II. Detailed Assessment of FOCUS AREA Knowledge Units

NGA/USGS Centers of Academic Excellence in Geospatial Sciences
RESULTS OF CAMPUS SURVEY
University of Maine

QUESTIONNAIRE TABLE OF CONTENTS

Summary: This document shows course content details on how 19 out of 36 FOCUS AREA Knowledge Units are met through the content contained within geospatial graduate courses offered at the University of Maine. Reporting was accomplished through an online questionnaire completed by the instructors teaching the various listed courses.

Note: Focus Area knowledge units highlighted in red and green below meet the minimum criteria. Thus, as shown, the University of Maine fulfills all of the Knowledge Unit criteria in the Focus Areas of ***Information Science*** and ***Navigation and Location***.

Course Legend for the Knowledge Unit Tables

I. Geospatial Courses offered by Spatial Informatics Graduate Programs within the UMaine School of Computing and Information Science		
Course Abbreviation	**Course Title**	**Regular Instructor**
SIE 502	Research Methods	Egenhofer
SIE 503	Principles of Experimental Design	Giudice
SIE 505	Formal Foundations for Information Science	Hahmann
SIE 507	Information Systems Programming	Moratz
SIE 509	Principles of GIS	Beard
SIE 510	GIS Applications	Beard
SIE 512	Spatial Analysis	Beard
SIE 515	Human Computer Interaction	Giudice
SIE 516	Virtual Reality Research and Applications	Giudice
SIE 525	Information Systems Law	Onsrud
SIE 550	Design of Information Systems	Egenhofer
SIE 554	Spatial Reasoning	Egenhofer
SIE 555	Spatial Database Systems	Nittel
SIE 557	Database System Applications	Nittel
SIE 558	Data Stream Management Systems	Nittel
SIE 559	GeoSensor Networks	Nittel
SIE 565	Reasoning with Uncertainty in Spatial Information Systems	Hahmann
SIE 570	Spatial Cognition and Computing	Moratz
SIE 571	Pattern Recognition & Robotics	Moratz
SIE 598 fo	Formal Ontologies	Hahmann
SIE 598 sln	Spatial Learning and Navigation	Giudice

II. Geospatial Courses offered by Other Graduate Programs at UMaine		
Course Abbreviation	**Course Title**	**Regular Instructor**
Bio 597	Advanced Biometry for the Environmental Sciences	McGill
Ece 574	Cluster Computing	Yifeng
Int 527	Integration of GIS and Remote Sensing Data Analysis in Natural Resource Applications	Sader
Sfr 406	Remote Sensing, Image Interpretation, and Forest Mapping	Sader
Sms 540	Satellite Oceanography	Thomas
Svt 437	Practical GPS	Hintz
Svt 531	Advanced Digital Photogrammetry	Hintz
Svt 541	Geodesy	Hintz

QUESTIONNAIRE
for
UMaine Courses incorporating Geospatial Science Knowledge Units
Supporting the National Center of Excellence in Geospatial Sciences Application

Title of Survey: UMaine Courses with Geospatial Science Knowledge Units
Description: This survey documents the geospatial science knowledge units covered within graduate as well as 400 and 300 level courses at the University of Maine. Please complete this survey for each of your germane courses.
Welcome: Please complete this survey **on or before Monday February 9** for each and every one of your courses that addresses geospatial knowledge. The final application to USGS/NGA will be constructed from the data you supply.
Administrator: Harlan Onsrud
Start Date: current day
Expiration Date:
End Message: Your responses have been recorded. Thank you for your contribution. You will have the opportunity to review the entire application prior to its submission to the federal government. For further questions or comments, contact Harlan Onsrud at harlan.onsrud@maine.edu

Exit Link (url to which survey goes after final step complete): http://www.umaine.edu/

Question Group A: Course Being Reported

A1. Course Designator and Number: _____
A2. Course Title: _____
A3. Last Taught (Please indicate Fall or Spring plus the Year):
A4. Frequency Offered: __ Every Semester, __ Annually, __ Bi-Annually, __ As Needed
A5. Most recent instructor: [small text box]
A6. Updates last made to course: __ current, __ within 1 year, __ within 2 years, __ other <list>
A7. Is this course regularly offered through distance technologies? __ Yes __ No

Question Group B: Core Geospatial Knowledge Units addressed within your UMaine Course

- See document 1 for the survey results on core knowledge units

Question Group C: Focus Area Requirements
C0 EXPLANATION FOR NEXT SET OF QUESTIONS: A qualifying university, in addition to meeting all of the 9 Core Knowledge Units set forth in the previous section, must meet a minimum of 5 additional Optional Knowledge Units out of a total of 36 that are set forth under seven Focus Areas. The focus areas are covered by the next sections of this survey and include: (1) Geospatial Analysis, (2) Cartographic Sciences and Geovisualization, (3) Remote Sensing Imagery Science, (4) Photogrammetry, (5) Information Science, (6) Aeronautical Analysis [not addressed by the survey] and (7) Navigation and Location [geodesy: not addressed by the survey]. If a university meets the requirements of all Knowledge Units within a Focus Area, they receive that additional Focus Area designation as part of their National Center recognition. At a minimum, we hope to meet all the requirements of the Information Science and Geospatial Analysis Focus Areas.

Question Group D: (1) Geospatial Analysis Focus Area - Optional Knowledge Units Addressed by your UMaine Course

D0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the Focus Area of **Geospatial Analysis**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.
D1. Geospatial Analytic Reasoning and Problem Solving Fundamentals __ Yes __No (If response is yes, the following questions appear.)
Help: Cognitive/social skills and knowledge required to understand and apply analytic reasoning and problem solving methods

D1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes								
		SIE 510	SIE 512	SIE 515	SIE 550	SIE 554	SIE 555	SIE 570	SIE 559	
F	Perception and cognition associated with analytic reasoning and problem solving		✓	✓	✓	✓	✓	✓ ✓	✓	
G	Understanding meta-cognition and socio-cultural thought foundations			✓	✓		✓	✓	✓	
H	Geographic and cultural influences that lead to analytic bias						✓	✓		
I	Analytical constraints associated with collective memory							✓		
J	Establishing appropriate analytic queries related to problem-solving and reporting requirements	✓						✓		
K	Making insightful judgments through sound analytical objectivity, healthy skepticism, and realistic pattern considerations		✓	✓				✓		
L	Translating requirements into appropriate analytic questions	✓							✓	
M	Solving complex analytics questions through right-sizing project scope		✓					✓	✓	

D1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes								
		SIE 510	SIE 512	SIE 515	SIE 550	SIE 554	SIE 555	SIE 570	SIE 559	
N	1. Discuss analytic bias as it relates to situational awareness, experience, and cultural differences					✓	✓	✓	✓	
O	2. Identify common biases regarded as the main reasons for judgment errors in analysis		✓	✓		✓	✓	✓	✓	
P	3. Describe the impact of social media, collective memory, and false information on creating sound analytical interpretations and judgment							✓		
Q	4. Identify information and sources for checking analytical relevance and accuracy			✓				✓	✓	
R	5. Recognize the difference between assumptions and inferences		✓	✓	✓	✓		✓		
S	6. Identify viewpoints and sources of judgment that serve self-interests							✓	✓	
T	7. Solve a problem applying spatial analytic techniques		✓			✓		✓	✓	
U	8. List common approaches used to identify project scope and management	✓			✓			✓		
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria							✔		

D2. Foundations of Spatial Thinking __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to understand historical, personal, and social perceptions of geographic information.

D2a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 554	SIE 555	SIE 558	SIE 559	SIE 570	SIE 598 sln	
W	Geography as a foundation for GIS	✓	✓		✓		✓	✓	✓		
X	Common-sense geographies				✓			✓	✓		
Y	The cultural and political influences affecting the perception and understanding of geographic information and phenomena				✓	✓		✓		✓	
Z	Tobler's first law of geography	✓		✓	✓			✓			
AA	Geographic contextualization and constraints for analysis and interpretations	✓		✓	✓						

D2b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 554	SIE 555	SIE 558	SIE 559	SIE 570	SIE 598 sln	
AB	1. Define the properties that make a phenomenon geographic	✓	✓	✓	✓		✓	✓	✓		
AC	2. Explore the history of geography and its role in Geospatial Information Sciences and Technology							✓	✓		
AD	3. Discuss the differing denotations and connotations of the terms spatial, geographic, and geospatial	✓				✓	✓	✓		✓	
AE	4. Describe the ways in which the elements of culture may influence the understanding and use of geographic information			✓	✓	✓		✓		✓	
AF	5. Recognize the impact of one's social background on one's own geographic worldview and perceptions, and how it influences one's use of GIS	✓						✓			
AG	6. Evaluate the influences of political ideologies on the understanding of geographic information							✓			
	Two courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: SIE 559 and (509, 512 or 554)	*		*	*		*				

D3. Geometric Measures __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to use measurements to extract meaning from geospatial datasets or to derive new data for further analysis

D3a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes								
		SIE 505	SIE 509	SIE 510	SIE 512	SIE 554	SIE 559	SIE 570	SIE 571	Bio 597	Int 527
AI	Distances and lengths		✓	✓	✓	✓	✓	✓	✓		
AJ	Direction, shape, area, volume, and time		✓			✓	✓	✓	✓		✓
AK	Proximity and distance decay				✓	✓	✓	✓		✓	
AL	Adjacency and connectivity	✓	✓	✓	✓	✓		✓		✓	✓

D3b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 505	SIE 509	SIE 510	SIE 512	SIE 554	SIE 559	SIE 570	SIE 571	Bio 597	Int 527
AM	1. Describe several different measures of distance between two points (e.g. Euclidean, Manhattan, network, spherical, time, social, cost)		✓	✓		✓		✓		✓	
AN	2. Describe operations that can be performed on qualitative representations of direction					✓		✓		✓	
AO	3. Explain why the shape of an object might be important in analysis		✓		✓	✓	✓	✓	✓	✓	✓
AP	4. Explain how variations in the calculation of area may have real-world implications (e.g. when calculating density		✓		✓			✓			✓
AQ	5. Explain the rationale behind the use of different forms of distance decay functions							✓		✓	
AR	6. Demonstrate how adjacency and connectivity can be recorded into matrices	✓	✓		✓	✓		✓		✓	
AS	7. Explain how different map projections can introduce errors in measurement of distance, direction or area.		✓	✓							✓
AT	8. Explain how topology relates to adjacency and connectivity.		✓	✓	✓	✓		✓			✓
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria							✔			

D4. Analysis of Workflow in Project Management __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to design a workflow of GIS procedures and data to implement mathematical, geographical, statistical, and other analytic models

D4a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when the Topic is met.

ID	TOPICS	Courses Responding Yes									
		SIE 502	SIE 510	SIE 512							
AV	Applying the scientific method to projects using geospatial and remote sensing data	✓	✓	✓							

D4b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 502	SIE 510	SIE 512							
AW	1. Discuss the scientific and algorithmic approaches to frame research questions and develop projects	✓		✓							
AX	2. Deconstruct a scientific hypothesis to identify possible strategies for testing	✓		✓							
AY	3. Identify the sequence of operations and statistical/mathematical methods appropriate for a specific application	✓		✓							
AZ	4. Develop a planned analytical procedure to solve a new unstructured problem			✓							

BA	5. Compare and contrast the relative merits of various tools and methods for procedure design, including flowcharting and pseudocode		✓								
BB	6. Select the appropriate environment (e.g. GIS software, software development environment) for implementing an analytical procedure		✓								
	Two courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: SIE 510 & 512		*	*							

D5. Analysis of Topographic or Field-based Data __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to conduct analysis with continuous surface data

D5a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 559	Int 527	Sfr 406				
BD	Digital Elevation Models (DEMs)	✓				✓	✓				
BE	Triangulated irregular networks (TINs)	✓	✓			✓					
BF	DEM-derived surface calculations (e.g. slope, aspect, visibility)	✓	✓			✓					
BG	Interpolation	✓	✓	✓	✓	✓					
BH	Friction surfaces	✓	✓								

D5b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 559	Int 527	Sfr 406				
BI	1. Explain why the properties of spatial continuity are characteristic of spatial surfaces		✓	✓							
BJ	2. Outline methods for calculating slope and aspect from a DEM	✓	✓			✓	✓				
BK	3. Outline methods for calculating slope and aspect from a TIN	✓	✓			✓					
BL	4. Explain why different interpolation methods (e.g. inverse distance weighted, bi-cubic spline fitting, kriging) produce different results, and suggest ways that they can be evaluated in the context of a specific problem	✓		✓	✓	✓					
BM	5. Perform siting analyses using specified visibility, slope, and other surface-related constraints	✓	✓			✓					
BN	6. Explain how friction surfaces are enhanced by the use of impedance and barriers		✓								
BO	7. Apply the principles of friction surfaces in the calculation of least-cost paths	✓	✓								
	Two courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: SIE 509 & 510	*	*								

D6. Geostatistics and Spatial Econometrics __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to analyze continuous data by understanding the concept of semi-variograms and their use in spatial prediction.

D6a. Question: Please check any and all of the following TOPICS covered by your course.

Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 512	Bio 597	Int 527							
BQ	Regionalized variable theory	✓									
BR	Spatial sampling for statistical analysis	✓	✓								
BS	Principles of semi-variogram construction and modeling	✓	✓								
BT	Weighted least squares method	✓	✓								
BU	Principles of kriging and different types of kriging	✓	✓	✓							
BV	Spatial trend analysis	✓	✓								
BW	Mathematical operations allowed at each level	✓	✓								
BX	Spatial econometrics										
BY	Spatial regression analysis and geographically weighted regression (GWR)	✓									
BZ	Spatial filtering			✓							

D6b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when at least seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 512	Bio 597	Int 527							
CA	1. Create spatial samples under a variety of requirements (e.g. coverage, randomness, and transects)	✓	✓								
CB	2. Construct a semi-variogram and illustrate with a semi-variogram cloud	✓	✓								
CC	3. Apply the method of weighted least squares and maximum likelihood to fit semi- variogram models to datasets	✓	✓								
CD	4. Conduct a spatial interpolation process using kriging from data description to final error map	✓	✓								
CE	5. Apply kriging to appropriate datasets, and interpret the results	✓	✓	✓							
CF	6. Identify geospatial trends within datasets	✓	✓								
CG	7. Explain and know how to test for spatial autocorrelation	✓	✓								
CH	8. Discuss statistical levels and the operations allowed at each level	✓									
CI	9. Apply appropriate levels to data types	✓									
CJ	10. Describe the metric content of the levels and know how to change among levels	✓									
CK	11. Discuss how the statistical data level affects geospatial manipulations	✓		✓							
CL	12. Describe the general types of spatial econometric models										
CM	13. Demonstrate how the spatial weights matrix is fundamental in spatial econometrics models	✓	✓								
CN	14. Justify the choice of a particular spatial autoregressive model for a given application	✓	✓								
CO	15. Apply a spatial autoregressive model to estimate spatial lags and spatial interactions among variables.	✓	✓								
CP	16. Identify modeling situations when and what			✓							

	spatial filtering will be useful.										
CQ	17. Explain the principles of Geographically Weighted Regression (GWR), and discuss what kinds of problems are most suited or not suited for GWR to model spatial relationships.	✓	✓								
CR	18. Perform an analysis using the GWR technique		✓								
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔									

D7. Network Analysis __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to examine phenomena that can be modeled in the form of connected sets of edges and vertices.

D7a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 505	SIE 509	SIE 510	SIE 554	SIE 570	Ece 574				
CT	Defining a network: geospatial networks and social networks	✓		✓		✓					
CU	Graph theory	✓		✓	✓	✓	✓				
CV	Network metrics that describe connections, distributions, and segmentation	✓		✓	✓	✓					
CW	Methods of modeling networks (least-cost path, flow modeling, accessibility modeling)			✓	✓		✓				
CX	Networks (e.g. hydrologic, transportation, telecommunications, transmission patterns of infectious diseases, social networks, natural disasters, etc.) used to define specific applications or industries		✓	✓							
CY	Understanding the inter-connectedness of networks, communities, patterns of behavior, etc. in analysis through defining and identifying network relationships	✓		✓							
CZ	Demonstrations of practical situations in which network fundamentals help define the analytical picture through relationship discovery			✓							

D7b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when at least seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 505	SIE 509	SIE 510	SIE 554	SIE 570	Ece 574				
DA	1. Describe terminology related to network analysis	✓	✓	✓	✓	✓					
DB	2. Demonstrate how networks can be measured using the number of elements in the network, the distances along network edges, and the network's level of connectivity in a network	✓		✓							
DC	3. Compute the optimum path between two points through a network using Dijkstra's algorithm	✓		✓			✓				
DD	4. Apply a maximum flow algorithm to calculate the largest flow from a source to a sink			✓			✓				
DE	5. Explain how the classic transportation problem can be structured as a linear program			✓	✓						

DF	6. Explain several classic problems to which network analysis is applied	✓		✓							
DG	7. Discuss methods for measuring different kinds of accessibility on a network	✓		✓							
DH	8. Define how exploiting networks and network relationships can be applied to address complex analysis problems			✓							
DI	9. Demonstrate how network analysis tools deepen analytic capabilities and enhance product outputs			✓							
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria			✔							

D8. Optimization and Location-allocation Modeling __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to enable the optimization of spatial decision support for business and government applications

D8a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
DK	Location modeling										
DL	Linear and non-linear programming										
DM	Integer programming										
DN	Critical Path Method (CPM)										
DO	Location-allocation modeling										
DP	Spatial Optimization										

D8b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
DQ	1. Compare and contrast the concepts of discrete vs. continuous location problems										
DR	2. Describe the structure of linear programs										
DS	3. Implement linear programs for spatial allocation problems										
DT	4. Assess the outcome of location-allocation models using other spatial analysis techniques										
DU	5. Use location-allocation software to find service facilities that meet given sets of constraints										
DV	6. Create working models to locate new or existing facilities for allocating resources										
DW	7. Define optimal alternative methods, and the trade-offs among solutions										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

D9. Spatial Data Integration __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to integrate disparate types of data that vary in data model, geometry, resolution, accuracy and temporarily

D9a. Question: Please check any and all of the following TOPICS covered by your course.

Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 510	SIE 550	SIE 558	SIE 559	SIE 570	SIE 571	SIE 598 fo			
DY	Spatial integration (geometric integration, edge-matching, horizontal integration, vertical integration, data fusion)	✓			✓	✓	✓				
DZ	Attribute and semantic integration	✓	✓		✓	✓		✓			
EA	Temporal integration (time conversion, temporal lineage)	✓		✓	✓	✓					

D9b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 510	SIE 550	SIE 558	SIE 559	SIE 570	SIE 571	SIE 598 fo			
EB	1. Describe the methods used for data integration.	✓	✓	✓	✓	✓	✓	✓			
EC	2. Provide methods for vertical and horizontal data integration	✓		✓	✓	✓					
ED	3. Appraise when geometric and semantic integration are possible	✓		✓	✓	✓	✓	✓			
EE	4. Discuss the practical limits of data integration based on data attribution, resolution, and accuracy	✓		✓	✓	✓		✓			
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔				✔					

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Question Group E: (2) Cartographic Sciences and Geo-visualization Focus Area
Description: Optional Knowledge Units Addressed by your UMaine Course

E0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the focus area of **Cartographic Sciences and Geo-visualization**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

E1. Foundations of Cartography __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to understand change in the motives for mapping, the history of exploration, printing technologies, data collection technologies, design technologies, the scientific understanding of map use, visual analysis of graphic displays, application domains, and creative design innovations

E1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 598 sln						
EH	History of cartography										
EI	Understanding audience and purpose of a map	✓	✓		✓						
EJ	Technological trends and transformations		✓								
EK	Map elements (legends, insets, neatlines, etc.), map scale, and map design	✓	✓								
EL	Source materials for mapping, and scale of measurement	✓	✓								

EM	Reference maps and thematic maps (and types of thematic maps: choroplethic maps, dasymetric maps, contour maps, etc.)		✓		✓						
EN	Data abstraction, classification, selection, generalization, symbolization		✓	✓							
EO	Map reading and induction										
EP	Projection as a map design issue		✓								
EQ	Visual variables		✓	✓							
ER	Color theory		✓								

E1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when at least seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	SIE 510	SIE 512	SIE 598 sln						
ES	1. Describe how symbolization methods used in map-making affect viewer interpretation of the information being presented	✓	✓	✓	✓						
ET	2. Discuss the impact that Web mapping via applications such as Google Earth has had on the practice of cartography										
EU	3. Explain how emerging technologies in related fields (e.g., the stereoplotter, aerial and satellite imagery, GPS and lidar, the World Wide Web, immersive and virtual environments) have advanced cartography and visualization methods										
EV	4. Explain how technological changes have affected cartographic design and production		✓								
EW	5. Evaluate the advantages and limitations of various technological approaches to mapping				✓						
EX	6. Select new technologies in related fields that have the most potential for use in cartography and visualization										
EY	7. Explain the impact of advances in visualization methods on the evolution of cartography										
EZ	8. Describe how compilation, production, and distribution methods used in map-making have evolved										
FA	9. Identify the map projections commonly used for specific types of maps		✓								
FB	10. Identify the most salient projection property of various generic mapping goals and proper use of different types of thematic maps (e.g., choropleth map, navigation chart, flow map)		✓								
FC	11. Explain why certain map projection properties have been associated with specific map types		✓								
FD	12. Select appropriate projections for world or regional scales that are suited to specific map purposes and phenomena with specific directional orientations or thematic areal aggregations	✓	✓								
FE	13. Determine the parameters needed to optimize the pattern of scale distortion that is associated with a given map projection for a particular		✓								

	mapping goal and area of interest										
FF	14. Diagnose an inappropriate projection choice for a given map and suggest an alternative		✓								
FG	15. Construct a map projection suited to a given purpose and geographic location; re-create the same map using a different projection and describe what the different views communicate		✓								
FH	16. Identify the criteria used in the selection of data to be represented on a map.	✓	✓								
FI	17. Apply the concepts of classification, selection, and generalization of data for portrayal on a map.	✓	✓								
FJ	18. Describe map projections in general, the types of projections, the distortions inherent to each type and how this relates to map design.	✓	✓								
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria		✔								

E2. Mapping and Design Principles __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to produce and reproduce maps, and understand the computation issues relating to these workflows. Capabilities for map and product distribution methods are also included.

E2a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 510	SIE 512								
FL	Raster and vector formats	✓	✓								
FM	Modern and historic map production methods										
FN	Map preparation (standard and custom products)										
FO	Typography and placement principles	✓									
FP	Data distribution methods										
FQ	Collaborative map design										
FR	Information visualization techniques applied to geographic information		✓								
FS	Developing animated and interactive maps	✓									
FT	"Mapping mashup" construction and programming										
FU	Sources of dynamic geographic information use	✓									
FV	Usability of dynamic maps										

E2b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when at least seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 510	SIE 512								
FW	1. Distinguish between raster and vector formats and how each is used in the production of mapping and geospatial products	✓	✓								
FX	2. Describe historical map production methods										
FY	3. Discuss the principles of map preparation and production to include projections, cartographic license and displacement, rules for typography placement,										
FZ	4. Explain modern and historic map production methods										

GA	5. Prepare maps for standard and custom products										
GB	6. Describe the impacts of conversion on practical use and visualization										
GC	7. Discuss questions of locational and attribute accuracy	✓	✓								
GD	8. Explain projection changes (forward and inverse)	✓									
GE	9. Discuss appropriate algorithms and questions of data loss										
GF	10. Explain methods used to distribute/disseminate map products and outputs (e.g. interactive and on-line distribution, hand help devices, web services, social media sites such as Map Story)										
GG	11. Describe the principals for collaborative map design (e.g. VGI, Map Story, Wiki Maps)										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

E3. Extraction and Generalization of Geospatial Data for Geographic Visualization and Cartography __ Yes __No
(If response is yes, the following questions appear.)
Help: Skills and knowledge required to extract data from primary imagery sources to include commercial sources that represent varying degrees of resolution and spectral characteristics (e.g. panchromatic, multi-spectral, hyper-spectral, etc.)

E3a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		Sfr 406									
GI	Imagery types and their characteristics	✓									
GJ	Proper selection and use of imagery to produce maps and geospatial products	✓									
GK	Techniques for data extraction from imagery source	✓									
GL	Classification (per pixel)	✓									
GM	Object-based image analysis										
GN	Neural networks and learning classifiers										
GO	Fuzzy maps										

E3b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Sfr 406									
GP	1. Discuss imagery types	✓									
GQ	2. Describe proper use of imagery types to support a range of mapping applications	✓									
GR	3. Demonstrate the capability to extract content from an imagery source to support mapping outputs										
GS	4. Explain the role of content specifications and standards in data extraction										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

E4. Integration of Geospatial Information Sources __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to integrate geospatial content, using modern methods to acquire and update data from non-traditional sources.

E4a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 510	SIE 512	SIE 554	SIE 559	SIE 571					
GU	Emerging geospatial information sources (social media, open sources, VGI)	✓	✓	✓	✓						
GV	Data crowdsourcing fundamentals				✓						
GW	Pros/cons of using open source and social media data in mapping applications	✓	✓	✓	✓						
GX	Sources and methods for evaluating and incorporating open source and VGI	✓		✓	✓						
GY	Data transaction and update methods from hand-held and mobile devices				✓						
GZ	Emerging techniques for integrating non-traditional geospatial data and content for cartographic use.				✓						
HA	CAD to GIS conversion, data interoperability in cartography										
HB	Integrating floor plans/CAD diagrams into maps (Building Information Modeling (BIM))					✓					

E4b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 510	SIE 512	SIE 554	SIE 559	SIE 571					SIE 571
HC	1. Describe non-traditional and emerging data types and their applicability to mapping and product generation	✓		✓	✓						
HD	2. Explain the principles of crowdsourcing data (methods, pros/cons, the crowd to self- police content)				✓						
HE	3. Examine methods for crowd ranking. (employing manual and automated techniques to understand the validity of open source data, applying automated methods for continuous crowd ranking to support the updating of geospatial data)				✓						
HF	4. Explore methods for incorporating data from mobile devices into larger geospatial activities in near real-time (e.g. how to take data from Twitter feeds and media reports and incorporate to rapidly update geospatial data to support Humanitarian Assistance and Disaster Relief (HADR) missions)				✓	✓					✓
HG	5. Describe the limitations of using open source data and issues of data quality	✓	✓	✓	✓						
HH	6. Develop fit for use products from open, community, and crowd-sourced data										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

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Question Group F: (3) Remote Sensing/Imagery Science Focus Area
Description: Optional Knowledge Units Addressed by your UMaine Course

F0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the focus area of **Remote Sensing/Imagery Science**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

F1. Remote Sensing Collection Platforms __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to describe and understand remote sensing collection platforms and applying this knowledge to solving spatio-temporal problems

F1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	SIE 571	Int 527	Sfr 406	Sms 540					
F	Basics of aerial photography	✓			✓						
G	High altitude and low altitude airborne platforms				✓						
H	Basics of aircraft position / orientation measurement (i.e., GPS and Inertial Navigation Systems (INS))										
I	Basic relationships between aircraft operation (i.e., flight speed) and collection parameters (i.e., sensor integration time)										
J	Using aerial photography in geospatial information and production problem solving	✓			✓						
K	US imaging satellite constellation	✓		✓		✓					
L	Non-US imaging satellites constellation					✓					
M	Imaging satellite orbits (e.g. geosynchronous, sun synchronous, etc.)			✓	✓	✓					
N	Using imaging satellite types and orbits in geospatial information and production problem solving					✓					
O	Basic UAV aviation and safety		✓								
P	UAV mission planning										
Q	UAV data collection and processing		✓								

F1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	SIE 571	Int 527	Sfr 406	Sms 540					
R	1. Describe the basic theories of aerial photography	✓									
S	2. Describe common applications for remote sensing using aerial photography	✓	✓		✓						
T	3. Describe the basic terms related to aircraft flight path and image parameters: Field of View (FOV), Instantaneous FOV (IFOV), Ground Instantaneous FOV (GIFOV) and their relationship					✓					
U	4. Describe the differences between roll, pitch, and yaw and their impact on resulting imagery				✓	✓					
V	5. Describe how platform speed and collection parameters influence image quality (i.e., blur,				✓						

	resolution, etc.)										
W	6. Describe the difference between nadir-looking and "agile" satellites (i.e., Worldview-2)			✓	✓	✓					
X	7. Describe the full constellation of imaging satellites (US and non-US) in space, to include their uplink and downlink architectures										
Y	8. Describe how a satellites orbit can affect when and what type of data can be collected.			✓		✓					
Z	9. Apply the knowledge of the global satellite constellation to solving geospatial problems such as disaster response/humanitarian relief, military operations support, global disease surveillance, crop surveillance, earth sciences (e.g. earthquakes, volcanoes, ice melt) and other areas			✓	✓	✓					
AA	10. Describe UAV imagery collection and its applications ranging from precision agriculture, to disaster response/humanitarian relief/search and rescue, and homeland security and military applications	✓									
	Two courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: Sfr 406 & Sms 540				*	*					

F2. Radiometry __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to comprehend the quantitative measurement of electromagnetic energy and its application to simple imaging systems

F2a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
AC	Basic radiometric and photometric terms.										
AD	Derivation of source propagation and sensor output equations										
AE	How / why do specific materials detect photons at various wavelengths										
AF	Ways to characterize radiometric performance of detectors										
AG	Sensor calibration										

F2b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
AH	1. Comprehend the quantitative measurement of electromagnetic energy and how it is applied to simple imaging systems.										
AI	2. Discuss radiometric and photometric terms										
AJ	3. Describe basic characteristics of detector materials and figures of merit										
AK	4. Explain basic principles and approaches to radiometric sensor calibration.										

	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F3. Electro-optical (EO) Sensor Science __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and basic knowledge required to comprehend passive visible and infrared phenomenology, theory, and design.

F3a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		Int 527	Sfr 406	Sms 540							
AM	Basic focal-plane and detector applications in remote sensing sensors										
AN	Visible, shortwave-, midwave- and longwave-infrared measurement theory and techniques	✓		✓							
AO	Accounting for reflected and emitted energy as described in spectral signatures	✓									
AP	Atmospheric interactions, windows and absorption regions/bands	✓	✓	✓							
AQ	Basic theory, application, and design of a broad range of sensors	✓	✓	✓							
AR	Basic passive EO systems and types.	✓	✓	✓							

F3b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Int 527	Sfr 406	Sms 540							
AS	1. At a fundamental level, explain the process of passive EO signal generation, (propagation, target interaction, signal receipt and recording)	✓		✓							
AT	2. Discuss atmospheric effects on passive EO collections	✓	✓	✓							
AU	3. Describe reflected and emitted energy and spectral signature generation.	✓	✓	✓							
AV	4. Explain sensor theory and application as specifically associated with passive EO imaging										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F4. Thermal Remote Sensing __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and basic knowledge required to comprehend concepts, issues and applications relating to thermal imaging systems

F4a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		Sfr 406	Sms 540								
AX	Principles of thermal remote sensing (Planck function, black body radiation)		✓								
AY	Atmospheric effects	✓	✓								
AZ	Spectral emissivity and kinetic temperature		✓								
BA	Factors affecting kinetic temperature										

BB	Radiant temperature	✓	✓								
BC	Solar heating, longwave upwelling and downwelling radiation										
BD	Daytime vs. night-time acquisition	✓	✓								
BE	Thermal data applications	✓	✓								
BF	Measured radiance as a function of observed material temperature and emissivity										
BG	Methods to separate temperature and emissivity										
BH	Thermal hyperpectral systems										

F4b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Sfr 406	Sms 540								
BI	1. Describe the principles of thermal imaging systems and factors to consider when processing thermal data		✓								
BJ	2. Identify tools, processing techniques, and applications of thermal data		✓								
BK	3. Recognize thermal data benefits and limitations	✓	✓								
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F5. Basic Radar Science __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and basic knowledge required to comprehend radar phenomenology, theory, and design.

F5a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		Sfr 406	Sms 540								
BM	Wave-guiding and radiation as applicable to microwave antennas.										
BN	Radio Frequency/microwave measurement theory and techniques		✓								
BO	Basic theory, application, and design of a broad range of antennas	✓	✓								
BP	Basic radar systems and types.	✓									

F5b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Sfr 406	Sms 540								
BQ	1. At a fundamental level, explain the process of radar operation from signal generation, to propagation, target interaction, signal receipt and recording.	✓	✓								
BR	2. Discuss atmospheric effects on radar operation		✓								
BS	3. Describe the use and purpose of signal chirping.		✓								
BT	4. Explain antenna theory and application as specifically associated with radar imaging										
	Course by itself meets minimum TOPIC and										

	LEARNING OBJECTIVE criteria										

F6. Lidar data collection and processing __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and basic knowledge of how lidar data is collected and processed

F6a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 571	Sfr 406								
BV	Lidar data ingest/manipulation in 3D viewer	✓									
BW	Basic analysis of lidar data	✓									
BX	Lidar data quality	✓									
BY	Types of lidar sensors	✓	✓								
BZ	Different forms of lidar data (multiple point returns, intensity data, waveform data)		✓								
CA	Introduction to lidar data analysis tools, principles, and applications (viewshed/line of sight analysis, DEM/DSM estimation)										
CB	Lidar classification		✓								
CC	Application of lidar to real-world missions	✓									
CD	Lidar systems for military applications										

F6b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when at least seven (7) Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 571	Sfr 406								
CE	1. Use lidar data in at least one software package	✓									
CF	2. Perform basic point cloud and raster based analysis	✓									
CG	3. Recognize basic lidar artifacts and the limitations of lidar data										
CH	4. Describe the fundamental physics behind lidar collections	✓	✓								
CI	5. Discuss the limitations of lidar collection (e.g. altitude, weather, dust)		✓								
CJ	6. Identify different lidar modalities (e.g. airborne, terrestrial, atmospheric)										
CK	7. Explain scientific, military, homeland security uses for lidar data	✓									
CL	8. Describe lidar systems employed by the military (e.g. the Buckeye System)										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F7. Remote Sensing Data Analysis __ Yes __No (If response is yes, the following questions appear.)
Help: Introduction to the basic applications of quantitative remote sensing data analysis and the mathematical tools used for data exploitation

F7a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes

		SIE 509	SIE 571	Int 527	Sfr 406	Sms 540					
CN	Remote Sensing applications (classification, spectral signature analysis, change detection, anomaly detection, target detection, spectral unmixing)	✓	✓	✓	✓	✓					
CO	Mathematical frameworks for algorithm development (multivariate statistics, linear algebra and subspace geometry, spectral linear mixture model, basic signal detection theory)		✓								
CP	Spectral Classification Algorithms (supervised and unsupervised, minimum distance to the mean, Mahalanobis distance, Gaussian maximum likelihood)		✓	✓		✓					
CQ	Spectral signature analysis algorithms (band ratio analysis such as NDVI, NDWI), geologic mineral analysis			✓	✓	✓					
CR	Spectral Detection algorithms (anomaly detection such as RX, change detection such as chronocrome, covariance equalization), target detection such as GLRT, spectral matched filtr, ACE, CEM)										
CS	Linear spectral unmixing										

F7b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	SIE 571	Int 527	Sfr 406	Sms 540					
CT	1. Explain the (semi-) automated applications of quantitative remote sensing image analysis		✓	✓		✓					
CU	2. Describe the mathematical principles behind quantitative remote sensing image analysis		✓								
CV	3. Discuss the basics of spectral signature analysis	✓		✓	✓	✓					
CW	4. Identify the limitations of quantitative remote sensing image analysis		✓	✓	✓						
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F8. Digital Image Processing __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to process of remote sensing images.

F8a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 571	Int 527	Sfr 406	Sms 540						
CY	Radiometric and geometric correction				✓						
CZ	Histogram manipulation, image enhancement and restoration	✓		✓	✓						
DA	Spatial and morphological filtering	✓		✓	✓						
DB	Image transformation and data/feature dimensionality reduction	✓		✓	✓						
DC	Basics of image/data compression	✓									
DD	Image classification and segmentation	✓		✓							

DE	Basics of image storage format and representations	✓			✓						
DF	Image processing algorithms and techniques to support image enhancement; image filtering, resampling, interpolation	✓			✓						
DG	Automatic and assisted feature recognition algorithms and their limitations	✓									
DH	Point and feature matching algorithms	✓									

F8b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 571	Int 527	Sfr 406	Sms 540						
DI	1. Describe the steps necessary to prepare raster images for analysis	✓									
DJ	2. Apply various forms of pixel and histogram manipulation to extract information from image	✓	✓		✓						
DK	3. Apply methods to classify an image into various features and classes	✓	✓	✓							
DL	4. Explain the concepts of digital counts, image histogram processing, and compression	✓	✓		✓						
DM	5. Demonstrate basic proficiency in the computational manipulation of imagery	✓									
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔									

F9. Computational Radiometry __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to develop, generate, and apply synthetic scenes

F9a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 571									
DO	Understanding of imaging system modeling (e.g. NIIRS, general image quality equation)										
DP	Understanding of material and optical properties										
DQ	Understanding of atmospheric modeling										
DR	Scene construction basics and geometry modeling	✓									

F9b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 571									
DS	1. Explain the process to produce synthetic imagery covering various regions of the electromagnetic spectrum										
DT	2. Use synthetic scenes to test image system designs	✓									
DU	3. Use synthetic scenes to evaluate image exploitation algorithms										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

F10. Imagery Time Series Analysis __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and basic knowledge required to conduct temporal analysis of pixel-wise observations over space and time

F10a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 571	Int 527	Sms 540							
DW	Understanding of basic temporal signal analysis methods such as Harmonic Analysis of Time Series (HANTS) and Savitsky-Golay Filter, to include			✓							
DX	Using the Iterative Fourier transform to model pixel-wise observations										
DY	Decomposing complex temporal signals into series of simple sinusoidal waves	✓									
DZ	Replacing outliers and noisy data with values from the Fourier series										
EA	Appling least-squares polynomial regression and fitting successive subsets of adjacent data points	✓									
EB	Understanding various time scales of phenomenology in remotely sensed imagery, such as daily vs. annual (i.e., seasonal) cycles	✓		✓							
EC	Understanding various time scales of remote sensing systems, such as video rate vs. daily observation vs. Landsat revisit rate		✓	✓							

F10b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 571	Int 527	Sms 540							
ED	1. Describe the algorithms used for temporal signal decomposition.	✓									
EE	2. Explain the various timescales of interest in remote sensing systems	✓		✓							
EF	3. Explain the observable phenomenologies in temporal remote sensing systems		✓	✓							
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

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Question Group G: (4) Photogrammetry Focus Area
Description: Optional Knowledge Units Addressed by your UMaine Course

G0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the focus area of **Photogrammetry**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

G1. Photogrammetric Theory __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge of photogrammetry concepts and theory.

G1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes

		Sfr 406	Svt 531								
EI	The importance of photogrammetry in geospatial applications	✓	✓								
EJ	Photogrammetric interior orientation (focal length, principal point, image coordinate systems, transformations, and fiducials)	✓	✓								
EK	Photogrammetric exterior orientation (location, orientation, and transformations)		✓								
EL	Photogrammetric optics, ray tracing, lens/telescope design and lens distortion modeling		✓								
EM	Camera, sensor and platform coordinate systems and associated transformations for satellite, airborne, and UAV platforms		✓								
EN	Sensor models (modeling ground to image and image to ground projections for various sensors and platforms and colinearity equations)		✓								
EO	Rigorous vs. replacement sensor models, generic sensor models, and community sensor model (CSM)		✓								
EP	Approximations to sensor models (polynomial [RPC, RSM], DLT, orthographic and accuracy/performance characteristics)		✓								
EQ	Single image resection to recover camera model		✓								
ER	Relative orientation, multi-image intersection		✓								
ES	Camera calibration		✓								
ET	Perspective geometry		✓								
EU	Block adjustment/triangulation of multiple photos to recover imaging and ground parameters, including interior and exterior orientations		✓								
EV	Stereoscopy, parallax, and relief displacement	✓	✓								

G1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Sfr 406	Svt 531								
EW	1. Discuss sensor modeling and accuracy characterization		✓								
EX	2. Explain how to determine interior and exterior orientation of sensors on satellite, airborne and UAV platforms and how they are used in photogrammetric operations		✓								
EY	3. Describe a variety of multi-image photogrammetric techniques and their application to camera calibration, exterior orientation, and image exploitation		✓								
EZ	4. Discuss optics theory and application										
FA	5. Compare and contrast the similarities and differences among the photogrammetric exploitation of imagery data from satellite, airborne and UAV platforms	✓	✓								
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

G2. Photogrammetric Application __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge to apply photogrammetry to spatial problems

G2a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		Svt 531									
FC	Image measurement techniques and autocorrelation	✓									
FD	Monoscopic ray intersection	✓									
FE	Stereoscopic/multiscopic ray intersection	✓									
FF	Triangulation, single sensor and multi-sensor block adjustment,	✓									
FG	Perspective, orthographic, and epipolar rectification	✓									
FH	Terrain/surface/object models (types, formats, how constructed, how to use, accuracy)	✓									
FI	Automated and manual terrain extraction techniques	✓									
FJ	Line of sight extractions from multiscopic imagery	✓									
FK	Image registration	✓									
FL	Algorithms and techniques for measuring object properties from imagery (dimensions, shape, locations, orientation)	✓									
FM	Algorithms, techniques and limitations of using solar information for measuring object properties from imagery										
FN	Algorithms, techniques and limitations of using shadow information for measuring object properties from imagery										
FO	CAD modeling and fusing CAD models with imagery to include draping imagery over urban 3D models	✓									
FP	Image simulation techniques										

G2b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Svt 531									
FQ	1. Discuss algorithms to generate terrain models and their various formats	✓									
FR	2. Explain how image rays can be used to determine object dimensions and orientations	✓									
FS	3. Describe how to build CAD models of objects and project them into imagery for multiple types of terrain (e.g. earth surface, urban areas, etc.)	✓									
FT	4. Explain the theory and application of rectification	✓									
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔									

G3. Close Range Photogrammetry __ Yes __No (If response is yes, the following questions appear.)

Help: Skills and knowledge to apply close-range photogrammetry to GEOINT problems

G3a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		Svt 531									
FV	Characteristics of handheld cameras (point and click, single lens reflex, and mobile devices)	✓									
FW	Close-range camera calibration	✓									
FX	Perspective geometry and single photo perspective photogrammetric techniques.	✓									
FY	Recovering camera model from vanishing perspective										
FZ	Block adjustment/triangulation of multiple photos to recover imaging and ground parameters, including interior and exterior orientations	✓									
GA	Stereoscopy, parallax, and relief displacement	✓									
GB	Algorithms and techniques for measuring object properties from close-range imagery (dimensions, shape, locations, orientation)	✓									
GC	Algorithms, techniques and limitations of using solar information for measuring object properties from close-range imagery										
GD	Incorporation of photogrammetric results into 3D visualization products, e.g., point clouds, surface models, and engineering models.	✓									
GE	Perspective geometry and characteristics of immersive imagery (e.g. digital street view images, Google Earth,)	✓									

G3b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Svt 531									
GF	1. Describe the characteristics of close-range cameras	✓									
GG	2. Explain how image rays can be used to determine object dimensions and orientations	✓									
GH	3. Discuss perspective geometry and how to use it in building camera models	✓									
GI	4. Apply relevant techniques of computer vision to close-range photogrammetry	✓									
GJ	5. Apply relevant techniques of measurement to determine object dimensions and orientations in immersive imagery (e.g. digital street view images, Google Earth)	✓									
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔									

G4. Mathematics, Statistics and Optimization for Imagery Applications __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge in statistics and optimization theory for photogrammetric applications

G4a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		Svt 531									
GL	Understanding statements of absolute and relative accuracy for geopositioning, distance, azimuth, and various object properties	✓									
GM	Error propagation theory and its application to geopositioning, relative mensuration, and measured object properties	✓									
GN	Statistical representation and analysis of sensor or image product absolute and relative accuracy performance	✓									
GO	Optimization theory using least squares techniques (general least squares, constrained, unified least squares, sequential, least squares filtering)	✓									
GP	Linear algebra (matrix representation, linear transformations, equation solution)	✓									
GQ	Numerical analysis (numerical considerations, iteration, numerical approximation)	✓									
GR	Projective geometry	✓									

G4b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Svt 531									
GS	1. Identify general concepts of statistics and their application to spatial information	✓									
GT	2. Discuss statistical graphing and analysis of absolute and relative accuracy performance for sensors and their derived products.	✓									
GU	3. Explain theory and application of least squares optimization techniques	✓									
GV	4. Describe how to model 3D space	✓									
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria	✔									

G5. Digital Photogrammetry __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge to understand algorithms and practices in image processing and computer vision and their application to image exploitation

G5a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at least seven (7) Topics are met.

ID	TOPICS	Courses Responding Yes									
		Svt 531									
GX	Image processing algorithms and techniques to support image enhancement (image filtering, resampling, interpolation)	✓									
GY	Automatic and assisted feature recognition algorithms and their limitations	✓									
GZ	Point and feature-matching algorithms	✓									
HA	Computer vision (camera calibration, image	✓									

	formation, 3D shape reconstruction, object recognition, feature detection, motion estimation, feature matching, transformations, computational photography)										
HB	Digital signal processing										
HC	Digital scanning algorithms, techniques, and accuracy	✓									
HD	Incorporation of photogrammetric results into 3D visualization products (e.g., point clouds, surface models, engineering models)	✓									
HE	Implications for photogrammetry in immersive 3D environments (e.g. Oculus Rift, holograms, first-person video, anaglyphs)										

G5b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		Svt 531									
HF	1. Identify overall image processing algorithms for remotes sensing applications	✓									
HG	2. Describe theory and algorithms of computer vision and apply them to photogrammetric problems	✓									
HH	3. Describe theory and algorithms of immersive 3D technologies such as Oculus Rift, holograms, first person video, anaglyphs, etc. and apply them to photogrammetric problems										
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria										

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Question Group H: (5) Information Science Focus Area
Description: Optional Knowledge Units Addressed by your UMaine Course

H0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the focus area of **Information Science**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

H1. Spatial Applications of Big Data __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge relating to techniques and concepts for employing data science and big data analytic methods to cartographic activities

H1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 512	SIE 516	SIE 550	SIE 558	SIE 559					
HK	Big data for spatial applications		✓		✓	✓					
HL	Big data analytics for spatial applications		✓		✓	✓					
HM	Methods for spatial data analysis in big data				✓	✓					
HN	Using data science principles in cartographic design	✓									
HO	Application of data science principles to	✓									

	cartography										
HP	Future and emerging areas of data science inquiry for spatial applications	✓			✓						
HQ	QA/QC of geospatial data in big data applications	✓		✓							

H1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 512	SIE 516	SIE 550	SIE 558	SIE 559					
HR	1. Explain the concepts and principles of big data analytics for spatial applications (meaning, methods, outcomes)	✓	✓		✓	✓					
HS	2. Demonstrate the use of big data analytics concepts in geospatial analysis	✓		✓							
HT	3. Describe QA/QC methods for geospatial data in big data applications and discuss the implications for analysis and analytics results			✓							
HU	4. Describe the future directions for big data analytics in geospatial applications.				✓	✓					
HV	5. Discuss approaches to geospatial metadata/data tagging in big data applications, why metadata/data tagging is important and challenges to managing geospatial data in big data applications.				✓						
	Three courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: SIE 512, 550 and 558	*		*	*						

H2. Advanced Spatial Analysis Through Programming __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to expand existing data processing functionality and develop new applications for geospatial analysis, spatial statistics, remote sensing applications, etc. using common programming languages.

H2a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 510	SIE 512	SIE 558	SIE 571	Bio 597					
HX	Common scripting languages for spatial applications (e.g. Python, etc.)	✓	✓		✓	✓					
HY	Common programming languages for spatial applications (e.g. IDL, C++/JAVA, ERDAS Imagine Spatial Modeler)		✓		✓						
HZ	Cloud-based programming for spatial applications			✓	✓						
IA	Creating spatial applications for mobile and web-based platforms				✓						

H2b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 510	SIE 512	SIE 558	SIE 571	Bio 597					
IB	1. Describe the basics of scripting and programming languages used for spatial applications (desktop, mobile, web-based	✓	✓		✓	✓					

	applications)										
IC	2. Explain the basics of programming and coding algorithmic routines in expanding existing applications and/or developing new functionality and capabilities to address hard-problem challenges with niche solutions.	✓	✓		✓						
ID	3. Discuss the basics of how programming and scripting languages are used with common geospatial software packages (e.g. ENVI, ESRI, ERDAS Imagine)	✓									
IE	4. Demonstrate the applied application of programming for spatial applications (e.g. automate the QC of 40 maps)	✓	✓								
IF	5. Demonstrate the applied use of cloud-based technologies (e.g. MapReduce, Hadoop) for geospatial applications			✓							
	Three courses together meet minimum TOPIC and LEARNING OBJECTIVE criteria: SIE 510, 558 and 571	*		*	*						

H3. Spatial Query Operations and Query Languages __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge required to conduct basic data queries

H3a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when at all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 505	SIE 509	SIE 510	SIE 550	SIE 554	SIE 555	SIE 558	SIE 559		
IH	Set theory	✓		✓	✓	✓	✓	✓	✓		
II	Application of query operations/query languages to GIS and spatial data analysis (e.g. Structured Query Language (SQL), non-SQL, SPARQL, JSON, JAVA, HTML)			✓	✓	✓	✓	✓	✓		
IJ	Attribute queries vs. spatial queries		✓	✓	✓		✓	✓	✓		

H3b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 505	SIE 509	SIE 510	SIE 550	SIE 554	SIE 555	SIE 558	SIE 559		
IK	1. Explain how set theory relates to spatial queries	✓		✓	✓	✓	✓	✓	✓		
IL	2. Perform a logic (set theoretic) query using GIS software			✓	✓	✓	✓	✓	✓		
IM	3. Define basic terms of query processing (e.g. SQL, primary and foreign keys, table join)		✓	✓	✓		✓	✓	✓		
IN	4. Demonstrate multiple query language techniques (e.g. SQL, non-SQL, SPARQL, JSON, JAVA, HTML) to retrieve elements from a GIS			✓	✓		✓	✓	✓		
IO	5. Compare and contrast attribute queries and spatial queries		✓	✓	✓		✓	✓	✓		
IP	6. Construct a query statement to search for a specific spatial or temporal relationship; compare/contrast the use of different query languages for spatio-temporal data searches and describe when to choose one language over another			✓	✓		✓	✓			

	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria			✔	✔		✔	✔			

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The following section has NOT been included for assessment at UMaine
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Question Group I: Aeronautical Analysis Focus Area
Optional Knowledge Units Addressed by your UMaine Course

D0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the Focus Area of **Aeronautical Analysis**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

Knowledge Unit I1. Airspace Analysis __ Yes __No (If response is yes, the following questions appear.)
Knowledge Unit description: Skills and knowledge required to determine aeronautical accuracy, validity and/or safety of domestic and foreign airspace data and information
Requirement satisfaction: This KU is satisfied when all Topics and all Learning Objectives are met.

Topics:
Domestic airspace boundary formulation, limitations and characteristics
Foreign airspace boundary formulation, limitations and characteristics
International airspace structures, regulations and policy
Domestic and international piloting procedures in airspace of the world
Learning objective(s):
1. Identify the various types and characteristics of worldwide airspace structures.
2. Describe US military mission requirements in using worldwide airspace structures.
3. Determine if, how, and when domestic/international airspace is safe for US military use.

Knowledge Unit F2. Airway Analysis __ Yes __No (If response is yes, the following questions appear.)
Knowledge Unit description: Skills and knowledge required to determine aeronautical accuracy, validity and/or safety of domestic and foreign airway data and information
Requirement satisfaction: This KU is satisfied when all Topics and all Learning Objectives are met.

Topics:
Domestic airway limitations and characteristics
Foreign airway limitations and characteristics
International airway structures, regulations and policy
Domestic and international piloting procedures on airways of the world
Learning objective(s):
1. Identify the various types and characteristics of worldwide airway structures.
2. Describe US military mission requirements in using worldwide airway structures.
3. Determine if, how and when a domestic/international airway is safe for US military use.

Knowledge Unit F3. Airfield Analysis __ Yes __No (If response is yes, the following questions appear.)
Knowledge Unit description: Skills and knowledge required to analyze and determine various airfield characteristics
Requirement satisfaction: This KU is satisfied when all Topics and all Learning Objectives are met.

Topics:
Airfields logistics
Airfield infrastructure
US military aircraft usage of domestics/international airfield services
Common signs of airfield upgrades and expansion
Learning objective(s):
1. Identify common and uncommon forms of domestic and international airfield infrastructure

2. Describe the variety and complexity of US military mission requirements in using worldwide airfields
3. Determine if, how and when domestic/international airfields are safe and/or suitable for US military use.

Knowledge Unit F4. Flight Procedure Analysis __ Yes __No (If response is yes, the following questions appear.)

Knowledge Unit description: Skills and knowledge required to determine aeronautical accuracy, validity and/or safety of domestic and foreign flight procedures
Requirement satisfaction: This KU is satisfied when all Topics and all Learning Objectives are met.

Topics:
Domestic flight procedure limitations and characteristics
Foreign flight procedure limitations and characteristics
International flight procedure formulation, regulations and policy
Domestic and international piloting procedures of the world
Learning objective(s):
1. Discuss the various worldwide flight procedures
2. Describe US military mission requirements in using worldwide flight procedures
3. Determine if, how and when domestic/international flight procedures are safe for US military use.

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Question Group J: (7) Navigation and Location Analysis Focus Area
Optional Knowledge Units Addressed by your UMaine Course

J0. Does this course partially or completely address any of the following Geospatial Knowledge Units under the Focus Area of **Navigation and Location Analysis**?
Help: For each of your courses, please attempt to respond positively to as many items as possible under each of these optional areas.

J1. Geodesy __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge relating to the theory and application of geodesy to photogrammetric applications

J1a. Question: Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied only when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	SIE 510	Svt 541							
E	Geometric geodesy (ellipsoid characteristics, geometry, WGS84)	✓	✓	✓							
F	Gravity modeling and earth gravity models; the geoid and geoid separation, mean sea level approximation.	✓	✓	✓							
G	Earth coordinate systems and associated transformations (ECI, ECF, spherical, ellipsoidal)	✓		✓							
H	Local coordinate systems and associated transformations (spherical, ENU, geographic projection systems [UTM, state plane])	✓	✓	✓							
I	Absolute and relative survey coordinate and accuracy information			✓							
J	Ellipsoid height, geoid height, and orthographic height		✓	✓							
K	Universal time and earth orientation parameters			✓							

J1b. Question: Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied only when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes

		SIE 509	SIE 510	Svt 541							
L	1. Discuss the general theory of geodesy and gravity modeling (relations of gravitational models and geoid, the effects of gravitational distribution on the height datum problem)	✓	✓	✓							
M	2. Identify the various spatial coordinate systems and how to transform between them		✓	✓							
N	3. Explain what the geoid is, and how it relates to mean sea level	✓	✓	✓							
O	4. Discuss the importance of ground survey information and the use of the word "control" to describe a surveyed point or feature.	✓	✓	✓							
P	5. Describe the differences between ellipsoid height, geoid height, msl height, and orthographic heights		✓	✓							
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria			✔							

J2. Fundamentals of the Global Positioning System (GPS) and the Global Navigation Satellite System (GNSS) __ Yes __No (If response is yes, the following questions appear.)
Help: Skills and knowledge relating to how GPS and GNSS work and the diverse range of uses for satellite navigation

J2a. Please check any and all of the following TOPICS covered by your course.
Help: This KU is satisfied when all Topics are met.

ID	TOPICS	Courses Responding Yes									
		SIE 509	Svt 437								
R	How GPS works	✓	✓								
S	Orbits and signals		✓								
T	Accuracy and error analysis		✓								
U	GPS modernization and GNSS		✓								
V	GNSS today and the into the future		✓								

J2b. Please check any and all of the following LEARNING OBJECTIVES covered by your course.
Help: This KU is satisfied when all Learning Objectives are met.

ID	LEARNING OBJECTIVES	Courses Responding Yes									
		SIE 509	Svt 437								
W	1. Describe a GNSS system (hardware, software and control of system) and relate it to GPS	✓	✓								
X	2. Describe a plan for collecting GPS data (hardware, software, process) for different types of applications.		✓								
Y	3. Describe what can affect the accuracy or cause errors for data collected by a GPS	✓	✓								
Z	4. Demonstrate how to collect accurate GPS data useful in different applications		✓								
AA	5. Discuss the historic development of GNSS and describe possible future uses and trends.		✓								
	Course by itself meets minimum TOPIC and LEARNING OBJECTIVE criteria		✔								