge and skills necessary for hiring into their positions and may also leverage the learning objectives to develop job and position descriptions. Individuals seeking employment, career changes, or professional development can utilize the EBK as a guide for what skills, knowledge, and experience levels are necessary to qualify for various jobs in the GEOINT field.

The EBK 3.0 is reorganized to differentiate between subtopics and learning objectives more clearly and so that the learning objectives are organized by subtopic and build on one another based on proficiency level. USGIF retired and/or deemphasized content that is no longer considered universally essential, including subtopics about outdated technology, redundant learning objectives, and learning objectives outside of the scope of essential GEOINT knowledge. The goal of this reorganization, as well as any added and removed content, is to update the EBK to 2024 standards, make the EBK more approachable for students and those outside academia, and to structure the EBK with consistent subtopics separated by proficiency level. The EBK was also reformatted to utilize Bloom's Taxonomy, a framework for creating learning objectives. Bloom's Taxonomy includes six levels of learning and aligns action verbs with each level so that learning objectives are written appropriately based on the associated proficiency level (USC Center for Excellence in Teaching, n.d.).

USGIF is committed to ensuring the GEOINT community can meet its workforce needs and understands that the field of GEOINT will continue to expand and develop -- as will the GEOINT EBK. As the GEOINT tradecraft is ever-changing, USGIF plans to frame reviewing and updating the EBK as an ongoing project rather than something undertaken every few years. If you are interested in contributing to the EBK or have feedback for future updates, email education@usgif.org

USGIF extends a deep thanks to all who gave their input and time to updating the GEOINT EBK. The EBK 3.0 is a testament to the expertise and commitment of the USGIF community.

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# PART I: TECHNICAL COMPETENCIES

## 1.1 COMPETENCY 1: GIS and Analysis Tools

**GIS and Analysis Tools** describes the knowledge areas and skills used to ensure the various elements and approaches of geographic information systems (GIS) and analysis are properly understood to successfully capture, store, manage, and visualize data that is linked directly to a location.

**Proficiency Levels:**

- **Prerequisites (P) –** Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A) –** Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M) –** Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| **T1. Vector and Vectorization** | | |
| **Proficiency Level** | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Cartesian and polar coordinate systems | 1. Describe cartesian and polar coordinate systems.<br>2. Identify where an x,y point should be plotted on a graph using a cartesian coordinate system.<br>3. Identify where an x,y point should be plotted on a graph using a polar coordinate system. |
| | 2. Feature tracing | 1. Define what it means to trace a feature and outline the steps taken to perform a trace. |
| **Foundational (F)** | 1. Cartesian and polar coordinate systems | 1. Define angular displacement and summarize how it is calculated for a polar and cartesian coordinate system. |
| | 2. Vector data models | 1. List the general tables used for vector data models and summarize their uses.<br>2. Describe the relationship between the various general tables used for vector data models. |
| | 3. Points, lines, and polygons | 1. Summarize the roles points, lines, polygons, and surfaces play in vectorization. |

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| | 4. Image resolution | 1. Summarize the relationship between image resolution and positional error for digitized features.<br>2. Summarize the relationship between image resolution and feature shape/identification.<br>3. Apply the most effective and appropriate scale to use when digitizing features given the resolution of an image. |
| | 5. Image caching | 1. Summarize the effect caching of imagery has on the digitizing process. |
| | 6. Supervised and unsupervised classification | 1. Compare supervised imagery classification and unsupervised imagery classification and summarize how each is used when digitizing images. |
| | 7. Raster to vector | 1. Compare the advantages and disadvantages of converting raster data to vector data.<br>2. Summarize the process taken to convert raster data into vector data. |
| | 8. Attribute | 1. Explain what an attribute is and summarize the purpose it has in the digitization of an image.<br>2. Describe the different attribute data types and summarize the role they play in the digitization of image (text, Boolean, single precision, double precision, date, and time). |
| | 9. Scale | 1. Explain scale and vertex placement and outline the relationship they have with each other. |
| **Application (A)** | 1. Attribute | 1. Compare/contrast float, double, test, and Boolean attribute data types. |
| | 2. Scale | 1. Explain how vertices should be spaced given the scale of a source image.<br>2. Explain what scale should be used to digitize features given the resolution of a source image. |
| | 3. Points, lines, polylines, and polygons | 1. Explain how basic data models change when they are developed for point, polyline, and polygon data.<br>2. Demonstrate what polygon or line should be created given a set of bearings and distances. |

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| | 4. Digitization | 1. Compare/contrast at least three different means for smoothing digitized features.<br>2. Compare/contrast at least three methods used to simplify complex features when digitizing images.<br>3. Assess how digitized route features should be converted into a geographic network (i.e., m-values).<br>4. Assess how elevated terrain features should be converted in a topographic data model (i.e., z-values).<br>5. Analyze how features can be digitized with respect to time (i.e., spatio-temporal representation). |
| **Mastery (M)** | 1. Smoothing | 1. Evaluate the advantages and disadvantages of current statistical methods for smoothing features to develop more efficient methods. |
| | 2. Interpolation | 1. Develop methods for interpolating missing points and/or vertices in an image. |
| | 3. Four-dimensional (4D) data models | 1. Formulate methods for developing 4D data models (Two-dimensional [2D], three-dimensional [3D], and time change data) that support vectorization. |
| **T2. Raster and Imagery Analysis** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Imagery | 1. Define the following terms and outline how they relate to photography:<br>• Pixel<br>• Tone<br>• Contrast<br>• Digital number<br>• Dynamic range<br>• Brightness<br>2. Identify the major components of a digital camera and summarize their purpose.<br>3. Define resolution and image scale and summarize the role they play in collecting raster data. |
| | 2. Discrete and continuous data | 1. Define discrete and continuous numeric data. |
| | 3. Least squares | 1. Define least squares and residual and recall what information they provide. |

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| **Foundational (F)** | 1. Raster data | 1. Compare the advantages and disadvantages of converting raster data to vector data.<br>2. Summarize the process taken to convert raster data into vector data.<br>3. Explain the similarities and differences among the following raster data sources:<br>• Direct acquisition by a sensor system<br>• Scanning<br>• Interpolation<br>• Conversation from vector data<br>• Map algebra<br>4. Summarize quantization and discuss its role in analyzing raster data.<br>5. Discuss how raster data is affected when it is transformed from one coordinate system into another coordinate system. |
| | 2. Analog to digital conversion | 1. Demonstrate the process of converting an electrical signal into a pixel digital number. |
| | 3. Tessellation | 1. Summarize what a tessellation model is and how it is used with raster data.<br>2. Describe three common cell types used in a tessellation model. |
| | 4. Image caching | 1. Discuss image caching and summarize why it is important when working with raster data. |
| | 5. Imagery | 1. Summarize the similarities and differences between 8-bit imagery and 24-bit imagery.<br>2. Indicate how color is represented in a 24-bit image.<br>3. Summarize the process performed to represent color in a 24-bit image. |
| | 6. Image transmission | 1. Understand the process taken to prepare and transmit images using electro-optical sensor systems. |
| | 7. Georeferencing, orthorectification, and georectification | 1. Summarize the similarities and differences among georeferencing, orthorectification, and georectification for providing correct spatial reference to raster data. |

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| | 8. Histogram | 1. Describe the process taken to create a histogram that represents the distribution of values in a raster image and summarize why it is important to understand the distribution of values.<br>2. Discuss the various uses of histograms in digital image processing and summarize how each type of histogram is used. |
| | 9. Classification | 1. Distinguish between supervised and unsupervised classification. |
| **Application (A)** | 1. Mosaic process | 1. Explain the process of creating a mosaic from individual raster data tiles. |
| | 2. Raster data | 1. Compare/contrast the following methods for visually representing raster datasets:<br>• Equal interval<br>• Quantile<br>• Percentile<br>• Jenks<br>• Histogram normalization<br>2. Calculate the total area from raster data based on the spatial resolution or pixel size.<br>3. Compare/contrast the process of converting raster data to vector data and vice versa.<br>4. Explain how metadata is created for raster data.<br>5. Differentiate among the various models used to store data and identify which models are appropriate for raster data.<br>6. Compare/contrast the different types of lossy raster data.<br>7. Compare/contrast the various "lossy" methods, "lossy" pyramids, and caching of "lossy" data.<br>8. Differentiate common lossy raster data formats.<br>9. Conclude when it is and is not appropriate to re-scale raster data.<br>10. Explain how quantization is used in imagery analysis and in analyzing raster data and compare the different methods of performing quantization. |

| GIS and Analysis Tools (GIS) | | |
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| | 3. Resolution | 1. Compare/contrast the major imagery resolution types:<br>• Spatial resolution<br>• Spectral resolution<br>• Radiometric resolution<br>• Temporal resolution<br>2. Differentiate when it is appropriate to combine images of different resolutions during the analytic process. |
| | 4. Resampling | 1. Explain the resample process.<br>2. Differentiate among the various methods used to resample data and explain when each method is used. |
| | 5. Downsampling | 1. Conclude when downsampling should and should not be used. |
| | 6. Least squares | 1. Explain how an image should be georeferenced using least squares. |
| | 7. Interpolation | 1. Demonstrate how inverse distance weighting (IDW) is used to interpolate data to a raster layer from point data. |
| | 8. Digital number | 1. Outline how data is selected based upon digital numbers. |
| | 9. Ground sample distance (GSD) | 1. Calculate GSD when provided sensor size, sensing element size, focal length, and height. |
| | 10. Map algebra | 1. Outline which conditions are necessary to perform map algebra.<br>2. Explain how math is used to derive new surfaces and images from combinatorial techniques. |
| | 11. Electromagnetic spectrum | 1. Compare/contrast the following wavelengths:<br>• Gamma<br>• X-ray<br>• Ultraviolet (UV)<br>• Visible<br>• Infrared (IR)<br>• Far infrared (FIR)<br>• Microwave<br>2. Interpret a Normalized Difference Vegetation Index (NDVI) and distinguish which wavelengths are used to calculate the NDVI. |
| **T3. Geodesic Science, Geographically Referencing Spatial Information, and Positioning** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |

| GIS and Analysis Tools (GIS) | | |
|---|---|---|
| **Prerequisites (P)** | 1. Map projections and coordinate systems | 1. Describe the purpose of map projections and coordinate systems. |
| | 2. Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) | 1. Recall a generalized description of GPS. |
| **Foundational (F)** | 1. Map projections and coordinate systems | 1. List the fundamental styles of map projection and explain how each style is utilized.<br>2. List the primary defining features of a cylindrical, conical, and azimuthal projection.<br>3. Give examples of coordinate systems.<br>4. Give examples of Military Grid Reference System (MGRS) projections and coordinate systems.<br>5. Distinguish among the basics of projections, coordinate systems, and datums.<br>6. Summarize how to transform a point coordinate system among planar and spherical coordinate systems.<br>7. Summarize what "unprojected" map data is and how it is used in georeferencing and positioning.<br>8. Summarize why a projected coordinate system (PCS) is necessary for 2D maps. |
| | 2. Ellipsoids | 1. Identify the major components used to describe an ellipsoid.<br>2. Discuss components that determine whether an object is a geoid or an ellipsoid.<br>3. Summarize the similarities and differences between orthometric and ellipsoid heights. |
| | 3. Coordinate conversion | 1. Describe how to manually plot various types of coordinates (e.g., spherical and planar) on a map without the aid of a computer.<br>2. Discuss the relationship between decimal degrees, degrees, minutes, and seconds.<br>3. Summarize how to convert a coordinate from decimal degrees to degrees, minutes, seconds and vice versa. |
| | 4. GPS and GNSS | 1. Identify the major components of a GPS and explain how each is used. |
| | 5. Georeferencing, orthorectification, and georectification | 1. Describe how georeferencing provides a spatial reference to an unknown coordinate system.<br>2. Summarize the similarities and differences between georeferencing and orthorectification of an image. |

| GIS and Analysis Tools (GIS) | | |
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| | 6. Geocoding | 1. Define geocoding and reverse geocoding and discuss example applications. |
| **Application (A)** | 1. Map projections and coordinate systems | 1. Deduce which coordinate system and projection is most appropriate to use given the end use of a map.<br>2. Deduce which projection(s) is/are appropriate given the scale and extent for a given project.<br>3. Decide when to use a PCS vs. geographic coordinate system (GCS).<br>4. Explain which of the properties (area, shape, distance, etc.) is targeted to maintain when converting from GCS to PCS.<br>5. Consider how gravity and the Earth's magnetic field affect coordinate measurement.<br>6. Illustrate how to use datums. |
| | 2. GPS | 1. Categorize the major wavelength and information carrier bands associated with GPS and describe their purpose.<br>2. Outline the relationship between positioning error and the number of visible satellites in a GPS constellation.<br>3. Explain how "lag" relates to the transmission and receiving time of GPS signals.<br>4. Compare/contrast casual factors that may inhibit the transmission and reception time of GPS signals.<br>5. Differentiate the dilution of precision and absolute accuracy for the following:<br>• Uncorrected, handheld GPS<br>• Differential GPS for navigation<br>• Real Time Kinematic (RTK) GPS for surveying<br>6. Explain the relationship between GPS accuracy and the time spent occupying a point.<br>7. Interpret how "epoch" relates to GPS.<br>8. Explain how false accuracy changes based on the positioning of devices. |
| | 3. Georeferencing, orthorectification, and georectification | 1. Identify factors required for georeferencing imagery and explain the potential sources of error in the georeferencing process.<br>2. Identify factors required for orthorectifying imagery and explain the potential sources of error in the orthorectification process. |

| GIS and Analysis Tools (GIS) | | |
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| | 4. Geocoding | 1. Outline the steps involved in geocoding a street address.<br>2. Explain the purpose of an address locator.<br>3. Compare/contrast the sources of error in address geocoding and why each source of error occurs. |
| | 5. Scale | 1. Conclude the appropriate accuracy required for mapping at the following scales based on the National Map Accuracy Standard:<br>• 1:2,400<br>• 1:5,000<br>• 1:10,000<br>• 1:25,000<br>• 1:50,000<br>• 1:100,000<br>• 1:250,000<br>• 1:1,000,000 |
| **Mastery (M)** | 1. Map projections and coordinate systems | 1. Judge the most important aspects of the features being mapped and select the most optimal projection to preserve the integrity of those features. |
| **T4. Spatial Topology** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Topology fundamentals | 1. Define topology and summarize why it is important to geographic information systems (GIS).<br>2. Describe the fundamental rules for how common geographic features relate to one another.<br>3. Describe the spatial relationships among a group of objects. |
| **Foundational (F)** | 1. Topology rules | 1. Explain how topologic rules can verify the integrity of a dataset.<br>2. List the various topologic rules used to manage cadastral datasets.<br>3. Understand the topological rules for points, lines, and polygons when digitizing or working on a spatial database. |
| **Application (A)** | 1. Geodatabases | 1. Compare/contrast how different versioned geodatabases are used to manage topology. |
| | 2. Topology rules | 1. Conclude appropriate topology rules based on the project needs. |
| | 3. Logic diagram | 1. Select an appropriate logic diagram that illustrates how to apply topology to a data model. |

| GIS and Analysis Tools (GIS) | | |
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| | 4. Topology in relational databases | 1. Compare/contrast the fundamental tables required to create and maintain topology in a relational database.<br>2. Evaluate the integrity and correctness of data or measurements. |
| | 5. Topology rules | 1. Assess the fundamental topologic rules for managing various datasets (e.g., parcel datasets and road network datasets). |
| **T5. Data Selection and Validation** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Data selection and validation key terms | 1. Define the following terms and summarize why each are important for selecting and validating data:<br>• Precision<br>• Accuracy<br>• Uncertainty of measure<br>• Relative uncertainty<br>• Absolute uncertainty of measure |
| | 2. Units | 1. List System International (SI) and Imperial units for the following:<br>• Distance<br>• Direction<br>• Velocity<br>• Luminance<br>• Illuminance<br>• Energy<br>• Work |
| | 3. Dimensional analysis | 1. Define dimensional analysis and determine when it should and should not be used to convert units of measure. |
| | 4. Round and truncate numbers | 1. Identify when it is appropriate to round and truncate numbers.<br>2. Describe the similarities and differences of rounding and truncation as they relate to data selection and validation. |
| | 5. Integer and ratio data | 1. Define integer and ratio data.<br>2. Describe the similarities and differences between integer and ratio data. |
| | 6. Qualitative and quantitative data | 1. Define qualitative and quantitative data.<br>2. Describe the similarities and differences between qualitative and quantitative data. |

| GIS and Analysis Tools (GIS) | | |
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| **Foundational (F)** | 1. Simple potential for error | 1. Describe the simple potential for error using significant digits. |
| | 1. Precision and accuracy | 1. Summarize the concepts precision and accuracy and describe the differences.<br>2. Define absolute accuracy and relative accuracy and summarize the relationship between the two.<br>3. Summarize how the precision of measurement is calculated. |
| | 2. Measures of central tendency and measures of dispersion | 1. Summarize different measures of central tendency and measures of dispersion, including:<br>• Mean<br>• Median<br>• Mode<br>• Range<br>• Variance<br>• Standard deviation |
| | 3. Standard deviation, standard error, skewness, and kurtosis | 1. Define the following terms and summarize how each is calculated:<br>• Standard deviation<br>• Standard error<br>• Skewness<br>• Kurtosis |
| | 4. Relative error and relative uncertainty | 1. Define relative error and relative uncertainty and summarize the relationship between the two.<br>2. Summarize how relative error and relative uncertainty are calculated. |
| | 5. Random and systemic error | 1. Define random error and systematic error and summarize the relationship between the two.<br>2. Describe common causes of random error and systematic error.<br>3. List and define the means for propagation of error. |
| | 6. Correlated and independent measures | 1. Explain correlated and independent measures. |
| | 7. Distribution types | 1. Identify normal, binomial, and discrete rare event distributions. |
| | 8. Confidence interval | 1. Summarize the similarities and differences between confidence interval and percent confidence. |
| | 9. Quantitative sampling errors | 1. List and summarize the potential for error associated with various qualitative sampling methods. |

| GIS and Analysis Tools (GIS) | | |
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| **Application (A)** | 1. Authoritative-, open-, and crowd-sourced data | 1. Differentiate the characteristics among authoritative-sourced data, open-sourced data, and crowd-sourced data (including social media data).<br>2. Characterize the fundamental risks associated with crowd-sourced data.<br>3. Determine methods that mitigate against risks associated with crowd-sourced data. |
| | 2. Structured vs. non-structured data | 1. Compare/contrast the characteristics of structured and non-structured data. |
| | 3. Metadata | 1. Categorize at least five of the following critical metadata components that are necessary to maintain geospatial data by level of importance (e.g., critical, important, etc.):<br>• Author<br>• Generation date<br>• Attribute descriptions<br>• Attribute units of measure<br>• Projection and coordinate system<br>• Collection scale or resolution<br>• Source method<br>• Horizontal/vertical accuracy<br>• Modification dates |
| | 4. Data standards organization | 1. Identify the correct primary data standards organizations governing civilian U.S. federal data standards.<br>2. Identify the correct primary data standards organization governing U.S. military data standards.<br>3. Identify the two international standards organizations for geospatial data. |
| | 5. Units of measure standards organizations | 1. Compare/contrast U.S. and international standards organizations for units of measures. |
| | 6. Data and position "spoofing" | 1. Compare/contrast data “spoofing” and position “spoofing” and summarize when each are used. |
| | 7. Precision and accuracy | 1. Explain the requirements necessary to obtain data precision and data accuracy. |
| | 8. Error analysis | 1. Evaluate whether the steps necessary to conduct an error analysis have been performed correctly.<br>2. Evaluate which error analysis method should be used for quantitative datasets and qualitative datasets to construct geographic layers and their attributes. |

| GIS and Analysis Tools (GIS) | | |
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| | 9. R-squared value | 1. Conclude what the most appropriate use of imagery is (e.g., targeting and general positioning) based on the image's r-squared value. |
| | 10. Types of error | 1. Compare/contrast the three main categories of error and summarize when each occurs.<br>2. Identify the factors associated with Type I error and Type II error and determine the probability of each happening.<br>3. Compare/contrast relative error and absolute error and characterize how each is calculated.<br>4. Explain the various categories of error associated with Intelligence Community Directive (ICD) 203.<br>5. Explain at least five of the common sources of error found in geospatial datasets. |
| | 11. Model validation | 1. Evaluate whether data can self-validate a model. |
| | 12. Combining datasets | 1. Evaluate when it is and is not appropriate to combine datasets of different ages, spatial resolutions, numeric types, and collection methods. |
| **Mastery (M)** | 1. Advanced statistical modeling techniques | 1. Integrate advanced statistical modeling techniques into geospatial data selection and validation. |
| | 2. Programming skills | 1. Integrate advanced programming skills to select and validate data efficiently and effectively. |
| **T6. Spatial Data Structures and Models** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Transmission rate | 1. Identify transmission time given a file's size and transfer rate. |
| | 2. Binary system | 1. Summarize how a binary system is used to store, retrieve, and compute data. |
| | 3. Attribute and geographic components | 1. Identify attributes and geographic components within a spatial dataset and summarize the similarities and differences. |
| | 4. Points, lines, and polygons | 1. Summarize what information is needed to construct point, line, and polygon features.<br>2. Summarize what information is needed to display 3D data (e.g., voxels). |
| | 5. File size | 1. Describe the relationship between spatial data file size and spatial resolution. |
| | 6. Specifications | 1. List the primary considerations necessary to establish specifications for a spatial data model. |

| GIS and Analysis Tools (GIS) | | |
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| | 7. Geometry type | 1. List the primary considerations necessary to select geometry type. |
| **Application (A)** | 1. Data storage models | 1. Compare/contrast the following data storage models:<br>• Flat<br>• Hierarchical<br>• Sequential<br>• Network<br>• Relational<br>• Graph |
| | 2. Spatial data model | 1. Classify the fundamental tables required to create and maintain topology in a relational database. |
| | 3. Dynamic segmentation and linear referencing | 1. Explain dynamic segmentation and linear referencing and outline how these factors are modeled in spatial data structures. |
| | 4. Raster cell shape | 1. Classify which cell shapes are appropriate for use in raster data.<br>2. Compare/contrast the use cases for cell shapes used in raster data. |
| | 5. Raster data | 1. Explain the structure and components of a fundamental raster dataset (include information in the header). |
| | 6. Entity Relationship Diagrams (ERDs) | 1. Categorize shapes associated with entities, attributes, and their relationships in ERDs. |
| | 7. Cardinality | 1. Explain database cardinality and possible cases associated with cardinality. |
| | 8. Spatial and attribute join | 1. Differentiate a spatial join from an attribute join. |
| | 9. Relationship class and related table | 1. Differentiate between a relationship class and a related table. |
| | 10. File size | 1. Determine the approximate disk size/file size given an image's resolution and dimensions. |
| | 11. Redundant Array of Independent/Inexpensive Disks (RAID) | 1. Explain the purpose of RAID and differentiate the different levels of RAID. |
| | 12. Cloud computing | 1. Explain cloud computing and evaluate its use in data structures and models. |
| | 13. Disaster recovery | 1. Outline the various strategies for disaster recovery and conclude the most appropriate strategy for disaster recovery. |
| | 14. Versioning | 1. Explain versioning and differentiate between its various uses in data structures and models. |

| GIS and Analysis Tools (GIS) | | |
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| | 15. Parity | 1. Explain parity and compare/contrast how it is applied to data storage solutions and data structures. |
| **T7. Analytic Techniques Using Geometric and Topologic Relations** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Histogram | 1. Discuss histogram distributions and interpret how data is distributed. |
| | 2. Statistical distribution | 1. Summarize the following distributions and their appropriate use cases:<br>• Normal<br>• Binomial<br>• Poisson |
| **Application (A)** | 1. IDW | 1. Explain IDW interpolation and how it is calculated. |
| | 2. Nearest neighbor analysis | 1. Explain nearest neighbor analysis and describe use cases. |
| | 3. Tobler's Law | 1. Explain Tobler's First Law of Geography and how it applies to geometric analytic techniques and topologic relations. |
| | 4. Momentum and anisotropy | 1. Explain momentum and anisotropy as they relate to spatial datasets. |
| | 5. Spatial autocorrelation | 1. Conclude the correct application for the following spatial statistics:<br>• Geary's C<br>• Moran's I<br>• Getis-Ord Gi* |
| | 6. Interpolation | 1. Differentiate among the following Kriging methods:<br>• Normal<br>• Ordinary<br>• Cokriging<br>2. Explain the role nugget size and lag play in kriging. |
| **T8. Terrain and 3D Analysis** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Key terms | 1. Define slope, aspect, and hillshade. |
| | 2. Day length, latitude, longitude, and elevation | 1. Discuss the relationship among day length, latitude, longitude, and elevation. |
| | 3. Symbology | 1. List the five basic colors used in topographic maps. |

| GIS and Analysis Tools (GIS) | | |
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| | 4. North | 1. Define true north, magnetic north, and grid north and discuss the differences. |
| **Application (A)** | 1. Line of sight | 1. Explain how line of sight is used in terrain and 3D analysis.<br>2. Compare/contrast the significant application spaces (e.g., visual, radio/telecommunications, object flight/trajectory, and terrain avoidance) that use line of sight. |
| | 2. Slope | 1. Differentiate among the components of the equation for calculating the slope of terrain.<br>2. Calculate slope given two elevations. |
| | 3. Aspect | 1. Explain how aspect relates to terrain modeling. |
| | 4. Hillshade | 1. Explain how "hillshade" is used in terrain and 3D analysis.<br>2. Interpret the illumination of a hillshade model while considering the effect of increasing light source angles.<br>3. Explain how the increasing light source angle affect influences the illumination of a hillshade model. |
| | 5. Topographic features | 1. Identify the following features on a topographic map:<br>• Depression<br>• Hill<br>• Glacial valley<br>• Water valley<br>• Saddle<br>• Ridge<br>• Cliff |
| | 6. Day length, latitude, longitude, and elevation | 1. Analyze the relationship between an object's height, shadow length, time of day, and latitude/longitude. |
| | 7. Symbology | 1. Employ the appropriate color ramp for a given terrain sample.<br>2. Conclude the correct National System for Geospatial Intelligence (NSG) symbol for a topographic map feature. |
| | 8. Grid-Magnetic (G-M) angle | 1. Conclude the G-M angle given a declination diagram.<br>2. Demonstrate how to convert a grid angle to a magnetic angle and vice versa when given the G-M angle. |

| GIS and Analysis Tools (GIS) | | |
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| | 9. Interpolated elevation | 1. Deduce an interpolated elevation from two contour lines. |
| | 10. Contour line interval | 1. Conclude an appropriate contour line interval given a range of elevations and a corresponding horizontal distance. |
| **Mastery (M)** | 1. Topographic map | 1. Generate a topographic map from imagery and elevation data. |
| **T9. Non-Structured Data Analysis** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Organization and meaning in geospatial science | 1. Define semantics, taxonomy, semantic analysis, and ontology and summarize their differences. |
| **Application (A)** | 1. Data complexity | 1. Compare/contrast methods for estimating the complexity of data. |
| | 2. Unstructured data analysis | 1. Compare/contrast common techniques for visualizing unstructured data or partially structured data.<br>2. Explain the role of data connectors in unstructured data analysis. |
| | 3. Filtering and tuning | 1. Compare/contrast filtering and tuning. |
| | 4. Co-occurrence | 1. Explain co-occurrence (bigram/unigram pair). |
| | 5. Machine learning (ML) | 1. Explain the ML process. |
| **T10. Scientific Methods and Conceptual Analytic Modeling** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Hypothesis development | 1. Discuss the hypothesis development process. |
| | 2. Measurements and error | 1. Define the following pairs of terms and discuss their differences:<br>• Accuracy vs. precision<br>• Absolute error vs. relative error |
| **Application (A)** | 1. Types of reasoning | 1. Compare/contrast inductive, deductive, and abductive reasoning. |
| | 2. Conceptual and logical models | 1. Differentiate between conceptual and logical models. |
| | 3. Hypothesis development | 1. Develop an appropriate hypothesis for a given problem.<br>2. Compare/contrast Type I and Type II errors and summarize how each relates to hypothesis testing. |
| | 4. Sourcing requirements | 1. Explain how the scope and applicability of ICD 206 relates to the analytic process. |

| GIS and Analysis Tools (GIS) | | |
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| | 5. Principles | 1. Differentiate the following terms:<br>• Natural law<br>• Theory<br>• Theorem |
| **T11. Structured Analytic Techniques** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Application (A)** | 1. System thinking | 1. Compare/contrast System 1 and System 2 thinking. |
| | 2. Structured analytic techniques | 1. Explain the objectives of applying structured analytic techniques to geospatial science (US Government, 2009).<br>2. Compare/contrast the following structed analytic techniques (US Government, 2009):<br>• Venn Diagramming<br>• Red team<br>• Devil's advocate<br>• Matrices<br>• Brainstorming<br>• Starbursting<br>• Diagnostic reasoning<br>• Argument mapping<br>• Role playing<br>• Delphi method<br>• Structured debate<br>• Force field analysis<br>• SWOT |
| | 3. Terms of likelihood and numeric probability | 1. Conclude which of following terms should be used based on a given numeric probability (US Government, 2009).:<br>• Remote<br>• Highly improbable<br>• Improbable<br>• Roughly even odds<br>• Probable<br>• Highly probable<br>• Nearly certain |
| | 4. Sourcing requirements | 1. Compare/contrast ICD 206 with scientific hypothesis testing. |

| GIS and Analysis Tools (GIS) | | |
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| | 5. Bias | 1. Compare/contrast the following types of biases (US Government, 2009).:<br>• Cognitive bias<br>• Conformity bias<br>• Affinity bias<br>• Attribution bias<br>• Confirmation bias<br>• Halo effect<br>• Horns effect<br>• Contrast effect |
| **T12. Fundamental Concepts in Geography** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Foundational (F)** | 1. Foundations of geospatial intelligence (GEOINT) | 1. Define GEOINT and summarize its major principles.<br>2. Discuss the role of geography in GEOINT.<br>3. Understand major historical events and key figures in the history of computer science, geospatial technologies, and geography as they relate to GEOINT. |
| | 2. Human and physical geography | 1. Define human and physical geography.<br>2. List and discuss sub-disciplines within human geography, including:<br>• Cultural geography<br>• Economic geography<br>• Health geography<br>• Military geography<br>• Political geography<br>• Urban geography<br>3. Define meteorology, climatology, and geomorphology and explain their differences.<br>4. Discuss major weather phenomena and explain which is represented given its primary physical characteristics in a landscape.<br>5. Distinguish why plate tectonics are important to understand geography.<br>6. Identify the major effects the following natural disasters have on the physical geography of a landscape:<br>• Volcanic eruptions<br>• Tsunamis<br>• Earthquakes<br>• Landslides |

| GIS and Analysis Tools (GIS) | | |
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| **Application (A)** | 1. Geographic thought | 1. Compare/contrast the following trends in geographic thought and discuss how they relate to GEOINT (Couper, 2015):<br>• Positivism<br>• Critical rationalism<br>• Marxism and critical realism<br>• Phenomenology and post-phenomenology<br>• Social constructionism and feminism<br>• Structuralism, poststructuralism, and postmodernism<br>• Complexity theory<br>2. Compare/contrast the following geographic theories:<br>• Environmental determinism<br>• Possibilism<br>• Environmental perception<br>• Cultural determinism |
| | 2. Human and physical geography | 1. Differentiate between the roles of human and physical geography in GEOINT.<br>2. Analyze the major application areas for human geography and physical geography in GEOINT.<br>3. Explain how various aspects of physical geography relate to and impact GEOINT, including:<br>• Earth orbit<br>• Climate types<br>• Tectonic processes<br>• Weathering and erosion<br>• Temperature and insolation<br>• Major weather phenomena<br>• Types of regions (arid, arctic, coastal, urban, etc.)<br>• Landforms |

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| | 3. History of GEOINT | 1. Explain the contributions of key figures the field of GEOINT, including but not limited to:<br>• Sun Tzu - 500 BCE<br>• George Washington - 1780<br>• John Snow - 1830s<br>• Ivan A. Getting – 1940<br>• Constance Babington Smith - 1942<br>• Mary Sears - 1945<br>• Irene K. Fischer - 1946<br>• Waldo Tobler - 1960s<br>• Edgar Frank Codd - 1970<br>• Thomas C. Finnie - 1972<br>• Brad Parkinson - 1973<br>• Jack Dangermond - 1970<br>• Lt. Gen. Howard W. Penney - 1972<br>• Penman R. Gilliam - 1982<br>• Gladys West - 1986<br>• Annette J. Krygiel - 1999<br>• Lt. Gen. James R. Clapper - 2010<br>2. Outline the lineage of the National Geospatial-Intelligence Agency (NGA) from creation of the Defense Mapping Agency in 1972 to the present.<br>3. Analyze the significance of the following event classes and events as they pertain to GEOINT:<br>• Disasters, e.g.,<br>- Space Shuttle Columbia disaster<br>- 2004 Indian Ocean tsunami<br>- Hurricane Katrina<br>- 2010 Haiti Earthquake<br>- Fukushima nuclear accident<br>- COVID-19<br>- 2023 Maui wildfires<br>• Military operations, e.g.,<br>- Ho Chi Minh Trail<br>- Battle of 73 Easting<br>- Dayton Accords<br>- War in Afghanistan<br>- Russia-Ukraine War<br>- Space GEOINT<br>• Technologic change, e.g.,<br>- Reconnaissance satellites<br>- Apollo 11<br>- Landsat<br>- GPS and GIS<br>- Shuttle Radar Topography Mission<br>- Space-based radio frequency (RF) sensors |

| GIS and Analysis Tools (GIS) | | |
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| | | - Drones<br>- GeoAI |
| **T13. Neural Networks/Artificial Intelligence (AI)** | | |
| | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Statistics, probabilities, economics, and decision analysis | 1. Describe the basic principles of statistics, probabilities, and economics and explain how they can be used in other fields.<br>2. List the various methods of performing a decision analysis. |
| | 2. Relational and non-relational database technologies | 1. Define relational and non-relational database technologies. |
| **Foundational (F)** | 1. Statistical and neural network scenario modeling | 1. Summarize how statistical modeling and neural network scenario modeling are used in GEOINT. |
| | 2. Automation and AI | 2. Define automation and AI and discuss their differences.<br>3. Discuss real world use cases for when automation or AI would be used. |
| | 3. ML, data mining, and statistical algorithms | 4. Summarize how ML, data mining, and statistical algorithms refine pattern recognition, anomaly detection, and prediction. |
| | 4. Debugging software | 1. Discuss how neural networks and AI are used to design, test, and debug software. |
| | 5. Neural networks | 1. Identify characteristics of six types of neural networks:<br>• Feed forward<br>• Recurrent<br>• Convolutional<br>• Deconvolutional<br>• Modular<br>• Transformers |
| **Application (A)** | 1. Supervised, unsupervised, and reinforced ML | 1. Differentiate supervised, unsupervised, and reinforced ML.<br>2. Decide when supervised, unsupervised, and reinforced ML should be applied. |

| GIS and Analysis Tools (GIS) | | |
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| **Mastery (M)** | 1. ML techniques | 1. Assess and utilize the following techniques when using neural networks and AI:<br>• Regression<br>• Naive Bayesian classifier<br>• Clustering<br>• Matrix factorization<br>• K-nearest neighbors<br>• Natural language processing<br>• Decision trees<br>• Support vector machines<br>• Deep learning (DL) |

# 1.2 COMPETENCY 2: Remote Sensing and Imagery Analysis

**Remote Sensing and Imagery Analysis** describes the knowledge necessary to generate products and/or presentations of any natural or manmade feature or related object of activity through satellites, airborne platforms, unmanned aerial vehicles, terrestrially based sensors, or other similar means. This competency area contains the knowledge necessary to synthesize technical, geographic, and intelligence information derived through the interpretation or analysis of imagery and collateral materials as well as the processes, uses, interpretations, and manipulations of imagery for dissemination.

**Proficiency Levels:**

- **Prerequisites (P)** – Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A)** – Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M)** – Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| Remote Sensing and Imagery Analysis (RS) | | |
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| **T1. Remote Sensing Fundamentals** | | |
| **Proficiency Level** | **Matrix Subtopic** | **Learning Objective(s)** |
| **Prerequisites (P)** | 1. Terminology | 1. Define remote sensing. |
| **Foundational (F)** | 1. Terminology | 1. Summarize the differences of light as a particle and light as a wave.<br>2. Summarize black body, gray body, radiant emittance, energy flux, power, wavelength, and frequency.<br>3. Define the following terms: spectral reflectance, absorbance, emittance, transmittance.<br>4. Define Raleigh, Mie, and nonselective scattering in the atmosphere.<br>5. Define the atmospheric windows and identify those most appropriate for remote sensing. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 2. Radiation | 1. Discuss Planck's law with respect to spectral density, temperature, and a black body.<br>2. Discuss Stefan-Boltzmann's law with respect to radiant emittance and temperature.<br>3. Identify emissivity when given radiant emittance, Stefan-Boltzmann constant, and temperature.<br>4. Define the Law of Conservation of Energy.<br>5. Define the solar constant and the associated terms at the outer-most edge of the Earth's atmosphere: electromagnetic radiation (EMR), bandwidth, illumination, energy flux, irradiance, radiance, and radiant exitance. |
| | 3. Electro-magnetic spectrum | 1. List the major bandwidth groups associated with the electro-magnetic spectrum.<br>2. Compare the following wavelengths along the electromagnetic spectrum:<br>• X-ray<br>• Gamma ray<br>• UV<br>• Visible<br>• Near infrared (NIR)<br>• Shortwave infrared (SWIR)<br>• Thermal infrared (TIR)<br>• Microwave |
| | 4. Pixels | 1. Define resolution and discuss the major types of resolution:<br>• Spatial resolution<br>• Spectral resolution<br>• Radiometric resolution<br>• Temporal resolution<br>2. Summarize the relationship between pixel depth and data size on disk.<br>3. Summarize the similarities and differences between Tagged Image File (TIFF), Geographic Tagged Image File Format (GeoTIFF), Joint Photographic Experts Group (JPG), Portable Network Graphic (PNG), and similar image storage formats. |
| **Application (A)** | 1. Terminology | 1. Outline applications of remote sensing in various fields (e.g., crop monitoring, climate monitoring, military applications, hydrologic monitoring, etc.)<br>2. Explain Fraunhofer lines and why they are useful in remote sensing. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 1. Radiation | 1. Assess the spectral signature of an object.<br>2. Explain spectroscopy and its uses.<br>3. Compare/contrast resources that help with the identification of an object based upon spectral properties.<br>4. Analyze variables and constants used when given Plank's Law and/or Stefan-Boltzmann's Law. |
| | 2. Image distortion | 1. Explain how image distortion can be corrected for the following: perspective of the sensor optics, the motion of the scanning system, the motion and (in)stability of the platform, the platform altitude, attitude, and velocity, the terrain relief, and the curvature and rotation of the Earth.<br>2. Differentiate between and correct for skew and tangential scale distortion. |
| | 3. Mathematics | 1. Given a set of values for an equation with stated units of measure that are not compatible for calculation, convert to appropriate SI units and solve.<br>2. Estimate the area under a curve.<br>3. Perform compensatory calculations to adjust for atmospheric effects. |
| | 4. Pixels | 1. Differentiate between GSD, pixel size, and Light Detection and Ranging (LiDAR) point spacing and explain how each are used. |
| | 5. Processing level | 1. Differentiate and select the appropriate processing level of data for a given need (L1, L2…). |
| **Mastery (M)** | 1. Advanced remote sensing | 1. Code numeric solutions using Taylor approximation and similar computational methods.<br>2. Design and build sensors and systems using advanced engineering skills.<br>3. Design and build sensors and systems using advanced engineering skills. |
| **T2. Remote Sensing Systems** | | |
| **Proficiency Level** | **Matrix Subtopic** | **Learning Objective(s)** |

| Remote Sensing and Imagery Analysis (RS) | | |
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| **Foundational (F)** | 1. Orbits | 1. List and define various types of orbits, including:<br>• Low-Earth orbit (LEO)<br>• Medium-Earth orbit (MEO)<br>• Polar orbit<br>• Sun-synchronous orbit (SSO)<br>• Geo-stationary orbit (GEO) |
| | 2. Active and passive sensors | 1. Describe a passive sensor.<br>2. Identify passive sensor systems from a list of remote sensing systems.<br>3. Describe an active sensor.<br>4. Identify active sensor systems from a list of remote sensing systems. |
| **Application (A)** | 1. Orbits | 1. Compare/contrast various orbits, including SSO, GEO, and polar orbits.<br>2. Compare/contrast ascending and descending orbital trajectories.<br>3. Differentiate between a swath, nadir, and revisit period. |
| | 2. Active and passive sensors | 1. Explain the general phenomena measured by remote sensing systems (time, intensity, distance).<br>2. Differentiate how a single sensing element works with linear mechanical motion and a flat sensor arranged as a strip vs. as a ring.<br>3. Explain look angle, slant range distance, and ground range distance.<br>4. Compare/contrast layover, foreshortening, and radar shadow. |
| | 3. Sensor types | 1. Differentiate the use of the following sensor types: laser altimeter, LiDAR, rangefinder, scatterometer, sounder, hydrographic echo sounder, radar, and sonar.<br>2. Differentiate the use of the following sensor types: radiometer, spectrometer, spectroradiometer, accelerometer, panchromatic camera, imaging radiometer, and TIR sensor.<br>3. Connect sensor type to the wavelength in which it measures.<br>4. Connect sensor types to mission requirements.<br>5. Connect mission requirements to end user needs (e.g., the end user needs to estimate wildland fire danger).<br>6. Identify instances when multiple types of sensors must be converged (focused on the same target |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | | simultaneously), staggered (timed at different intervals), or separated (used on different elements of a target) to gain maximum benefit in solving given problems. |
| | 4. Electromagnetic spectrum | 1. Decide the appropriate electromagnetic spectrum based on the radiometer type provided.<br>2. Differentiate among K, Ka, Ku, X, C, ERS-1, ERS-2, RADARSAT, S, L, and P microwave bands and their uses.<br>3. Differentiate between visible, IR, TIR, multi-spectral, and hyper-spectral applications. |
| | 5. Sensor systems | 1. Explain the major components of a single sensing element.<br>2. Explain the major components of a line sensor system.<br>3. Explain the major components of an array sensor system.<br>4. Analyze the purpose and process of increasing azimuth resolution for microwave systems.<br>5. Assess the relationship between Instantaneous Field of View (IFOV), sensor resolution, and altitude. |
| | 6. Polarization | 1. Differentiate among horizontal transmit and horizontal receive (HH), horizontal transmit and vertical receive (HV), vertical transmit and vertical receive (VV), and vertical transmit and horizontal receive (VH) polarizations and their uses. |
| | 7. Quantization | 1. Explain the process of signal acquisition and transduction from kinetic to potential energy.<br>2. Explain the process of sampling as it relates to quantization and pixel size.<br>3. Assess how dynamic range is utilized in remote sensing.<br>4. Explain how sampling is related to signal amplitude.<br>5. Explain how quantization is used in remote sensing.<br>6. Compare/contrast linear vs. coordinate indexing.<br>7. Compare/contrast spatial and intensity resolution.<br>8. Analyze the relationship between detected intensity and output voltage.<br>9. Order the steps taken to calibrate different sensors. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | | 10. Analyze the relationships between bit depth to image color.<br>11. Categorize the factors that affect sensor calibration and the means used to minimize their influence. |
| | 8. Film | 1. Evaluate the history of film in remote sensing and describe the transition from film to digital. |
| | 9. Satellite systems | 1. Analyze the following satellite platforms and select the appropriate satellite platform(s) given a case study for obtaining the needed data:<br>● Geostationary Operational Environmental Satellite (GOES)<br>● Landsat series<br>● Advanced Very High-Resolution Radiometer (AVHRR)<br>● Terra/Aqua Moderate Resolution Imaging Spectroradiometer (MODIS)<br>● Defense Meteorological Satellite Program (DMSP)<br>● Commercial satellites: WorldView series, PlanetScope<br>● SPOT<br>● Indian Remote Sensing Satellite (IRS)<br>● Multispectral Electro-optical Imaging Scanner (MEIS-II)<br>● Compact Airborne Spectrographic Imager (CASI)<br>● Nimbus<br>● Sentinel series<br>● Aqua and Sea-viewing Wide Field-of-view Sensor (SEAWiFS) |
| | 10. Flight planning | 1. Outline the major steps involved with planning an aerial platform-based remote sensing mission.<br>2. Identify the advantages and disadvantages among the different types of orbits used by remote sensing platforms.<br>3. Identify the advantages and disadvantages between high- and low-altitude Unmanned Aerial Vehicles (UAVs). |
| **Mastery (M)** | 1. Sensor package | 1. Decide the appropriate sensor package given a description of a target and the desired use of collected data. |
| **T3. Targets** | | |
| **Application (A)** | 1. Surface reflection | 1. Differentiate between specular and diffuse reflection. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 2. Vegetation | 1. Explain the spectral characteristics of vegetation.<br>2. Explain the effects of seasonality on remote sensing processes associated with vegetative life.<br>3. Calculate Standard Vegetation Index (SVI) and NDVI. |
| | 3. Water | 1. Explain the spectral characteristics of water.<br>2. Differentiate how sediment, salinity, temperature, and algae/phytoplankton affect the remote sensing of water.<br>3. Explain the effects of target moisture content. |
| | 4. Angular Field of View (AFOV) | 1. Assess the effects of AFOV on target detection and interpretation. |
| | 5. Surface roughness | 1. Analyze the relationship between wavelength and surface roughness. |
| | 6. Corner reflection | 1. Explain corner reflection and its effects on image interpretation. |
| | 7. Speckle, scattering, and antenna pattern | 1. Differentiate speckle, scattering, and antenna pattern and the means by which each is overcome. |
| | 8. Bi-temporal and multi-temporal | 1. Explain bi-temporal and multi-temporal characteristics associated with common targets. |
| | 9. Stokes vectors | 1. Explain stokes vectors in association with common targets and when they are considered. |
| | 10. Relief displacement | 1. Explain relief displacement and relate it to terrain types. |
| **T4. Positioning** | | |
| **Application (A)** | 1. Photogrammetry | 1. Compare/contrast photogrammetry, radargram, and interferometry. |
| | 2. Polarization | 1. Explain the process of using polarization to determine elevation. |
| | 3. Fiduciary marks | 1. Assess how fiduciary marks are used. |
| | 4. Elevation | 1. Differentiate among orthometric height and elevation.<br>2. Explain the purpose and process of deriving elevation from visible imagery. |
| | 5. Ground reference points | 1. Explain how ground reference points are used in positioning an image. |
| | 6. Least squares | 1. Outline the steps in the process of using the least squares method to adjust the position of an image. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 7. Errors | 1. Compare/contrast the errors created by adjusting the position of an image using rubber sheeting, rotation, and least squares fitting. |
| | 8. Mosaicking | 1. Explain the process, advantages, and disadvantages of mosaicking an image set with respect to positioning. |
| | 9. Geometric registration | 1. Explain sensor parameters that should be considered when performing geometric registration. |
| **Mastery (M)** | 1. Algorithm creation | 1. Create algorithms for positioning imagery with respect to custom coordinate systems, locations with extreme terrain relief, and fine scale needs. |
| | 2. Automation | 1. Design automated systems for positioning imagery. |
| **T5. Image Analysis and Signal Processing** | | |
| **Foundational (F)** | 1. Image processing | 1. List the following major image processing steps and summarize their associated events:<br>• Image preprocessing<br>• Image enhancement<br>• Image transformation<br>• Image classification<br>• Image analysis<br>2. Compare various image processing techniques, including bilinear interpolation, nearest neighbor analysis, and cubic convolution. |
| | 2. Image interpretation | 1. Discuss how the following factors affect image interpretation: tone, shape, size, pattern, texture, shadow, and association. |
| **Application (A)** | 1. Image processing | 1. Outline the process of data integration (i.e., fusion).<br>2. Relate the additional concerns needed for terrestrial image processing.<br>3. Explain the concept of separability and why a separability analysis would be performed. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 2. Image correction | 1. Explain striping and dropped lines and the processes used to correct for them.<br>2. Explain how cross-sensor radiometric correction is different from other correction techniques.<br>3. Demonstrate the major steps for color correction.<br>4. Explain the traceability of standards and outline why it is important and customary practice when performing radiometric corrections and calibrations. |
| | 3. Image enhancement | 1. Differentiate the following processing techniques and their uses: spatial filtering, band rationing, and principal component analysis (PCA).<br>2. Differentiate the appropriate processing cases for using bilinear interpolation, nearest neighbor analysis, and cubic convolution.<br>3. Explain how a contrast stretch is performed and what in the data would indicate that it should be performed.<br>4. Explain pan-sharpening and when it is used.<br>5. Compare/contrast linear contrast stretch and histogram equalize stretch.<br>6. Explain the process of edge detection.<br>7. Differentiate low- and high-pass filtering and their associated used cases. |
| | 4. Image classification | 1. Compare/contrast supervised and unsupervised classification.<br>2. Differentiate the use cases for supervised and unsupervised classification.<br>3. Explain the concept of separability and why a separability analysis would be performed. |
| | 5. Image histogram | 1. Outline the differences between continuous and discrete representations of image histograms.<br>2. Explain probability density.<br>3. Summarize the purpose of probability density.<br>4. Outline the different cumulative distribution functions and why each is used.<br>5. Decide when histogram matching/equalization should be performed and explain the steps needing to be performed.<br>6. Differentiate the various histogram segmentation methods and how to know when each method should be used. |

| Remote Sensing and Imagery Analysis (RS) | | |
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| | 6. Repeat photography | 1. Explain the additional concerns needed for terrestrial image processing.<br>2. Differentiate situations for which repeat photography would and would not be appropriate.<br>3. Explain repeat photography. |
| | 7. PCA | 1. Explain what orthogonal subspaces are and how they are used in PCA.<br>2. Explain data reduction.<br>3. Outline the various data reduction concepts and the role they play in PCA.<br>4. Interpret principal component transformation (PCT) and PCA output to determine if the results should be used.<br>5. Deduce where certain PCT and PCA output are located.<br>6. Interpret PCT and PCA output to determine if the results should be used.<br>7. Demonstrate basic PCT and PCA tasks using an electronic light table (ELT) and related software.<br>8. Differentiate between the spectral and temporal uses of PCT and PCA output.<br>9. Differentiate between various algorithms related to PCT and PCA (e.g., Independent Component Analysis (ICA) and Minimum/Maximum Noise Fraction (MNF)) and why they would be used.<br>10. Explain the Tasseled Cap (Kauth-Thomas) transformation and when it is used. |
| | 8. Image quality | 1. Apply the General Image Quality Equation (GIQE) and explain its use case.<br>2. Explain the National Image Interpretability Rating Scale (NIIRS) and its use case.<br>3. Decide when it is and when it is not necessary to perform a radiometric calibration. |
| **Mastery (M)** | 1. Image processing | 1. Develop numerical methods for improved signal and image processing.<br>2. Compose methods of interpreting and manipulating data within multivariate histograms.<br>3. Propose which methods for classification should be used to produce class maps.<br>4. Perform ML and DL for image classification and object detection. |
| **T6. Raster data** | | |

| Remote Sensing and Imagery Analysis (RS) | | |
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| **Application (A)** | 1. Raster dataset analysis and visualization | 1. Outline the steps taken to create a mosaic from individual raster data tiles.<br>2. Compare/contrast the following methods for visually representing raster datasets:<br>• Equal interval<br>• Quartile<br>• Percentile<br>• Jenks<br>• Histogram normalization<br>3. Differentiate among the various methods used to resample data and explain when each method is used. |
| | 2. Resampling | 1. Differentiate among the various methods used to resample data and explain when each method is used. |
| | 3. Least squares | 1. Deduce how an image should be georeferenced using least squares. |
| | 4. Interpolation | 1. Explain how inverse distance weighted is used to interpolate data to a raster layer from point data. |
| | 5. Convert from raster to vector and vector to raster | 1. Compare/contrast the process of converting raster data to vector data.<br>2. Compare/contrast how vector data is converted to raster data. |
| | 6. Metadata | 1. Differentiate how metadata is created for raster data.<br>2. Outline the key elements required for metadata with respect to most all remote sensing products. |
| | 7. Data storage | 1. Differentiate between the various models used to store data and identify which models are appropriate for raster data. |
| | 8. Lossy raster data | 1. Compare/contrast the different types of lossy raster data.<br>2. Compare/contrast the various "lossy" methods, "lossy" pyramids, and caching of "lossy" data. |
| | 9. Digital number | 1. Classify how data is selected based upon digital numbers. |
| | 10. Re-scaling | 1. Decide when it is and is not appropriate to re-scale raster data. |
| | 11. GSD | 1. Calculate GSD distance when provided sensor size, sensing element size, focal length, and height. |
| **T7. Ethics and Legal Concerns** | | |

| Remote Sensing and Imagery Analysis (RS) | | |
|---|---|---|
| **Foundational (F)** | 1. Unmanned aircraft | 1. Discuss why it is important to take ethics and legal concerns into account when using and/or collecting data with an unmanned aircraft.<br>2. Explain the Federal Aviation Administration (FAA) regulations governing the use of unmanned aircraft.<br>3. Explain the FAA conditions required for hobbyist use of unmanned aircraft. |
| | 2. Remote sensing | 1. Discuss why it is important to take ethics and legal concerns into account when using and/or collecting remotely sensed/satellite data.<br>2. Discuss privacy concerns related to imagery. |
| **Application (A)** | 1. Unmanned aircraft | 1. Decide when operation of an unmanned aircraft is unsafe per FAA guidelines.<br>2. Apply ethics principles and demonstrate legal awareness |
| | 2. Remote sensing | 1. Differentiate between ethics and codes of conduct.<br>2. Practice basic ethical principles related to remote sensing when selected and/or collecting data. |
| **Mastery (M)** | 1. Advanced ethics | 1. Evaluate the purpose of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS).<br>2. Assess each of the 15 principles relating to remote sensing of the Earth from Outer Space as defined by the United Nations General Assembly.<br>3. Facilitate conversations regarding current laws/ethical standards related to remote sensing and unmanned aircraft and suggest updates. |
| **T8. Stereo Imaging** | | |
| **Foundational (F)** | 1. Stereoscopic visualization | 1. Define stereoscopic visualization.<br>2. Define parallax. |
| | 2. Elevation modeling | 1. Define Digital Elevation Model (DEM).<br>2. Define Digital Terrain Model (DTM).<br>3. Define Digital Surface Model (DSM). |
| | 3. 3D rendering | 1. Define 3D rendering.<br>2. Define Structure from Motion (SfM). |

| Remote Sensing and Imagery Analysis (RS) | | |
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| **Application (A)** | 1. Stereoscopic visualization | 1. Explain how advanced math principles apply to stereoscopic visualization.<br>2. Outline how basic optical principles (e.g., aperture size, focal length, etc.) play a role in the stereoscopic visualization of remote sensed data.<br>3. Compare/contrast the various stereoscopic visualization methods.<br>4. Decide which stereoscopic visualization method should be used for a given set of data.<br>5. Summarize the steps taken to perform basic digital image processing. |
| | 2. Parallax | 1. Explain the various parallax concepts (e.g., parallax difference, Y parallax, etc.) and their purpose. |
| | 3. Relief displacement | 1. Explain what relief displacement is and the different types of displacements that occur. |
| | 4. Elevation modeling | 1. Outline how various elevation models are made, including DEMs (Digital Elevation Models), DTMs (Digital Terrain Models), and DSMs (Digital Surface Models). |
| | 5. 3D rendering | 1. Conclude the most appropriate way to turn data into a 3D rendering or visualization. |
| **Mastery (M)** | 1. Stereoscopic visualization | 1. Design methods of creating a stereoscopic DEM. |
| | 2. 3D rendering | 1. Compile methods on how to derive 3D information from images taken from different perspectives.<br>2. Evaluate the advantages and disadvantages of current 3D rendering techniques to develop more accurate, efficient techniques.<br>3. Debate applications of SfM. |

## 1.3 COMPETENCY 3: Geospatial Data Management

**Geospatial Data Management** describes the knowledge required to acquire, manage, retrieve, and disseminate data to facilitate integration, analysis, and synthesis of geospatial information.

**Proficiency Levels:**

- **Prerequisites (P) –** Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A) –** Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M) –** Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| **Geospatial Data Management (GDM)** | | |
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| **T1. Interoperability** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Open-source | 1. List the basic principles of open source/Commercial Off-The-Shelf (COTS) GIS. |
| **Foundational (F)** | 1. National Spatial Data Infrastructure (NSDI) | 1. Summarize the NSDI guidelines with regard to interoperability. |
| **Application (A)** | 1. Open-source | 1. Differentiate different techniques for articulating and deploying open-source data. |
| | 2. COTS GISs (Geographic Information Systems) | 1. Compare the different COTS GISs and explain their use in interoperability. |
| | 3. Exact Transform Load (ETL) tools | 1. Analyze the different uses of ETL tools (e.g., Safe Software's Feature Manipulation Engine [FME]) for interoperability. |
| **Mastery (M)** | 1. System requirements | 1. Evaluate the system requirements necessary to allow developers to expand system offerings and to support the work of IT professionals. |
| **T2. Data Management and Sharing** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Database and file management | 1. Describe how to create, move, share, modify, remove, and delete data and files in a typical file sharing system. |

| Geospatial Data Management (GDM) | | |
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| | | 2. Describe fundamental database management concepts (e.g., cloud storage, file transfers and backups, encryption, file naming conventions and protocols, etc.).<br>3. List the functions of common geodatabases as they relate to data sharing. |
| **Foundational (F)** | 1. Database and file management | 1. Discuss the process of creating, moving, sharing, modifying, removing, and deleting data and files in a database.<br>2. Summarize the principles of geodatabase replication and explain its role in data sharing. |
| | 2. Relational Database Management System (RDBMS) | 1. Describe the purpose of a RDBMS and its impact on maintaining and sharing data. |
| | 3. Bandwidth | 1. Summarize bandwidth considerations that should be considered when sharing data (e.g., uploads, downloads, the first responder's data, etc.). |
| **Application (A)** | 1. Environment development | 1. Differentiate the best methods used to develop an environment that allows for optimal learning in the context of sharing data. |
| | 2. Data sharing | 1. Demonstrate how to share data by writing REpresentational State Transfer (REST) and Simple Object Access Protocol (SOAP) services and the frequency of revisions. |
| | 3. RDBMS | 1. Outline the process of RDBMS replication. |
| **Mastery (M)** | 1. Automation | 1. Evaluate current methods of data sharing automation to develop more efficient automation techniques. |
| | 2. Enterprise application integration | 1. Evaluate the different enterprise application integration tools (e.g., MuleSoft) and explain their role in data sharing. |
| **T3. Common Data Dictionary** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Definitions | 1. Identify how terminology is defined in the common data dictionary and explain how definitions are disseminated. |
| **Foundational (F)** | 1. Attribute | 1. Summarize what information and attributes make up a common data dictionary.<br>2. List the differing principle between entities and attributes. |
| | 2. NSDI | 1. Discuss the impact of the NSDI guidelines on common data dictionaries. |

| Geospatial Data Management (GDM) | | |
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| **Application (A)** | 1. Definitions | 1. Explain the importance of definitions, naming conventions, and values for establishing a common data dictionary. |
| **Mastery (M)** | 1. Descriptions | 1. Develop a design process to establish dictionary element descriptions. |
| **T4. Naming Conventions** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Supported naming conventions | 1. List the supported naming conventions for underlying databases. |
| | 2. Fundamental language | 1. Describe fundamental language and naming conventions within databases (e.g., upper case, lower case, camel case, and underscores). |
| **Foundational (F)** | 1. End users | 1. Discuss different end users and explain how they will use datasets. |
| | 2. Databases | 1. Summarize the basic principles of databases and explain the importance of each as it relates to naming conventions.<br>2. Demonstrate how to use databases and explain the impact of choosing a naming convention. |
| | 3. NSDI | 1. Summarize the impact of the NSDI guidelines on naming conventions. |
| | 4. Advantages and disadvantages | 1. Compare the advantages and disadvantages of utilizing naming conventions, and how they impact the professional field.<br>2. Explain how naming conventions can be used to make working with data easier. |
| **Mastery (M)** | 1. Automated naming | 1. Design techniques that can automate naming to improve efficiency when working with data. |
| **T5. Minimum Schema** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Schemas and geodatabases | 1. Describe the utilization of a schema in geospatial databases. |
| **Foundational (F)** | 1. Simple and complex geodatabase schemas | 1. Discuss the different principles for simple and complex geodatabase schemas. |
| **Application (A)** | 1. Geodatabase schema creation | 1. Categorize geodatabase schemas (e.g., ESRI, Hexagon, Intergraph, etc.) and understand the advantages and disadvantages of each.<br>2. Create geodatabase schemas and assess mistakes. |
| **Mastery (M)** | 1. Schema development | 1. Establish how to develop schemas that are simple yet fulfill requirements. |

| Geospatial Data Management (GDM) | | |
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| | | 2. Discuss how the principle of parsimony relates to schema development. |
| **T6. Data Normalization** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. RDBMS | 1. Describe the concepts of RDBMS. |
| | 2. Redundancy | 1. Define what unwanted redundancy is and the benefits of removing it from a table design. |
| **Foundational (F)** | 1. Redundancy | 1. List the rules used to detect excessive redundancy in table design and explain when they apply. |
| | 2. Data normalization process | 1. Discuss how to normalize data and explain why data normalization is important. |
| **Application (A)** | 1. NSDI | 1. Explain how the NSDI standards and guidelines apply to data normalization. |
| **Mastery (M)** | 1. Data normalization process | 1. Evaluate the methods for using Voronoi polygons, Thiessen polygons, and Dirichlet regions when applying to data normalization. |
| **T7. Conceptual Database Models** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Requirements | 1. Identify the requirements of conceptual database models. |
| | 2. Entities and attributes | 1. Describe how entities are formed from objects and how the entities' attributes are analyzed. |
| | 3. Data modeling tools | 1. List different data modeling tools and explain their uses. |
| | 4. Visually and non-visually representable models | 1. Recognize the difference between visually and non-visually representable conceptual database models.<br>2. Recall the advantages and disadvantages of various conceptual database models. |
| **Foundational (F)** | 1. ERD | 1. Summarize how ERD notation is used when developing database models. |
| | 2. Entities and attributes | 1. List the different entities and attributes used for conceptualizing database models. |
| | 3. Data flow modeling | 1. Discuss the key concepts of data flow modeling and explain their roles in database modeling. |
| **Application (A)** | 1. System design | 1. Explain how different schemas are converted into a system design. |

| Geospatial Data Management (GDM) | | |
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| **Mastery (M)** | 1. Object-oriented programming (OOP) languages | 1. Evaluate the benefits and limitations of using OOP languages to establish standards of application to database modeling. |
| | 2. Model implementation | 1. Design techniques for converting conceptual models into usable products. |
| **T8. Logical Database Models** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Logical and conceptual database models | 1. Describe how logical database models are based on conceptual database models. |
| | 2. Database schema | 1. Define database schema and describe how it relates to logical database models. |
| | 3. Normalization | 1. Identify how data normalization is different when applied to logical database models. |
| | 4. Entities and attributes | 1. List the different entities and attributes used for logical database models. |
| | 5. Impact analysis | 1. Describe how to perform impact analysis on logical database models. |
| | 6. Data modeling tools | 1. Outline the different data modeling tools used for logical database models. |
| | 7. Visually and non-visually representable models | 1. Explain the difference between visually and non-visually representable logical database models.<br>2. Identify the advantages and disadvantages of various logical database models. |
| **Foundational (F)** | 1. ERD | 1. Summarize how ERD notation is used when developing logical database models. |
| | 2. Entities and attributes | 1. List the different entities and attributes used for logical database models. |
| | 3. Data flow modeling | 1. Outline the key concepts of data flow modeling and explain their roles in logical database modeling. |
| **Application (A)** | 1. System design | 1. Explain how different schemas are converted into a system design in relation to logical database models. |
| **Mastery (M)** | 1. OOP languages | 1. Evaluate the benefits and limitations of using OOP languages to design methods for structuring and managing logical database models. |
| **T9. Physical Database Models** | | |
| | Matrix Subtopic | Learning Objective(s) |

| Geospatial Data Management (GDM) | | |
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| **Prerequisites (P)** | 1. Physical and logical database models | 1. Describe how physical database models are based on logical database models. |
| | 2. Database design | 1. Describe the concepts of database design and how each is used in physical database modeling. |
| | 3. Database storage | 1. List the concepts of database storage and how each is used in physical database modeling. |
| | 4. Database performance | 1. State the concepts of database performance and when it is best to use the different types of physical database models. |
| | 5. Data modeling tools | 1. Name the different data modeling tools and describe how they are used in physical databases. |
| **Foundational (F)** | 1. ERD | 1. Summarize how ERD notation is used when developing physical database models. |
| | 2. Entities and attributes | 1. List the different entities and attributes used for physical database models. |
| | 3. Data flow modeling | 1. Outline the key concepts of data flow modeling and explain their roles in physical database modeling. |
| **Application (A)** | 1. System design | 1. Explain how different schemas are converted into a system design in relation to physical database models. |
| **Mastery (M)** | 1. OOP languages | 1. Evaluate the benefits and limitations of using OOP languages in physical database modeling. |
| | 1. Database design | 1. Refine the database design in response to data or changes in purpose. |
| **T10. Schema Design/Creation** | | |
| | Matrix Subtopic | Learning Objectives(s) |
| **Prerequisites (P)** | 1. Database schemas | 1. Describe how the purpose of data influences which schema design will be used and how the data is created. |
| | 2. User feedback | 1. List the different types of user feedback that can be provided on schema design. |
| **Foundational (F)** | 1. Schema creation process | 1. Discuss how schemas are created and why schemas are useful when managing data. |
| | 2. Schema design types | 1. List the different types of schema designs and explain their uses. |
| **Application (A)** | 1. GIS Software | 1. Explain how GIS software is used to view existing schemas and how to create new schemas. |

| Geospatial Data Management (GDM) | | |
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| | 2. Data modeling tools | 1. Explain how different data modeling tools are utilized to design and create schemas. |
| **Mastery (M)** | 1. Automation | 1. Evaluate current methods of designing and creating schemas and determine how automation can be used to expedite the process. |
| | 2. Templates | 1. Evaluate current methods for using templates to design and create schemas to develop more effective templates. |
| | 3. Data modeling tools | 1. Develop techniques of using data modeling tools to manage the design and creation of schemas. |
| **T11. Types of Databases** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Database schemas | 1. Identify the uses and purposes of database schemas. |
| | 2. Entities and attributes | 1. Define entities and attributes and describe their roles in databases. |
| **Foundational (F)** | 1. Database types | 1. Summarize the following database types and explain how each is used:<br>● Hierarchical databases<br>● Network databases<br>● Sequential databases<br>● Relational databases<br>● Non-relational databases |
| **Application (A)** | 1. Semantic databases | 1. Deduce when semantic databases should and should not be used. |
| **Mastery (M)** | 1. Object-oriented databases | 1. Evaluate current methods of constructing an object-oriented database to develop more efficient methods. |
| | 2. OOP languages | 1. Evaluate the benefits and limitations of using OOP languages for each of the different database types. |
| **T12. Distributed Databases (DDBs)** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Limitations | 1. Identify the current limitations and scaling issues of distributed databases (DDBs) (e.g., access restrictions, costs, synchronization, replication, storage, services, etc.). |
| | 2. Data transfer | 1. Show in-depth knowledge of data transfer from the basic to advanced level (e.g., services vs. delivery). |

| Geospatial Data Management (GDM) | | |
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| | 3. Scripting languages | 1. List the various scripting languages used in DDBs.<br>2. Describe the use of scripting languages for parallelism in DDBs. |
| **Foundational (F)** | 1. Data placement options | 1. Explain the different data placement options and explain how each is used in DDBs. |
| | 2. Transparencies in DDBs | 1. Summarize the various transparencies in DDBs. |
| | 3. Two-phase commit | 1. Explain the concept of two-phase commit and summarize how it is used in DDBs. |
| | 4. Global deadlock detection | 1. Discuss how to use global deadlock detection in the context of DDBs. |
| **Application (A)** | 1. Enterprise application integration tools | 1. Compare/contrast the different types of enterprise application integration tools (e.g., MuleSoft) and explain their role in DDBs. |
| | 2. RESTful tools | 1. Differentiate among the different types of RESTful tools and explain when each should be used with DDBs. |
| **Mastery (M)** | 1. Data storage | 1. Evaluate the current methods for storing and managing distributed data across cloud platforms to design more efficient methods to store and manage data. |
| | 2. Limitations | 1. Assess the common limitations associated with remote data (e.g., bandwidth, synchronization, storage, services, etc.) to design methods of improving the use of remote data in DDBs. |
| **T13. Querying** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Query languages | 1. Identify the purpose and function of various query languages (e.g., Structure Query Language [SQL]). |
| | 2. SQL | 1. Describe basic SQL concepts including the purpose of SQL, how SQL functions, how to read and write SQL, and the benefits of SQL over ad-hoc queries. |
| | 3. Analytical skills | 1. List basic analytical skills including building queries, analyzing results of queries, categorization of data, and normalization of data. |
| **Foundational (F)** | 1. Proficiency with SQL | 1. Summarize basic SQL skills including building queries, analyzing results of queries, categorization of data, and normalization of data. |

| Geospatial Data Management (GDM) | | |
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| | 2. SQL and Python | 1. List the basic syntax used for SQL and Python and the purpose of each. |
| **Application (A)** | 1. SQL extensions | 1. Compare/contrast different data searching extensions to standard SQL and explain when to use each. |
| | 2. SQL and Python | 1. Explain when it is necessary to use SQL and Python for querying data. |
| **Mastery (M)** | 1. Not only SQL (NoSQL) | 1. Evaluate current methods of utilizing NoSQL when performing data searches and determine how the methods should be improved. |
| | 2. eXtensible Markup Language (XML) Query (XQuery) | 1. Evaluate current methods of utilizing XQuery when performing data searches and determine how the methods should be improved. |
| | 3. SQL-based data management tools | 1. Evaluate current and new SQL-based data management tools (e.g., MemSQL) and develop standards of when each tool should be used. |
| | 4. Innovation | 1. Design innovative methods and techniques for implementing different query tools. |
| **T14. Big Data Management** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Limitations | 1. Name the limitations of common tools and software when applied to big data (e.g., storage, data processing, etc.). |
| | 2. Volatility | 1. Describe how the volatility of data (e.g., the rate of change) changes in different scenarios of big data management. |
| | 3. Enterprise processing capacity | 1. Describe the concept of enterprise processing capacity and how it relates to big data management. |
| **Foundational (F)** | 1. Volume, velocity, and variety | 1. Define volume, velocity, and variety in relation to big data management. |
| **Application (A)** | 1. NoSQL | 1. Explain how big data applications have contributed to the growth of NoSQL databases. |
| | 2. Big data tools | 2. Assess common big data tools and their applications. |
| **Mastery (M)** | 1. NoSQL | 1. Evaluate how NoSQL is utilized in big data management and determine how NoSQL can be used more effectively. |
| | 2. AI | 1. Propose techniques for how AI can be applied to big data management. |

| Geospatial Data Management (GDM) | | |
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| | 3. Data aggregation | 1. Evaluate the principles of data aggregation and define more efficient and effective methods for application to big data. |
| **T15. Storage and Retrieval Principles** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Data sharing and data delivery | 1. Describe data sharing and data delivery and recognize their differences. |
| | 2. Data maintenance | 1. Describe why it is important for the creator of data to also maintain the data and list possible implications if the creator is not the maintainer. |
| **Foundational (F)** | 1. Archiving and tiered storage | 1. Distinguish between the archiving and tiered approaches to storing data. |
| | 2. Metadata | 1. Outline the techniques of using metadata to retrieve data. |
| **Application (A)** | 1. SQL | 1. Differentiate when it is and is not appropriate to use SQL for data retrieval. |
| | 2. RESTful | 1. Differentiate when it is and is not appropriate to use RESTful services for retrieving and disseminating data.<br>2. Assess how RESTful services are utilized for accessing and retrieving data. |
| | 3. Local and cloud storage | 1. Differentiate between local storage and cloud storage and explain when each should be used. |
| | 4. Off-site back-ups | 1. Differentiate among the different types of off-site back-ups and characterize when each type should and should not be used. |
| | 5. Automation | 1. Evaluate current methods of retrieving data and determine how automation can be used to expedite the process. |
| **Mastery (M)** | 1. On-site, off-site, and near-site storage | 1. Create standards for when on-site, off-site, and near-site storage options should be used.<br>2. Evaluate the issues associated with on-site, off-site, and near-site storage options to develop more efficient and effective storage options. |
| | 2. Automation | 1. Utilize automation to expedite the data retrieval process. |
| **T16. User and Role Management** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Fundamental user access management | 1. Describe fundamental user management concepts (e.g., cloud storage, file transfers and |

| Geospatial Data Management (GDM) | | |
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| | | backups, encryption, file naming conventions and protocols, etc.). |
| **Foundational (F)** | 1. Customer types | 1. List different types of customers a professional may encounter when performing user and role management duties. |
| **Application (A)** | 1. User and group permissions | 1. Differentiate between the permissions provided to users and those provided to groups.<br>2. Explain how to create users and group permissions when managing data. |
| **Mastery (M)** | 1. Automation | 1. Evaluate current methods of user and role management to define methods of automating the process for higher efficiency. |
| **T17. Schema Design/Creation** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Data purpose | 1. Recognize how the purpose of data influences which schema design will be used and how the data is created. |
| | 2. User feedback | 1. Describe the different types of user feedback that can be provided on schema design. |
| **Foundational (F)** | 1. Schema creation process | 1. Summarize how schemas are created and why schemas are useful when managing data. |
| | 2. Schema design types | 1. List the different types of schema designs and explain their uses. |
| **Application (A)** | 1. GIS software | 1. Explain how GIS software is used to view existing schemas and how to create new schemas. |
| | 2. Data modeling tools | 1. Explain how different data modeling tools are utilized to design and create schemas. |
| **Mastery (M)** | 1. Automation | 1. Evaluate current methods of designing and creating schemas and determine how automation can be used to expedite the process. |
| | 2. Templates | 1. Evaluate current methods for using templates to design and create schemas to develop more effective templates. |
| | 3. Data modeling tools | 1. Develop techniques of using data modeling tools to manage the design and creation of schemas. |
| **T18. Analysis Resulting in Metrics** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Spatial statistics | 1. Describe the basic concepts of spatial statistics including Root Mean Square Error (RMSE) testing, Chi-squared testing, spatial |

| Geospatial Data Management (GDM) | | |
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| | | autocorrelation, correlation vs. causation, and 2D/3D regression and correlation analysis. |
| **Foundational (F)** | 1. Spatial autocorrelation | 1. Explain the purpose of spatial autocorrelation and how the results are utilized. |
| | 2. Standard geoprocessing tools and methods | 1. Summarize how the most common tools and methods are used in data analysis (e.g., feature overlays, selections, topological processes, raster processes, and data conversion). |
| | 3. Analytical scripting languages | 1. Explain how different analytical scripting languages (e.g., JavaScript) are used in data analysis. |
| | 4. Spatial Statistics | 1. Discuss how spatial statistic results are utilized to manage data. |
| | 5. Programming languages | 1. Compare various programming languages (e.g., R and Python) and how they are used to script geospatial analysis. |
| **Mastery (M)** | 1. Data science | 1. Evaluate standard data science principles and practice to determine how data science can be applied to data management. |
| | 2. Data aggregation | 1. Design techniques for aggregating data using Voronoi polygons, Thiessen polygons, and Dirichlet regions. |
| **T19. Archiving Data** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Data archiving basics | 1. Describe the importance of tape backups, maintaining previous versions, and deleting unnecessary files when archiving data. |
| **Foundational (F)** | 1. Data storage techniques | 1. List the different data storage techniques and explain their roles in archiving data. |
| | 2. Collaboration | 1. Summarize the benefits of collaborating with IT (Information Technology) professionals when archiving data. |
| | 3. Metadata | 1. Outline the techniques of using metadata to retrieve data. |
| **Application (A)** | 1. Archiving requirements | 1. Differentiate the requirements that should be considered when archiving data. |
| | 2. Expiration policies | 1. Decide how long data should be available (e.g., expiration policies) based on the type of data and its intended use. |

| Geospatial Data Management (GDM) | | |
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| | 3. Automation | 1. Evaluate current methods of archiving data and determine how automation can be used to expedite the process. |
| | 4. AI | 1. Evaluate current techniques for classifying needs for access and determine how AI can be used to expedite the process. |
| **Mastery (M)** | 1. Automation | 1. Utilize automation to expedite the data archiving process. |
| | 2. AI | 1. Utilize AI to expedite the process of classifying needs for access. |
| **T20. Metadata Maintenance** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Metadata basics | 1. Define metadata and describe when and how it is used. |
| **Foundational (F)** | 1. Standards | 1. Summarize why it is important to understand the NSDI standards and guidelines when performing metadata maintenance.<br>2. Summarize why it is important to understand the Federal Geographic Data Committee (FGDC) metadata standards. |
| | 2. Standardized geospatial data exchange formats | 1. List the different standardized geospatial data exchange formats and explain how they are used to present metadata. |
| | 3. Data provenance | 1. Discuss data provenance and why it is an important element of metadata. |
| **Application (A)** | 1. Standards | 1. Differentiate which NSDI standards and guidelines relate to metadata maintenance.<br>2. Explain how each of the FGDC metadata standards influence metadata maintenance.<br>3. Explain how Open Geospatial Consortium (OGC) standards are applied to metadata maintenance. |
| **Mastery (M)** | 1. Global Spatial Data Infrastructure (GSDI) | 1. Evaluate the importance, purpose, and uses of the GSDI. |
| | 2. Standards | 1. Establish methods for ensuring FGDC standards for metadata are followed, especially when sharing geospatial data.<br>2. Establish methods for ensuring the OGC standards for metadata maintenance are followed. |
| **T21. Data Privacy and Confidentiality** | | |

| Geospatial Data Management (GDM) | | |
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| | Matrix Subtopic | Learning Objective(s) |
| **Foundational (F)** | 1. Privacy and confidentiality | 1. Compare data privacy and data confidentiality.<br>2. Discuss basic concepts of ethics as they relate to data privacy and confidentiality.<br>3. Discuss the importance of privacy and confidentiality as they relate to data collection, storage, and sharing. |
| | 2. Laws | 1. List and summarize the different laws that deal with data privacy and confidentiality (e.g., Health Insurance Portability and Accountability Act of 1996 [HIPAA] and General Data Protection Regulation [GDPR]). |
| | 3. Personally Identifiable Information (PII) | 1. Summarize the concept of PII and explain why it is important when considering data privacy and confidentiality. |
| | 4. Institutional policies | 1. Summarize the common data privacy and confidentiality policies and why it is important that policies change based on the ability of the institution. |
| **Application (A)** | 1. Laws | 1. Differentiate the various laws that deal with data privacy and confidentiality (e.g., HIPAA and GDPR). |
| | 2. PII | 1. Explain what constitutes PII and when PII should and should not be shared. |
| **Mastery (M)** | 1. Advanced study of ethics | 1. Demonstrate high-level understanding of the importance of ethics when dealing with data privacy and confidentiality. |
| **T22. Data Encryption** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Principles of encryption | 1. Define the principles of data encryption (e.g., obfuscation, encryption methods, public key vs. private key, etc.). |
| **Foundational (F)** | 1. Public and private key | 1. Compare public key and private key encryption and why each method is used. |
| | 2. Encryption tools | 1. List some of the different commercially available data encryption tools and explain their uses. |
| | 3. Common policies | 1. Summarize common policies that dictate how data encryption is used. |
| | 4. Cryptography | 1. Define cryptography |

| Geospatial Data Management (GDM) | | |
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| **Application (A)** | 1. Restrictions | 1. Explain which restrictions apply when exporting encryption tools internationally. |
| | 2. Reverse proxies | 1. Explain when reverse proxies should and should not be used when encrypting data. |
| | 3. Cryptography | 1. Outline various applications of cryptography. |
| | 4. Secure Sockets Layer (SSL) | 1. Assess when SSL technology should and should not be used when encrypting data. |
| | 5. JavaScript Object Notation (JSON) Web Token (JWT) | 1. Decide when it is and is not appropriate to encrypt a JSON JWT. |
| **Mastery (M)** | 1. Cryptography | 1. Evaluate current methods of encrypting data and determine how cryptography can be used to improve these methods. |
| | 2. Geo-blocking | 1. Assess how geo-blocking can be used to improve current data encryption techniques. |
| **T23. Database Security Ethics** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Database access | 1. Explain the basic concepts of database access. |
| **Foundational (F)** | 1. Knowledge of customers | 1. Summarize what customer considerations should be addressed when accessing database security (e.g., customers access to secure data). |
| | 2. Knowledge of institutional policies | 1. Summarize the common database security policies and why it is important that policies change based on the ability of the institution. |
| **Application (A)** | 1. Automation | 1. Evaluate current database security techniques and determine how automation can be used to expedite the process. |
| **Mastery (M)** | 1. Automation | 1. Evaluate current database security techniques and determine how automation can be used to expedite the process. |
| | 2. Ethics | 1. Establish standards for teaching and implementing advanced ethics principles. |
| **T24. Mechanisms of Compromise and Risk Management** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. User authorization | 1. Describe the purpose of user authorization.<br>2. Identify when user authorization should be granted or denied. |
| | 2. User access methods | 1. Recall the different types of user access methods. |

| Geospatial Data Management (GDM) | | |
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| | 3. User roles | 1. Describe the different roles that users can have when working with data (e.g., viewer, publisher, and administrator). |
| **Foundational (F)** | 1. Keyboard loggers | 1. Explain what keyboard loggers are and how they are installed. |
| | 2. Routing and wireless equipment | 1. Summarize techniques for adding routing and wireless equipment. |
| | 3. Connection types | 1. Discuss how to connect different types of computing devices properly (e.g., wired connections vs. wireless connections). |
| | 4. Knowledge of institutional policies | 1. Summarize common policies that influence the mechanisms of data compromise.<br>2. Summarize the risk management policies for various institutions. |
| | 5. Trust and privacy | 1. Compare the concepts of trust and privacy and explain how they prevent data from being compromised. |
| **Application (A)** | 1. Methods of detection | 1. Compare/contrast different methods of detecting data compromised by phishing, spoofing, and human agent activities. |
| | 2. Internal and external threats | 1. Differentiate between internal vs. external threats to data and explain how they can compromise data. |
| | 3. Information Technology Infrastructure Library (ITIL) framework | 1. Outline the five stages of the ITIL risk management process and summarize the purpose of each phase. |
| | 4. Consequent and outcome risk | 1. Differentiate between consequent risks and outcome risks about the data. |
| **Mastery (M)** | 1. Theory of risk management | 1. Evaluate the theory of risk management and explain why it is implemented in data risk management. |
| **T25. Common Programming Languages** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Units | 1. Define a bit and a byte and describe the purpose of each. |
| | 2. Languages | 1. List the different types of structured programming languages.<br>2. List the different types of query languages.<br>3. List the different types of scripting languages.<br>4. List the different types of schema languages. |
| | 1. Pseudocode and flow | 1. Summarize the purpose of pseudocode and flow diagrams. |

| Geospatial Data Management (GDM) | | |
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| **Foundational (F)** | | 2. Summarize the concept of flow control and why it is important when programming. |
| | 2. Counters | 1. Summarize the purpose of a counter and why it is important when programming. |
| | 3. Loops | 1. List and summarize the types and purpose of loops (e.g., Do [counter] and Do [while condition true]). |
| | 4. Conditional statements | 1. List and summarize the types of conditional statements (e.g., If and Else If [ElseIf]). |
| | 5. Subroutines | 1. Summarize the purpose of a subroutine and why it is important when programming. |
| | 6. Scripting and programming | 1. Summarize the relationship between scripting and programming. |
| | 7. Applications | 1. Summarize what an application is, and the role Application-Program Interfaces (APIs) have. |
| | 8. Key terms | 1. Define the following terms and summarize how they are used while programming:<br>• Variable<br>• Array<br>• Array depth<br>• Parameter<br>• String<br>• Single precision<br>• Double precision |
| | 9. Variable definition | 1. Summarize the purpose of variable definition and why it is important when programming. |
| | 10. Commenting in code | 1. Summarize the need for and use of commenting in code. |
| | 11. Versioning | 1. Summarize the steps taken during the versioning process. |
| **Application (A)** | 1. Multi-language competency | 1. Demonstrate multi-language competency by comparing and contrasting some of the different types of programming languages. |
| | 2. Variable | 1. Assess the value of a variable at the end of a given snippet of code and the variable's starting value. |
| | 3. Geographic Markup Language (GML) | 1. Distinguish spatial object names from a GML schema. |
| | 4. SQL | 1. Assess the output of a basic SQL query. |

| Geospatial Data Management (GDM) | | |
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| | 5. Pseudocode | 1. Conclude the most appropriate pseudocode statements for performing a given action given a block of text.<br>2. Characterize a block of pseudocode code used to search and replace numbers.<br>3. Characterize a block of pseudocode used to convert latitude and longitude in one format to another. |
| **T26. Application Program Interfaces (APIs)** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. API basics | 1. Define the concept and purpose of APIs. |
| | 2. Common APIs | 1. Outline the principles of the following common APIs:<br>• REST<br>• SOAP<br>• Remote Procedure Call (RPC) |
| | 3. Web programming | 1. Identify the fundamental concepts of web programming (e.g., web services and APIs). |
| | 4. Uniform Resource Identifiers (URIs) and Uniform Resource Locators (URLs) | 1. Describe URIs and URLs and when it is appropriate to use each in web APIs. |
| **Foundational (F)** | 1. XML | 1. Summarize basic concepts of reading and writing in XML in web APIs. |
| | 2. Common APIs | 1. Explain the basic concepts and principles of REST, SOAP, and RPC APIs. |
| **Application (A)** | 1. Graphical User Interface (GUI) | 1. Differentiate techniques used to develop and apply GUI in web APIs. |
| | 2. Common APIs | 1. Compare/contrast the following web APIs, and explain when it is appropriate to use each:<br>• REST<br>• SOAP<br>• RPC |
| | 3. API development | 1. Differentiate between the various techniques used to create advanced APIs, and when it is appropriate to use each method. |
| **Mastery (M)** | 1. API development | 1. Design techniques to create program interfaces for mobile devices using the following:<br>• Android Software Development Kit (SDK)<br>• iOS (Apple) SDK |

| Geospatial Data Management (GDM) | | |
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| | | • Other relevant SDKs (Software Development Kit) (e.g., Java Development Kits and .NET Framework SDKs) |
| | 2. API use cases | 1. Evaluate the advantages and disadvantages of the various APIs to construct new methods of utilizing APIs in varying environments. |
| **T27. Web Services and Web Mapping Services (WMSs)** | | |
| **Prerequisites (P)** | 1. Online mapping services | 1. Describe the major functions of the common online mapping services (e.g., Mapbox, Google, and ArcGIS Online). |
| **Foundational (F)** | 1. Data service types | 1. List the different types of data service (e.g., physical vs. logical) and explain when each is used. |
| | 2. Data service shapes | 1. Discuss the different shapes of data service (e.g., entity vs. library) and explain the importance of each. |
| | 3. Service-Oriented Architecture (SOA) | 1. Summarize SOA and explain its role in web mapping services (WMSs). |
| | 4. File types | 1. List the different web mapping file types, including:<br>• WMS<br>• Web mapping feature (WMF)<br>• Feature layers<br>• Map images<br>• JSON<br>• Geographic JSON (GeoJSON) |
| **Application (A)** | 1. Web services | 1. Explain the role of each of the following services in map service and WMS:<br>• XML<br>• REST<br>• SOAP<br>• RPC |
| | 2. Standards | 1. Assess how OGC standards are applied to map services and WMS. |
| **Mastery (M)** | 1. REST | 1. Evaluate when it is necessary to use REST services when working with mapping services. |

# 1.4 COMPETENCY 4: Data Visualization

**Data Visualization** is a subset of GEOINT that uses cartographic and visualization principles to generate products that represent information about the world and can be easily understood by decision-makers.

**Proficiency Levels:**

- **Prerequisites (P) –** Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A) –** Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M) –** Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| **Data Visualization (DV)** | | |
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| **T1. Precision and Accuracy** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Precision and accuracy | 1. Describe the difference between precision and accuracy and how each impact data visualization. |
| | 2. Cartography | 1. List the elements and principles of basic cartographic design |
| **Foundational (F)** | 1. Scale | 1. Summarize the relationship between scale and the size of a visualization product.<br>2. Define absolute scale and relative scale.<br>3. Understand when it is more appropriate to use an absolute scale vs. a relative scale.<br>4. Summarize why scale is important to map measurement.<br>5. Summarize when each type of scale is used on a map.<br>6. Distinguish between how scale is communicated and how it depicted on a map. |
| | 2. Precision and accuracy | 1. Summarize the similarities and differences among the concepts of uncertainty, precision, accuracy, and scale. |

| Data Visualization (DV) | | |
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| | 3. Cartography | 1. Summarize how elements and principles of cartographic design interact with geospatial datasets during data visualization. |
| **Application (A)** | 1. Scale | 1. Differentiate methods of depicting and implementing scale as a visualization concept.<br>2. Present domain-specific application of scale for a given problem. |
| | 2. Data visualization | 1. Explain implications of choices made while depicting and implementing data visualization. |
| | 3. Generalization | 1. Assess the relationship between generalization and scale.<br>2. Explain how generalization is used for small scales vs. large scales. |
| **Mastery (M)** | 1. Scale | 1. Design new representations and approaches for applying scale to data structures and cartographic products.<br>2. Design new representations and approaches for applying scale to domain-specific applications (e.g., dynamic scales).<br>3. Assess the differences between how relative and absolute scales are talked about and used on maps. |
| | 2. Cartography | 1. Construct multiple visualizations of a map so it may be tailored to fit the needs of several different products. |
| **T2. Color** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Color theory | 1. Describe color theory basics.<br>2. Remember the color wheel and how it relates to data visualization.<br>3. Define complementary and contrasting colors and distinguish between them. |
| **Foundational (F)** | 1. Color models | 1. Summarize the following color models:<br>• Red, green, and blue (RGB)<br>• Hue, saturation, and value (HSV)<br>• Cyan, magenta, yellow, and key (CMYK)<br>• Black and white |
| | 2. Color scale/ramps | 1. Summarize color scales and color ramps. |

| Data Visualization (DV) | | |
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| | 3. Color themes | 1. Summarize color themes for human induced phenomena (e.g., conflict, damaged infrastructure, etc.).<br>2. Connect terrain to commonly used color practices (e.g., water is blue, land is brown/green, etc.). |
| | 4. Color choice | 1. List commonly used band combinations in multispectral imagery and explain how they employ color.<br>2. List common geographic features and explain how they are generally depicted on maps. |
| **Application (A)** | 1. Advanced imagery coloring | 1. Differentiate advanced forms of imagery color display concepts for single-band and multi-band imagery. |
| | 2. Color choice | 1. Interpret and present advanced forms of imagery collected from various platforms that present features in false color.<br>2. Apply commonly used color depiction for several different types of geographic features.<br>3. Develop comprehensive knowledge of graphic design and hierarchy of information with use of color. |
| **Mastery/UGP (M)** | 1. Graphic design | 1. Evaluate knowledge of how color as a graphic design element can be used to create products that are easily understood.<br>2. Design products that visualize imagery using color while layering vector features on top in conjunction with the imagery layer. |
| **T3. Textual Elements** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Font literacy | 1. Possess basic understanding of textual elements as they relate to data visualization, including:<br>• Font families<br>• Serif vs. sans-serif,<br>• Bold, underline, and italics<br>• Font color and size as they relate to data visualization. |

| Data Visualization (DV) | | |
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| **Foundational (F)** | 1. Textual elements | 1. List common map lettering conventions (e.g., country names in all caps).<br>2. List effective title features and principles (e.g., keeping titles short and concise).<br>3. Summarize appropriate feature labeling approaches (e.g., colors, sizes, fonts, etc.).<br>4. Explain best practices in label placement that maximize connection with features and minimize overprinting. |
| **Application (A)** | 1. Textual elements | 1. Use proper distribution and placement of labels, contextual information, etc.<br>2. Demonstrate appropriate use of fonts and typographical emphases (e.g., bold, underline, and italicize) when using text on a map. |
| | 2. Abbreviations | 1. Interpret what common acronyms and initialisms in the GEOINT community stand for and mean.<br>2. Interpret and present advanced abbreviations of text. |
| | 3. Interactivity | 1. Decide when to display text interactively (for interactive maps; scale dependent text, not displaying labels for layers that are currently out of scale). |
| | 4. Naming conventions | 1. Use proper naming conventions. |
| | 5. Industry language | 1. Use proper industry language and decide when it is appropriate to use industry language (e.g., initials and acronyms) based on the end user population. |
| **Mastery (M)** | 1. Text hierarchy | 1. Implement complex text and labeling hierarchy that seamlessly integrates text with feature data. |
| | 2. Textual elements | 1. Integrate various textual options within maps to appropriately convey information to the end user.<br>2. Design methods for simplifying and shortening complex descriptions without compromising an individual's ability to understand the content. |
| **T4. Contrast** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Types of media | 1. Identify different visual media types, including static and interactive products, and describe their differences. |

| Data Visualization (DV) | | |
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| | 2. Visual contrast | 1. Explain the concept that objects can stand out from others.<br>2. Distinguish the visual impact between objects and features.<br>3. Recognize that some visual elements are more eye-catching than others. |
| **Foundational (F)** | 1. Visual contrast | 1. List effective variations in visual contrast (such as complementary colors, brightness, saturation, transparency, size, and position). |
| **Application (A)** | 1. Visual contrast methods | 1. Present proper contrast features (such as drop shadow and blending of colors and features).<br>2. Distinguish between gradients, hatching, and discrete colors.<br>3. Describe methods for blending colors and features and various use cases. |
| **Mastery (M)** | 1. Advanced knowledge of visual contrast | 1. Construct a single map with several overlapping features and differentiate them from one another without compromising information. |
| **T5. Hierarchy, Layout, and Representation** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Foundational (F)** | 1. Layout fundamentals | 1. Possess basic understanding of layout conceptualization to include balance, positioning, and feature relationships. |
| | 2. Visual hierarchy | 1. Explain the concept that the presentation of features on a map implies relative importance which is achieved with visual contrast (e.g., size, color, brightness, etc.).<br>2. Outline effective visual hierarchy features (such as positioning/placement, how to label, justification, and relationship between features). |
| | 3. White space | 1. Explain proper use of empty space and features on a map. |
| | 4. Legend and graphics | 1. Summarize effective legend and graphic placement. |
| | 5. Imagery elements | 1. Summarize how imagery elements (e.g., color, vibrancy, size, and transparency) are used to differentiate main and secondary features/objectives. |

| Data Visualization (DV) | | |
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| **Application (A)** | 1. Map objective | 1. Provide a clear objective of the map.<br>2. Interpret the end user's objective for using a map (e.g., reference tool, information gathering tool, or analytical tool) to determine the best way for the information to be depicted. |
| | 2. White space | 1. Differentiate plain white space from less significant mapped areas. |
| | 3. Cartographic design | 1. Combine multiple and complex graphics, labels, supporting text, legends, and other features on a map without compromising content. |
| | 4. Gestalt principles | 1. Explain Gestalt principles of design (e.g., proximity, similarity, continuity, closure, and figure/ground) and discuss how they apply to cartography. |
| | 5. Representation features | 1. Differentiate among various representation features (e.g., legibility, figure-ground, hierarchy, and balance). |
| **Mastery (M)** | 1. Advanced understanding of hierarchy | 1. Establish methods of sizing features/information, shading features/information, and positioning features/information in an order that will effectively communicate the map's purpose. |
| | 2. Advanced understanding of representation | 1. Evaluate current methods of incorporating numerous features of varying pronounced levels on a map and construct new techniques to mitigate against user error. |
| **T6. Maps** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Map types | 1. Identify different map types (e.g., thematic, reference, topographic, flow, choropleth, cartograms, and image) and describe their similarities and differences. |
| **Foundational (F)** | 1. GEOINT maps | 1. List the different types of maps used in the GEOINT community and explain how each map is used. |
| **Application (A)** | 1. Maps and communication | 1. Differentiate which type of map would best communicate information given the type of data. |
| **Mastery (M)** | 1. Maps and communication | 1. Construct multiple, blended map types to convey the most information without sacrificing content and meaning. |

| Data Visualization (DV) | | |
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| **T7. Graphs** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Types of graphs | 1. List types of graphs (e.g., bar, line, pie, etc.), how to make them, and use cases for each type.<br>2. Identify which graph is best for showing certain types of information. |
| | 2. Graphs and maps | 1. Summarize effective display of graph features like size, importance of the graph, and its relevance to the map. |
| **Application (A)** | 1. Graphs and GEOINT | 1. Differentiate between the common types of graphs used in the GEOINT community and explain how each can be used in a map. |
| | 2. Methods and software | 1. Demonstrate understanding of methods and common software used to incorporate graphs in maps. |
| **Mastery (M)** | 1. Graphs and Maps | 1. Compile and assemble graphs and maps at a mastery level. |
| | 2. Legends | 1. Establish standards for when it is appropriate to merge graphs and legends in order to depict more information on a map. |
| **T8. 3D Representation** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Basic methods | 1. Describe basic concepts of 3D representation (e.g., depth, perception, perspective, and aspect). |
| **Foundational (F)** | 1. Purpose of 3D | 1. Summarize purpose of 3D visualization and when it is appropriate to use. |
| | 2. Delivery methods | 1. Summarize understanding of 3D representation delivery methods (e.g., digital display, static display, and video). |
| | 3. Terrain | 1. Summarize how contour lines can be used to interpret 3D objects.<br>2. Summarize why understanding terrain is important when using or developing a map.<br>3. Outline the modes of visualizing terrain-related natural and social phenomena. |
| **Application (A)** | 1. Graphic design | 1. Differentiate between graphic design principles that add perspective to static products to transform them in 3D products. |

| Data Visualization (DV) | | |
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| **Mastery (M)** | 1. Extrusion and interpolation | 1. Create 3D elements from data that is not inherently 3D (e.g., numerical attributes) to emphasize information. |
| **T9. Interactive Media** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Interactive media types | 1. Describe types of interactive media (e.g., WebMaps, WebApps, Google API (Application Programming Interface), Open Source, JavaScript Maps, and Clickable Standard Vector Graphics [SVGs]). |
| **Foundational (F)** | 1. Network/bandwidth considerations | 1. Identify interactive mapping elements that may be affected by users' network connection and/or bandwidth conditions. |
| | 2. Types of features | 1. Summarize types of features used in interactive mapping (e.g., Keyhole Markup Language [KML], Keyhole Markup Zipped [KMZ], WMS, Web Feature Service [WFS], feature services, image services, and tiling). |
| | 3. Web publication | 1. Summarize how to publish interactive mapping services to the web. |
| **Application (A)** | 1. Security | 1. Differentiate among the various network-specific security features and explain when each may be used. |
| | 2. Permissions | 1. Compare/contrast how to implement layer and map permissions. |
| | 3. Attributes | 1. Explain how to adjust symbols, popup boxes, and other attributes of the web map. |
| | 4. Functionality | 1. Explain how to add functionality to web applications (widgets, etc.). |
| | 5. Standards | 1. Characterize OGC standards and how they impact interactive data visualization. |
| **Mastery (M)** | 1. Customization | 1. Develop custom functions like widgets to add greater functionality to web apps.<br>2. Design customized web applications for interactive maps with the use of Cascading Style Sheets (CSS), Syntactically Awesome Style Sheets (SASS), Leaner Style Sheets (LESS), and other style sheets. |
| | 2. Statistical and analytical tools | 1. Generate interactive charts and graphics using statistical and analytical tools to expand the functionality of maps. |

| T10. Animations | | |
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| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Chronology | 1. Describe the concept of chronology as it relates to visualization (that data can be collected over time and then animated). |
| **Foundational (F)** | 1. Story maps | 1. Identify common types of story maps and explain how each is used to display information. |
| | 2. Types of animation | 1. Summarize types of animation (e.g., spatial movement, time series, and data extrusion). |
| **Application (A)** | 1. Animated narratives | 1. Design products that lead the viewer through a web interface calling attention to new information along the way. |
| **Mastery (M)** | 1. Advanced understanding of animations | 1. Integrate graphics, pictures, and text with a map to produce a more complete product that conveys more information than a traditional map. |
| **T11. Temporal Representation** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Temporal representation fundamentals | 1. Recall temporal representation fundamentals (such as additive time series and interval time series).<br>2. Define exact time and time span and describe how they differ. |
| **Foundational (F)** | 1. Data organization | 1. Recall concepts and principles of temporal data organization. |
| | 2. Normalization | 1. Recall concepts and principles for normalizing data. |
| **Application (A)** | 1. Restrictions and limitations | 1. Explain restrictions of time enabled data and the limitations that may arise. |
| | 2. Information gaps | 1. Discover gaps or missing information in temporal data.<br>2. Discover and troubleshoot inconsistent record keeping (e.g., date and time formats). |
| **Mastery (M)** | 1. Normalization | 1. Establish standards for normalizing time when data has not been collected consistently or accurately. |
| **T12. Elements of a Map** | | |
| | Matrix Subtopic | Learning Objective(s) |

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| **Prerequisites (P)** | 1. Common map elements | 1. List the important elements to include in a map:<br>• North Arrow<br>• Scale<br>• Legend<br>• Sourcing<br>• Title<br>• Projection notation |
| **Foundational (F)** | 1. Formatting | 1. Explain the best practices for incorporating the following into a map:<br>• North arrow<br>• Scale<br>• Legend<br>• Sourcing<br>• Title<br>• Projection notation |
| | 2. Orientation and direction | 1. Explain directionality on a map and fundamentals like rotation and orientation.<br>2. Explain how to use the common North Arrow. |
| **Application (A)** | 1. Element placement | 1. Compare/contrast placement of elements on a map in standard locations in conjunction with each other. |
| **Mastery (M)** | 1. Element placement | 1. Evaluate current standards for using common map elements (e.g., scale, legend, and projection notation) and design new techniques that improve readability and usability of final products.<br>2. Appropriately assess when certain elements are needed or not in a map product. |
| | 2. Orientation and direction | 1. Rearrange orientation of common map displays to adapt a new perspective.<br>2. Generate new map displays that challenge current common practices to adapt to new perspectives. |
| **T13. Symbol Selection** | | |
| | Matrix Subtopic | Learning Objective(s) |

| | | |
|---|---|---|
| **Prerequisites (P)** | 1. Symbology fundamentals | 1. List common symbology used and explain their significance.<br>2. Recall appropriate symbology for natural, manmade, human behavior and natural occurrences.<br>3. Describe the relevance of feature size.<br>4. Describe knowledge of common formats used to symbolize points, lines, and polygons.<br>5. Describe how symbolizing raster datasets differs from symbolizing other datasets. |
| **Foundational (F)** | 1. GEOINT symbology | 1. Compare common GEOINT symbology against other general symbology and explain how and why they differ.<br>2. List types of human behavior and features mapping for GEOINT purposes. |
| **Application (A)** | 1. Symbology best practices | 1. Apply knowledge of best practices for symbolizing features. |
| **Mastery (M)** | 1. Symbology innovation | 1. Develop new symbol selection features to convey new meaning or understanding in an improved way. |
| **T14. Layering** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Feature types and layering | 1. Recognize various feature types like points, lines, and polygons and the purpose of layers. |
| **Application (A)** | 1. Layering best practices | 1. Decide how maps that use raster datasets should be assembled so that primary elements are layered appropriately. |
| | 2. Transparencies | 1. Differentiate when transparencies should and should not be used in a map. |
| **Mastery (M)** | 1. Layering best practices | 1. Construct maps that contain multiple layers without obstructing key information that can be understood by many audiences. |
| **T15. Resolution and Media** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Pixels | 1. Define pixels and describe their role as the smallest unit of information in an image or map. |
| **Foundational (F)** | 1. Scale | 1. Summarize the importance of scale when determining the resolution of features. |
| | 2. Map output | 1. Distinguish among various media for communicating information (printing, screen resolution, and scaling objects). |

| | | |
|---|---|---|
| **Application (A)** | 1. GEOINT | 1. Compare/contrast how maps are visualized in the most common forms of media in the GEOINT community (e.g., computer monitors, mobile devices, tablets, posters, letter pages, etc.). |
| | 2. Technological limits | 1. Differentiate between common graphic limitations and equipment to include printers and screens/displays. |
| **Mastery (M)** | 1. Advanced understanding of resolution and media | 1. Evaluate how to balance image resolution and complexity to deliver high quality products with fewer limitations.<br>2. Design maps that are highly complex but are still viewable/usable at lower resolutions. |
| **T16. Electronic Delivery and Device Limitations** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Common media types | 1. List common media types like computers, tablets, and smartphones, as well as file types, JPEG, PNG, Portable Document Format (PDF), etc., and explain considerations regarding electronic delivery. |
| | 2. Device processors and networks | 1. Recall basic elements of device processors and networks. |
| **Foundational (F)** | 1. Limitations of media delivery | 1. Summarize understanding of the limitations of media delivery like bandwidth, security, and size restrictions. |
| | 2. Connectivity | 1. Summarize how device and network connectivity varies based on devices and location. |
| **Application (A)** | 1. Limitations of media delivery | 1. Compare/contrast media delivery methods, what limitations each delivery method has, and how to overcome those limitations. |
| | 2. Network restrictions | 1. Apply knowledge of common restrictions with networks. |
| | 3. Security parameters | 1. Apply knowledge of security parameters with networks. |
| **Mastery (M)** | 1. Innovation | 1. Improve the current systems in place for media delivery. |
| | 2. Bandwidth | 1. Show the best method of transmitting a product over low bandwidth connections. |
| **T17. Resolution of Product** | | |
| | Matrix Subtopic | Learning Objective(s) |

| | | |
|---|---|---|
| **Prerequisites (P)** | 1. Pixels | 1. Describe basic concepts relating to pixels (e.g., resolution and history of picture elements). |
| **Foundational (F)** | 1. Delivery methods | 1. Discuss how different delivery methods impact resolution (i.e., printed vs. digital). |
| | 2. Knowledge of displays | 1. List and summarize the uses of different hardware display systems. |
| | 3. Common printer limitations | 1. Distinguish between common printer limitations to include printer size and print job quality. |
| **Application (A)** | 1. End user resolution | 1. Verify a product (i.e., static or interactive) is usable given the resolution the end user will be using (e.g., printed, cell phone, computer, projector, etc.). |
| **Mastery (M)** | 1. Resolution and multiple platforms | 1. Design products that are viewable across multiple platforms and resolutions. |
| **T18. Extended Reality** | | |
| | Matrix Subtopic | Learning Objective(s) |
| **Prerequisites (P)** | 1. Limitations | 1. List the benefits and limitations of virtual and augmented reality (VR/AR). |
| | 2. Virtually displaying geospatial data | 1. Outline the various methods and modes of virtually displaying geospatial data. |
| | 3. Visualization tools | 1. Describe the importance of visualizing data and list commonly used visualization tools (e.g., ArcGIS Online, D3.js, MapBox, Tableau, etc.). |
| | 4. Databases | 1. Define relational and non-relational database technologies and describe their differences. |
| **Foundational (F)** | 1. Virtually displaying geospatial data | 1. Outline how geospatial data is combined with other domains to create virtual visualization. |
| | 2. Designing a geospatial underpinning | 1. Summarize how to design a geospatial underpinning for VR/AR. |
| | 3. Designing, testing, and debugging | 1. Summarize how to design, test, and debug software applying core VR/AR methodologies. |
| **Application (A)** | 1. Projection, transformations, and accuracies | 1. Explain the projection, transformations, and accuracies of geospatial data. |
| | 2. Limitations | 1. Analyze the advantages and limitations of displaying geospatial data virtually. |
| | 3. Virtually displaying geospatial data | 1. Evaluate how multiple data sources should be synthesized to create a virtual display. |

| | | |
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| **Mastery (M)** | 1. VR/AR system design | 1. Design a VR/AR system with geospatial information as the base. |

# PART II: CROSS-FUNCTIONAL COMPETENCIES

**Cross-Functional competencies** describe the multitude of non-technical skills a student needs when entering the workforce. Cross-functional competencies are comprised of knowledge and skills that transcend specific technical skills and are found across the full scope of practice. Cross-functional GEOINT knowledge, skills, and abilities reflect:

- Qualitative non-technical or "soft skills" used by most GEOINTers
- Unique aspects of the GEOINT tradecraft applicable to the majority of practitioners
- Common GEOINT knowledge and practices that, if followed, will improve the performance of a practitioner

**Proficiency Levels:**

- **Prerequisites (P) –** Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A) –** Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M) –** Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| **Cross-Functional Knowledge and Skills** | | |
|---|---|---|
| **2.1 Critical Thinking** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Critical thinking basics | 1. Understand what makes a claim true or false.<br>2. Identify statements that lack support and those that possess supporting evidence.<br>3. Describe why they believe something to be true or false and use examples to support their stance. |
| **Foundational (F)** | 1. Critical thinking fundamentals | 1. Summarize, understand, and employ the following critical thinking concepts:<br>• Identifying evidence<br>• Evaluating evidence<br>• Inferences<br>• Logical connectives<br>• Common errors in reasoning<br>2. Elevate reasoning and critical thinking to the next level by more deeply exploring |

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| | | pieces of writing, evidence-based claims, and statements of facts. |
| | 2. Bias | 1. Understand the role that bias plays in critical thinking and decision-making.<br>2. Define, understand, and identify the following types of biases:<br>• Cognitive bias<br>• Conformity bias<br>• Affinity bias<br>• Confirmation bias<br>• Implicit bias<br>• Halo effect<br>• Horns effect<br>• Contrast effect<br>3. Discuss how these various types of biases can impact work and outcomes. |
| **Application (A)** | 1. Communication | 1. Assess arguments and claims and identify their strengths and weaknesses.<br>2. Evaluate multiple perspectives on opinion-based, philosophical, theoretical, and evidence-based arguments and statements.<br>3. Develop ideas about a given topic and apply old ideas to new situations or in new combinations. |
| | 2. Analysis | 1. Interpret and apply information into meaningful concepts and ideas.<br>2. Interpret a set of facts, discern patterns or trends, and differentiate the consequences of action relevant to the user. |
| | 3. Problem solving | 1. Separate (identify, define, and decompose) problems into parts to facilitate a search for a solution.<br>2. Outline the primary requirements that shape the solution.<br>3. Analyze the recipient/end user characteristics to focus on the solution.<br>4. Analyze any constraints that impact the solution. |
| | 4. Bias | 1. Identify and compensate for bias when performing analysis. |

<table>
<tr><th colspan="3">Cross-Functional Knowledge and Skills</th></tr>
<tr><td rowspan="3">Mastery (M)</td><td>1. High-level problem solving</td><td>1. Consider an issue, problem, set of data, or a text and evaluate information, its meaning and representation by:<ul><li>Asking thoughtful questions</li><li>Performing data analysis</li><li>Seeking information</li><li>Performing interpretation</li><li>Using proper judgment</li><li>Questioning evidence</li><li>Recognizing differences and similarities</li><li>Maintaining a level of skepticism</li></ul>2. Test conclusions and solutions by re-examining approaches to reduce errors and bias, while ensuring end goals are met.<br>3. Evaluate a problem, develop a solution, plan to implement, and verify with a follow-up assessment by/through:<ul><li>Applying standards</li><li>Paying attention to detail</li><li>Clarification</li><li>Collaboration</li><li>Decision-making</li><li>Evaluation</li><li>Identifying patterns</li><li>Innovation</li><li>Logical reasoning</li></ul></td></tr>
<tr><td>2. Communication</td><td>1. Effectively convey conclusions to decision-makers or a group of colleagues and work with others to evaluate and develop solutions to complex problems by:<ul><li>Asking critical questions</li><li>Performing logical argumentation</li><li>Collaboration and teamwork</li><li>Expressing opinions and ideas</li><li>Interpersonal communication</li><li>Understanding the audience</li><li>Presentation</li></ul></td></tr>
<tr><td>3. Ethics in application</td><td>1. Integrate skills related to critical thinking, reasoning, bias, analysis, and communication in an ethical manner.</td></tr>
<tr><td colspan="3">2.2 Reporting and Dissemination</td></tr>
</table>

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Written and oral reporting | 1. Recall basics of language conventions of spelling, punctuation, and grammar.<br>2. Outline and use organizational style guides and protocols. |
| **Foundational (F)** | 1. Delivery methods | 1. Understand the difference between various delivery methods, including but not limited to, memos, reports, and briefs.<br>2. Identify the characteristics/components of each delivery method. |
| **Application (A)** | 1. Written reporting | 1. Present ideas, information, and facts clearly and appropriately.<br>2. Produce products according to the organization, industry, and/or professional standards.<br>3. Produce products without bias and misinformation.<br>4. Provide synthesized recommendations to produce improved products, services, and processes.<br>5. Write memos that are relevant, organized logically, accurate, and succinct.<br>6. Prepare written reports that are thorough, address the proper audience, and are fully formed by credible and peer-reviewed sources.<br>7. Add and incorporate relevant and appropriate graphic and visual information. |
| | 2. Oral reporting | 1. Provide verbal communication tailored to intended purpose and audience.<br>2. Prepare and deliver briefs that are concise, clear, confident, and well prepared.<br>3. Add and incorporate relevant and appropriate graphic and visual information. |
| | 3. Graphic reporting | 1. Provide graphic and visual products that are relevant, organized, logical, and accurate.<br>2. Prepare graphic and/or visual products that are thorough, address the proper audience, and are fully formed by credible and peer-reviewed sources. |

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| **Mastery (M)** | 1. Communication studies | 1. Understand how to communicate various topics to many types of audiences.<br>2. Combine multiple delivery methods based on needs and ability of audience.<br>3. Translate highly technical information for a broad audience, including for use on social media.<br>4. Assess how different groups of people interpret information in unique ways. |
| | 2. Technical review | 1. Provide technical review of written and oral communications to account for purpose, audiences, and standards. |
| | 3. Novel data communication | 1. Discover and design efficient methods of communicating findings from research or analysis.<br>2. Optimize mediums for sharing critical information that emphasize comprehensive understanding.<br>3. Generate workflows that make data communication more efficient between and within organizations. |
| **2.3 Synthesis** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Synthesis concepts | 1. Describe the concept of disparate information being combined for complex or specific uses. |
| **Foundational (F)** | 1. Synthesis fundamentals | 2. Summarize and compile essential information efficiently and effectively.<br>3. Summarize by integrating information into meaningful concepts and ideas.<br>4. Summarize a set of facts, recognize patterns or trends, and determine the consequences of action relevant to the user. |

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| **Application (A)** | 1. Data synthesis | 1. Select essential information efficiently and effectively.<br>2. Separate problems into parts to facilitate a search for a solution.<br>3. Produce ideas about a given topic and apply old ideas to new situations or in new combinations.<br>4. Interpret and apply information into meaningful concepts and ideas.<br>5. Interpret a set of facts, discern patterns or trends, and differentiate the consequences of action relevant to the user. |
| | 2. Contextual analysis | 1. Use appropriate resources for assessing the influence of geographic setting and the cultural, historical, political, and economic factors associated with the study/subject.<br>2. Incorporate subject matter expert (SME) opinions and evaluations into the synthesis process.<br>3. Offer alternative scenarios that account for the influence of geographic setting and the cultural, historical, political, and economic factors associated with the study/subject, and provide a probability of likelihood for each offer (i.e., forecast). |
| **Mastery (M)** | 1. Synthesis mastery | 1. Recommend and use statistical methods to differentiate between correlation and causation.<br>2. Develop ideas about a given topic by assembling and constructing new situations in new combinations from old ideas.<br>3. Design and plan automated, repeatable workflows and modeling.<br>4. Develop creative approaches to integrate disparate information. |
| **2.4 Group Dynamics** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Teamwork | 1. Recognize the importance of interacting with others in a friendly, courteous, and tactful manner. |

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| | | 2. Recognize factors that build trust, including communication, transparency, and honesty). |
| **Foundational (F)** | 1. Teamwork | 1. Work with others in a manner that demonstrates respect for individual and cultural differences and the attitudes and feelings of others.<br>2. Manage disagreements, facilitate conflict resolution, and understand resources available for outside support. |
| | 2. Collaboration | 1. Listen and consider the various perspectives, skills, and needs of their group members.<br>2. Carry out work cooperatively and collaboratively with others to achieve goals through sharing or integrating ideas, knowledge, skills, information, support, resources, responsibility, and recognition.<br>3. Seek out diverse perspectives to support critical thinking and expose blindspots. |
| **Application (A)** | 1. Collaboration | 1. Facilitate agreements that involve sharing or exchanging resources within your organization. |
| **Mastery (M)** | 1. Mentoring | 1. Establish mentor-mentee relationships as appropriate. |
| | 2. Collaboration | 1. Facilitate agreements that involve sharing or exchanging resources across industry or security domains to promote mutual goals and interests. |
| **2.5 Project Management** | | |
| | Matrix Subtopic | Learning Objectives |
| **Foundational (F)** | 1. Organization | 1. Track deadlines and implement timelines to meet goals.<br>2. Maintain clear communication with supervisors regarding project updates. |
| | 2. Teamwork | 1. Recognize importance of working cooperatively and collaboratively with others to achieve goals through sharing or integrating ideas, knowledge, skills, information, support, resources, responsibility, and recognition. |
| | 1. Organization | 1. Set benchmarks and achievable goals with the group. |

| Cross-Functional Knowledge and Skills | | |
|---|---|---|
| **Application (A)** | | 2. Anticipate potential issues related to project timeline and delivery and develop potential plans forward. |
| | 2. Leadership | 1. Delegate work to teammates based on individual strengths.<br>2. Conduct check-ins on team's work and ensure team meets goals. |
| **Mastery (M)** | 1. Project management mastery | 1. Show mastery of project management skills related to organization, leadership, teamwork, and more to achieve project goals. |

# PART III: EMERGING COMPETENCIES

**Emerging competencies** aim to bridge the gap between existing knowledge and accelerated changes in the GEOINT environment and the structure of GEOINT work. This section provides new directions for the application and mastery of emerging GEOINT areas along with an overview of the expected prerequisites and foundational skills and knowledge needed to improve organizational learning and tradecraft.

**Proficiency Levels:**

- **Prerequisites (P) –** Knowledge and skills an individual must possess before they are prepared to learn about the topic.
- **Foundational (F)** – Knowledge and skills an individual must possess to demonstrate basic knowledge about the topic.
- **Application (A) –** Knowledge and skills an individual must possess to apply the topic to complex situations in a work setting.
- **Mastery (M) –** Knowledge and skills an individual must possess to demonstrate a comprehensive understanding of the topic that can be used to advance knowledge in the field.

| **Emerging Knowledge and Skills** | | |
|---|---|---|
| **3.1 Data Science** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Computational and statistical skills | 1. Describe real world applications of math.<br>2. Execute basic computer tasks including internet navigation and downloading and uploading files.<br>3. Understand use of researched commercial software products. |
| **Foundational (F)** | 1. Geospatial analysis | 1. Distinguish opportunities for data science to help advance geospatial analysis. |
| | 2. Computational and statistical skills | 1. Summarize how advanced math principles (e.g., algebra, trigonometry, geometry, and statistics) apply to data science.<br>2. Execute simple computer tasks including navigating file systems, reading, and writing computer files of various formats, and accounting for prerequisite software and/or parameters that need to be configured for software installs.<br>3. Use commercial and open-source software products that are appropriate for the problem.<br>4. Understand fundamentals of data management and organization. |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | 3. Data sources | 1. Identify new and existing data sources. |
| | 4. Data conflation | 1. Define data conflation and summarize why it is important in data science. |
| | 5. Data normalization and aggregation | 1. Summarize the purpose of data normalization and data aggregation and how they affect data. |
| | 6. Authoritative quantitative analysis | 1. Discuss how different authoritative quantitative analysis skills can be used to understand data science issues, suggest solutions, and make decisions. |
| **Application (A)** | 1. Data selection and filtering | 1. Conclude how to appropriately select and filter data. |
| | 2. Determine data veracity | 1. Assess the veracity of data and explain why it is important in data science. |
| | 3. Data normalization and aggregation | 1. Normalize data appropriately across and within disparate data.<br>2. Resolve and aggregate disparate data scales, formats, and temporal periods. |
| | 4. Data mining | 1. Differentiate the various data mining methods and when each method should/should not be used.<br>2. Collect multi-modal and multi-INT disparate data. |
| **Mastery (M)** | 1. Geospatial solutions | 1. Develop improved geospatial analytics and representations augmented via data science methods. |
| | 2. Projections and transformations | 1. Evaluate how projections and transformations can be used in data science. |
| | 3. Hyper parameter optimization | 1. Integrate hyper parameter optimization solutions to yield higher predictive accuracy. |
| | 4. Advanced data science techniques | 1. Advance the geospatial solution employing advanced data science techniques, including:<br>• Predictive analytics<br>• Statistical analysis<br>• Anomaly detection<br>• Sentiment analysis<br>• Time series analysis<br>• Modeling and simulation |
| **1.2 Use of Varied Datasets** | | |
| | Matrix Subtopic | Learning Objectives |

| Emerging Knowledge and Skills | | |
|---|---|---|
| **Prerequisites (P)** | 1. Data sources | 1. Describe the similarities and differences of the following data sources:<br>• Open-source data<br>• Volunteer derived<br>• User-generated<br>• Authoritative |
| | 2. Data conflation | 1. Recall when data conflation should and should not be performed. |
| | 3. Relational and non-relational database technologies | 1. Describe the similarities and differences of relational and non-relational database technologies. |
| **Foundational (F)** | 1. Combining data | 1. Outline how to perform data extraction, transformation, and loading from multiple data sources and sinks. |
| **Application (A)** | 1. Data mining | 1. Differentiate how data mining is performed when using structured, semi-structured, and unstructured data.<br>2. Decide which data mining approach is appropriate for the data (e.g., large amounts of structured, semi-structured, and unstructured data). |
| **Mastery (M)** | 1. Combining data | 1. Design strategies to extract, resolve, and unify information of various types from disparate data sources. |
| **3.3 Machine Learning (ML)** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Coding | 1. Recall basic knowledge of various programming languages and functions and why they are used, including, but not limited to:<br>• Python<br>• Java<br>• R<br>• C++<br>• Scala |
| | 2. Data design | 1. Understand the requirements and purposes for training, tuning, and testing data.<br>2. Understand the benefits and constraints of ground truth and synthetic data. |
| **Foundational (F)** | 1. ML fundamentals | 1. List the various ML algorithms and provide examples of when each should and should not be used. |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | | 2. Distinguish between ML, DL, and AI. |
| | 2. ML methodologies | 1. Understand the general mathematics and applications of the following:<br>• Bayesian learning<br>• Generative classifications<br>• Non-parametric learning<br>• Discriminative classifications<br>• Kernel machines<br>• Dimensionality reduction and manifold learning<br>• Artificial neural networks (ANN)<br>• Convolutional neural networks (CNN)<br>• Transfer learning<br>2. Summarize how to design, test, and debug software applying core ML methodologies. |
| **Application (A)** | 1. ML methodologies | 1. Analyze relevant real-world problems as instances of canonical ML problems.<br>2. Develop and implement effective strategies for data preprocessing.<br>3. Explain and utilize concepts of ML for data science.<br>4. Source relevant libraries or algorithms to solve problems. |
| | 2. ML evaluation | 1. Compare/contrast evaluation metrics.<br>2. Anticipate and mitigate human-based liabilities of ML algorithms.<br>3. Report and optimize efficiency of chosen methods. |
| | 3. DL and AI | 1. Compare/contrast the following learning methods:<br>• DL<br>• Supervised learning<br>• Unsupervised learning<br>• Reinforcement learning |
| | 4. Data design | 1. Conclude the data requirements for the method and the problem. |
| **Mastery (M)** | 1. ML process development | 1. Code and implement custom ML scripts from scratch.<br>2. Explore ML solutions to big data problems.<br>3. Explore novel applications of ML to solve real-world problems. |
| | 2. Geospatial ML | 1. Establish best practices and patterns for how to use geospatial ML. |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | | 2. Automate ML processes to solve geospatial problems.<br>3. Develop mission-specific feature recognition capabilities for use in intelligence exploitation.<br>4. Generate acceptable metrics for ML performance for a particular problem. |
| | 3. Organization training and optimization | 1. Establish organization norms for ML use in problem solving.<br>2. Enable use of applicable ML tools and techniques at the lowest organizational levels. |
| | 4. Reusable technical components | 1. Develop reusable technical components that can be used for ML. |
| | 5. Feature recognition | 1. Design a range of feature recognition capabilities (e.g., natural features recognition and man-made feature recognition). |
| **3.4 Virtual Reality (VR)** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Limitations | 1. Describe the limitations of VR. |
| | 2. Virtually displaying geospatial data | 1. Outline the various methods and modes of virtually displaying geospatial data. |
| | 1. Visualization tools | 1. Describe the importance of visualizing data and list commonly used visualization tools, including:<br>• ArcGIS Online<br>• D3.J3<br>• MapBox<br>• Tableau |
| **Foundational (F)** | 1. Virtual visualization | 1. Outline how geospatial data is combined with other domains to create virtual visualization. |
| | 2. Geospatial underpinning | 1. Summarize how to design a geospatial underpinning for a VR. |
| | 3. Design, test, and debug | 1. Summarize how to design, test, and debug software applying core VR methodologies. |
| **Application (A)** | 1. Projection, transformations, and accuracies | 1. Characterize the projection, transformations, and accuracies of geospatial data. |
| | 2. Limitations | 1. Characterize the advantages and limitations of displaying geospatial data virtually. |
| | 3. Multiple data sources | 1. Determine how multiple data sources should be synthesized to create a virtual display. |

| Emerging Knowledge and Skills | | |
|---|---|---|
| **Mastery (M)** | 1. Design | 1. Design a VR system with geospatial information as the base. |
| **3.5 Artificial Intelligence (AI)** | | |
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Scenario modeling | 1. Describe how statistical and neural network scenario modeling is performed and summarize their purposes. |
| | 2. Statistics, probabilities, and economics | 1. Describe the basic principles of statistics, probabilities, and economics and explain how they can be used in other fields.<br>2. List the various methods of performing a decision analysis. |
| **Foundational (F)** | 1. ML | 1. Outline how ML, data mining, and statistical algorithms refine pattern recognition, anomaly detection, and prediction. |
| | 2. Design, test, and debug software | 1. Outline how to design, test, and debug software applying neural networks/AI methodologies. |
| | 3. Generative AI | 2. Describe generative AI and compare various models. |
| **Application (A)** | 1. ML | 1. Differentiate supervised, unsupervised, and reinforced ML and characterize when each should be applied. |
| | 2. Generative AI | 1. Explain appropriate use cases for generative AI at work<br>2. Analyze the ethics of using generative AI. |
| **Mastery (M)** | 1. Analysis techniques | 1. Implement the following techniques when developing neural networks and automated intelligence:<br>• Regression<br>• Naive Bayesian classifier<br>• Clustering<br>• Matrix factorization<br>• K-nearest neighbors<br>• Natural language processing<br>• Decision trees<br>• Support vector machines<br>• Neural networks and DL |
| | 2. Generative AI | 1. Develop generative AI models to solve specific problems. |
| **2.6 Unmanned Aerial Vehicles (UAVs)/Unmanned Aerial Systems (UASs)** | | |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Autonomous and manually piloted platforms | 1. Describe the similarities and differences between automated and manually controlled unmanned systems. |
| | 2. Sensor selection | 1. Select the appropriate sensor.<br>2. Identify payloads by type and mission set.<br>3. Describe the differences between active and passive sensors in terms of collected data and basic function. |
| | 3. Multi-use UAV/unmanned aerial system (UAS) | 1. Identify multi-use from single-use UAV/UAS. |
| **Foundational (F)** | 1. Unmanned system employment | 1. Generate flight plans in autopilot software to meet mission requirements.<br>2. Identify major components of unmanned systems, including, but not limited to:<br>• Payload<br>• Power source<br>• Propulsion system<br>• Communication equipment<br>3. Perform preventative maintenance on platform and payload. |
| | 2. Use cases | 1. Summarize the uses for UAV/UAS over manned collection methods.<br>2. Identify where to find regulations governing UAV/UAS.<br>3. Demonstrate ability to download collected data to applicable processing system(s). |
| | 3. Limitations and advantages | 1. Outline the limitations of UAV/UAS collection (e.g., legal concerns, physical concerns, and privacy concerns) vs. alternate methods of collection.<br>2. Outline the advantages of UAV/UAS collection vs. alternate methods of collection. |
| **Application (A)** | 1. Mission design and implementation | 1. Apply the following collection and detection systems to meet different mission requirements:<br>• True-color imagery (RGB)<br>• Multispectral imagery (beyond-visible spectrum)<br>• Hyperspectral imagery (HSI)<br>• LiDAR<br>• Radar<br>• Synthetic Aperture Radar (SAR) |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | | 2. Build and optimize collection plans based on platform/payload combination and mission requirements.<br>3. Recommend methodologies to meet mission intent and intelligence collection requirements.<br>4. Brief, deconflict, and manage system use in various airspaces and in coordination with applicable authorities. |
| | 2. Data acquisition and processing | 1. Discover and mitigate flight conditions that may negatively impact data quality.<br>2. Successfully transfer data from collection system to processing system.<br>3. Execute accuracy assessment of collected data and identify causes of sub-par system performance.<br>4. Communicate limitations of system and recommend alternative collection methods to cover data gaps. |
| **Mastery (M)** | 1. Algorithm improvement | 1. Evaluate current algorithms to determine methods for improving sensor performance to enhance exploitation. |
| | 2. Payload optimization | 1. Evaluate current sensors to determine methods for improving performance.<br>2. Adjust sensor configuration and/or construction to meet mission requirements.<br>3. Assess sensor calibration techniques and execute in-situ calibrations. |
| | 3. Data optimization | 1. Design and apply Kalman filter to account for flight and collection conditions.<br>2. Execute accuracy assessment methodologies for regular collection missions.<br>3. Build executable processing software using open-source resources. |
| | 4. Platform design | 1. Recommend and/or implement changes to system to exceed previously established specifications. |
| | 5. Automation | 1. Build and automate workflows for mission planning and approval.<br>2. Automate processing workflows post-mission.<br>3. Implement ML and DL methodologies for data exploitation. |
| **3.7. Automation** | | |

| Emerging Knowledge and Skills | | |
|---|---|---|
| | Matrix Subtopic | Learning Objectives |
| **Prerequisites (P)** | 1. Repeatable processes | 1. Define and identify a repeatable process. |
| | 2. Advanced mathematics | 1. Describe the principles of advanced mathematics including probability and statistics and how they are used in other disciplines. |
| **Foundational (F)** | 1. Design, test, and debug | 1. Outline how to design, test, and debug software by applying automation methodologies. |
| | 2. Domain-specific technologies | 1. Summarize how domain-specific technologies are used to build efficient and effective systems. |
| **Application (A)** | 1. Geospatial scripting and task automation | 1. Characterize how geospatial scripting/task automation functions can be used to automate operational and/or repetitive tasks. |
| | 2. Automated and semi-automated | 1. Differentiate automated and semi-automated geospatial workflows and processes.<br>2. Determine when automated or semi-automated geospatial workflows and processes should be used. |
| **Mastery (M)** | 1. Reusable technical algorithms | 1. Design reusable technical algorithms and methods. |
| | 2. ML | 1. Design automation solutions to harness ML. |

# EBK Glossary

| | |
|---|---|
| 2D | Two-Dimensional |
| 3D | Three-Dimensional |
| 4D | Four-Dimensional |
| AFOV | Angular Field of View |
| AI | Artificial Intelligence |
| API | Application Programming Interface/Application-Program Interface |
| AR | Augmented Reality |
| AVHRR | Advanced Very High-Resolution Radiometer |
| CASI | Compact Airborne Spectrographic Imager |
| CMYK | Cyan, Magenta, Yellow, and Key |
| COPUOS | Committee on the Peaceful Uses of Outer Space |
| COTS | Commercial Off-The-Shelf |
| CSS | Cascading Style Sheets |
| DDB | Distributed Databases |
| DEM | Digital Elevation Model |
| DL | Deep Learning |
| DMSP | Defense Meteorological Satellite Program |
| DSM | Digital Surface Model |
| DTM | Digital Terrain Model |
| ElseIf | Else If |
| ELT | Electronic Light Table |
| EMR | Electromagnetic Radiation |
| ERD | Entity Relationship Diagram |
| ETL | Extract Transform Load |
| FAA | Federal Aviation Administration |
| FGDC | Federal Geographic Data Committee |
| FIR | Far Infrared |
| FME | Feature Manipulation Engine |
| G-M | Grid-Magnetic |
| GCS | Geographic Coordinate System |
| GDPR | General Data Protection Regulation |
| GEO | Geo-Stationary Orbit |
| GEOINT | Geospatial Intelligence |
| GeoJSON | Geographic JavaScript Object Notation |
| GeoTIFF | Geographic Tagged Image File Format |
| GIQE | General Image Quality Equation |
| GIS | Geographic Information System |
| GML | Geographic Markup Language |
| GNSS | Global Navigation Satellite System |

| | |
|---|---|
| GOES | Geostationary Operational Environmental Satellite |
| GPS | Global Positioning System |
| GSD | Ground Sample Distance |
| GSDI | Global Spatial Data Infrastructure |
| GUI | Graphical User Interface |
| HH | Horizonal transmit, horizontal receive |
| HIPAA | Health Insurance Portability and Accountability Act of 1996 |
| HSI | Hyperspectral Imagery |
| HSV | Hue, Saturation, and Value |
| HV | Horizontal transmit, vertical receive |
| ICA | Independent Component Analysis |
| ICD | Intelligence Community Directive |
| IDW | Inverse Distance Weighting |
| IFOV | Instantaneous Field of View |
| iOS | Apple Operating Software |
| IR | Infrared |
| IRS | Indian Remote Sensing Satellite |
| ITIL | Information Technology Infrastructure Library |
| JPEG | Joint Photographic Experts Group |
| JSON | JavaScript Object Notation |
| JWT | JavaScript Object Notation (JSON) Web Token |
| KML | Keyhole Markup Language |
| KMZ | Keyhole Markup Zipped |
| LEO | Low-Earth Orbit |
| LESS | Leaner Style Sheets |
| LiDAR | Light Detection and Ranging |
| MEIS-II | Multispectral Electro-Optical Imaging Scanner |
| MEO | Medium-Earth Orbit |
| MGRS | Military Grid Reference System |
| ML | Machine Learning |
| MNF | Minimum/Maximum Noise Fraction |
| MODIS | Moderate Resolution Imaging Spectroradiometer |
| NDVI | Normalized Difference Vegetation Index |
| NGA | National Geospatial-Intelligence Agency |
| NIIRS | National Image Interpretability Rating Scale |
| NIR | Near Infrared |
| NoSQL | Not only Structure Query Language |
| NSDI | National Spatial Data Infrastructure |
| NSG | National System for Geospatial Intelligence |
| OGC | Open Geospatial Consortium |
| OOP | Object-Oriented Programming |
| PCA | Principal Component Analysis |

| | |
|---|---|
| PCS | Projected Coordinate System |
| PCT | Principal Component Transformation |
| PDF | Portable Document Format |
| PII | Personally Identifiable Information |
| PNG | Portable Network Graphic |
| RAID | Redundant Array of Independent/Inexpensive Disks |
| RDBMS | Relational Database Management System |
| REST | Representational State Transfer |
| RF | Radio Frequency |
| RGB | Red, Green, and Blue |
| RMSE | Root Mean Square Error |
| RPC | Remote Procedure Call |
| RTK | Real Time Kinematic |
| SAR | Synthetic Aperture Radar |
| SASS | Syntactically Awesome Style Sheets |
| SDK | Software Development Kit |
| SeaWiFS | Sea-viewing Wide Field-of-view Sensor |
| SfM | Structure from motion |
| SI | System International (a.k.a., International System of Units) |
| SME | Subject Matter Expert |
| SOA | Service-Oriented Architecture |
| SOAP | Simple Object Access Protocol |
| SQL | Structure Query Language |
| SSL | Secure Sockets Layer |
| SSO | Sun-Synchronous Orbit |
| SVG | Standard Vector Graphic |
| SVI | Standard Vegetation Index |
| SWIR | Shortwave Infrared |
| SWOT | Strengths, Weaknesses, Opportunities, and Threats |
| TIFF | Tagged Image File Format |
| TIR | Thermal Infrared |
| UAS | Unmanned Aerial System |
| UAV | Unmanned Aerial Vehicle |
| URI | Uniform Resource Identifier |
| URL | Uniform Resource Locator |
| UV | Ultraviolet |
| VH | Vertical transmit, horizontal receive |
| VR | Virtual Reality |
| VV | Vertical transmit, vertical receive |
| WFS | Web Feature Service |
| WMF | Web Mapping Feature |
| WMS | Web Mapping Service |

| | |
|---|---|
| XML | eXtensible Markup Language |
| XQuery | eXtensible Markup Language Query |

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# Appendix A

### Historical EBK Development Process

## Original EBK

The original GEOINT EBK was developed in 2014 by conducting a cross-industry job analysis led by psychometric consultants and with the help of members of the GEOINT Community. The goal of the analysis was to identify the knowledge, skills, and abilities critical to the GEOINT workforce. Qualified Subject Matter Experts (SMEs) from government, industry, and academia participated in each phase of the job/practice analysis to ensure accurate reflection of GEOINT practices. The original GEOINT EBK described the geospatial intelligence discipline and practice in terms of key job tasks and essential knowledge, skills, and abilities required for a professional to be successful. The four competency areas presented in the original GEOINT EBK are described below:

| |
|---|
| **Competency I**: **GIS and Analysis Tools** describes the knowledge necessary to ensure the various elements and approaches of GIS and analysis are properly understood to successfully capture, store, manage, and visualize data that is linked directly to a location. |
| **Competency II**: **Remote Sensing and Imagery Analysis** describes the knowledge necessary to generate products and/or presentations of any natural or manmade feature or related object of activity through satellites, airborne platforms, unmanned aerial vehicles, terrestrially based sensors, or other similar means. This competency area contains the knowledge necessary to synthesize technical, geographic, and intelligence information derived through the interpretation or analysis of imagery and collateral materials as well as the processes, uses, interpretations, and manipulations of imagery for dissemination. |
| **Competency III: Geospatial Data Management** describes the knowledge required to acquire, manage, retrieve, and disseminate data to facilitate integration, analysis, and synthesis of geospatial information. |
| **Competency IV: Data Visualization** describes the use of cartographic and visualization principles to generate products that represent information about the physical environment that can be easily understood by decision-makers. |

The original GEOINT EBK also included cross-functional knowledge areas, identified as being necessary when there are widely accepted knowledge, skills, and abilities that transcend specific core competencies or when competencies are found across the full scope of practice. Cross-functional GEOINT knowledge, skills, and abilities reflect qualitative “soft skills” used by most GEOINTers such as collaboration, synthesis, and reporting.

The development of the initial GEOINT EBK represented a significant step forward in establishing GEOINT as a profession by providing a standard framework for the competencies needed by GEOINT professionals. Nevertheless, it was initially developed for a narrow population (working professionals with three to five years of experience at the journeyman level). GEOINT as a profession continued to evolve after that first GEOINT

EBK was developed, and the need for a well-educated and trained GEOINT workforce led USGIF to revisit the GEOINT EBK and invest in a major update three years later.

## EBK 2.0

The GEOINT EBK version 2.0 revision began in August 2017 with a survey of 88 respondents from the GEOINT community to identify critical knowledge and skills not accounted for in the first version of the EBK. Following the survey, eight SMEs provided guidance on the interpretation of the survey results and agreed upon appropriate topic areas that were necessary to include in each of the four competencies. The draft version of the GEOINT EBK version 2.0 was presented to USGIF's Certification Governance Board (CGB), which requested the appointment of authors to lead the development and review of the new content. Five SMEs subsequently expanded the content, each leading and developing content for indexing the knowledge and skills necessary to address each topic area at the specified proficiency level.

The EBK 2.0 included a matrix tool for each competency so the content would be more comprehensive. The matrix comprised four different proficiency levels within the Major Topic Areas to allow for granularity (i.e., Prerequisites, Foundational, Application, and Mastery). Subtopics reflected knowledge and skills necessary to master the major topic areas and learning objectives that describe what is expected of the GEOINT Community at the given proficiency level. The proficiency levels include corresponding questions designed to prompt readers to use the information at the appropriate level:

| |
|---|
| **Prerequisites**: What do you need to know to be ready to learn about the Topic Area at a fundamental level? |
| **Foundational:** What do you need to learn about the Topic Area at the fundamental level? |
| **Application:** What do you need to know to apply the Topic Area? |
| **Mastery:** What do you need to know to advance fundamental knowledge in the Topic Area? |

The GEOINT EBK version 2.0 featured the following:

- Vetted learning objectives for each subtopic identified during the process.
- A numbering scheme for the EBK to facilitate easy communication and identification of learning objectives.
- A progression of subtopic knowledge necessary to grow and advance within a given competency.

The GEOINT EBK version 2.0 represented significant progress in terms of identifying the different fields that make geospatial intelligence multidisciplinary.

## EBK 3.0

The EBK 3.0 revision process began in late 2022 with the USGIF Education and Professional Development (EPD) team engaging in interviews with 12 professors from USGIF-accredited GEOINT certificate and degree programs. These professors are acknowledged as contributors to this updated document. The EPD team also held discussions with SMEs from government, including from the NGA College, and stakeholders from industry, particularly those with perspectives centered on hiring and the current job ecosystem.

These conversations focused on what technologies and skills were missing and what may be already outdated within the EBK 2.0. The EPD team investigated how the EBK 2.0 covered core topics as well as non-technical or "soft skills." When interviewing the professors, we were particularly interested in areas in which they had already modernized their coursework to cover skills beyond what is in the EBK 2.0. As the EPD team updated the EBK 2.0, each section was sent to multiple subject-matter experts for their input and review.

Because the EBK 2.0 revision was such an extensive review, much of the content of EBK 3.0 has remained the same. This version features a restructuring and reorganization of matrix subtopics and learning objectives. By grouping related learning objectives within the same subtopic, the goal is for learners to better understand how each learning objective fits within the broader competency. The intent was to make this document more approachable and useful for practitioners at all skill levels to assess their proficiency and understand where they need to grow their knowledge base. This version keeps pace with current geospatial intelligence trends and the needs of the GEOINT community across academia, industry, and government.

# Appendix B

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