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Addressing the Skills Gap of Geospatial Professionals in the Fourth Industrial Revolution

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Walden University
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Abstract

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by

Shannon M. Doyle

MBA, Strayer University, 2008

BS, Loyola University Maryland, 2001

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Management

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Abstract

Leaders of geospatial organizations are ill-prepared to manage rapid technological change critical to environmental and economic development due to an outdated list of technical competencies. However, there is a lack of consensus in the geospatial industry concerning the desired technical competencies of organizations and a gap in the literature regarding future trends when defining additional geospatial technical competencies. Therefore, the purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals. The research questions for this study were grounded by the interrelated elements of talent management theory and system theory. Through 3 rounds of surveys, 42 experts shared their views and suggestions based upon a predetermined list of categories and associated technical competencies. Frequencies and median scores were calculated using Likert-type scales of desirability and practicability for each technical competency to determine levels of consensus. Consensus-based findings included a final list of 54 forward-looking desirable and practicable technical competencies in 7 categories. This study may contribute to positive social change by providing geospatial organizations and talent managers with a consensus-based list of technical competencies to improve hiring strategies and develop training and reskilling programs for addressing future trends and technological advancements in the geospatial industry. Study results may also impact government policies and strategies to help preserve national security and promote economic growth and global diplomacy through informed decision making.

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Dedication

My dissertation is dedicated to my grandmother, Joyce Schreiner, and my aunt, Deborah McClanathan, who have both passed; my late grandmother, Lois Holbrook; my parents, Joyce and Sam Holden; my mother-in-law, Eva Mae Doyle; my husband, Michael Doyle; and my three daughters, Olivia, Avery, and Cassidy. To my grandmother, I thank you for always believing in me and encouraging me to push myself toward greatness. To my aunt, you are not here to see me finish this journey, but your love, laughter, and fond memories have carried with me and helped me keep pushing forward during times I wanted to give up. To my grandmother Lois, thank you for always knowing how to make me laugh and encouraging my love of learning. To my parents, I thank you for inspiring me to be the best version of myself and helping me become a strong, independent, and compassionate human being. To my mother-in-law, thank you for being my champion and supporting me in any way you could. To my husband, you are my rock and my best friend, and I could not have done this without all your love and support. To my daughters, you inspire me to be the best mother and female role model that I can be for you. I love you all and hope you know how proud I am to be your mom.

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Chapter 1: Introduction to the Study

As the world enters the fourth industrial revolution, rapid technological changes and the convergence of many types of technologies will change the way people work and live. Organizations need quick solutions to prepare their workforces for these rapid changes. Information technology-related employers, which include geospatial organizations, have reported the highest talent shortages since 2007, moving from a ranking of ninth in 2007 to second in 2015 (Orlikowski & Lozinak, 2016). The need for digitally competent employees is expected to increase more than twofold by the year 2021 (Geissbauer, Vedso, & Schrauf, 2016). A competency gap exists between the current geospatial workforce and future industry needs, as the focus has been on what is needed now, and the industry is always playing "catch up" (Cann, 2016; Meier, 2016; Wikle & Fagin, 2014). As high rates of geospatial job growth, upwards of 29%, are expected through 2024 (U.S. Department of Labor, 2014), human resource managers are questioning the competencies (i.e., the requirements, skills, and knowledge) needed by employees to be successfully reskilled for the digital transformation of the workplace (Wikle & Fagin, 2014). In this study, I attempted to address the need for updated technical competencies that are relevant to current and future industry needs.

Chapter 1 consists of background information related to the problem and a problem statement to anchor the research. The purpose of the study is given, in addition to the significance of the study to the geospatial industry and the community of scholars. Potential positive social implications are also discussed. The nature of the study and the conceptual framework are summarized. Assumptions, limitations, and delimitations

underpinning the research are introduced. The chapter concludes with a summary and transition statement to Chapter 2.

Background of the Problem

There is a lack of consensus in the industry regarding the desired geospatial technical competencies of organizations (Cann, 2016; DiBiase et al., 2006; Directions Magazine, 2018; Gaudet, Annulis, & Carr, 2003; Hong, 2015; Maynard, 2015; Plessis & van Nierkerk, 2013; Schwab, 2016a; Solem, Cheung, & Schlemper, 2008; Veenendaal, 2014), as well as a lack of studies regarding the forecast of competency needs for the future (Meier, 2016; Schwab, 2016a). Several gaps in the literature were identified. First, there is a clear lack of consensus regarding required geospatial technical competencies (Cann, 2016; Maynard, 2015; Plessis & van Nierkerk, 2013; Schwab, 2016a; Veenendaal, 2014), although several studies were conducted in the past to develop a competency model (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014). Some overlap exists between the competency lists, but there are also clear differences. Second, recent studies are lacking regarding the updating of geospatial technical competencies. The Geographic Information Science and Technology Body of Knowledge (GIS&T BOK) has not been officially updated since 2006 (DiBiase et al., 2006), and the original Geospatial Technology Competency Model (GTCM) was created in 2003 (Gaudet et al., 2003), with a recent update just published in 2018 (Directions Magazine, 2018). This updated GTCM is like the GTCM of 2003, but the wording of definitions was simplified, and some irrelevant technologies were omitted. The overall structure of the model remained the same, and

there was no mention of forward-looking competencies. Third, there is a gap in the literature regarding what kind of forward-looking geospatial technical competencies should be included on the list (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014). Future trends in the industry were discussed by scholars and practitioners, but there are no current studies that take into consideration future trends when defining additional geospatial technical competencies (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Meier, 2016; Schwab, 2016a; Solem et al., 2008; Wikle & Fagin, 2014). In this study, I aimed to close some of these gaps in the literature. This study was needed to develop a competency list that organizations can use to meet current and future hiring needs. A forward-looking competency list is necessary to prepare organizations for rapid changes resulting from the fourth industrial revolution and to better equip organizations for hiring and managing the existing talent, which includes the development of training and reskilling programs (Cann, 2016; Maynard, 2015; Meier, 2016; Plessis & van Nierkerk, 2013; Schwaba, 2016; Veenendaal, 2014).

Problem Statement

The world is at the beginning of the fourth industrial revolution; a major technological revolution that exploits the convergence of many emerging technologies for digital transformation. The fourth industrial revolution also involves the connecting of devices, machine components, and nearly anything with a power switch to the Internet for data exchange and data collection (AbuMezied, 2017). This revolution is changing how people work, live, and relate to each other (Maynard, 2015; Schwab, 2016a).

Although the dynamics and complexities of global markets in the fourth industrial revolution are largely unknown, it has become increasingly clear since 2010, that the preparation of a comprehensive and integrated response to rapid technological change is underway by public and private sector organizations such as academia, governments, and society (Schwab, 2016a). The geospatial industry is no exception, as geographic information systems (GIS) technology is essential for national security and informed decision making among many types of organizations (Foster & Mayfield, 2016; Salkin, 2005). Geospatial professionals provide the tools, technologies, and services to support informed decision making by organizational leaders based on geographic data (Boston Consulting Group, 2012). As high rates of geospatial job growth, upwards of 29%, are expected through 2024 (U.S. Department of Labor, 2014), human resources (HR) managers are questioning the competencies, or requirements, skills, and knowledge, needed by employees to be successfully reskilled for the digital transformation of the workplace (Wikle & Fagin, 2014). The general management problem is that the convergence of emerging technologies and the resulting rapid changes (Schwab, 2016a) are outpacing the ability of geospatial industry leaders to maintain a properly skilled workforce (Meier, 2016; Veenedaal, 2014; Wikle & Fagin, 2014). Talent deficits in the geospatial industry pose increased risks to national security (Foster & Mayfield, 2016; Salkin, 2005; Veenedal, 2014; Wikle & Fagin, 2014). The defense and intelligence sectors of the geospatial field are being affected by these deficits, as the need for digitally competent employees is expected to increase more than twofold by the year 2021 (Geissbauer et al., 2016). The specific management problem is that leaders of geospatial

organizations use an outdated set of competencies, codified in 2006, which makes industry leaders ill-prepared to manage rapid technological change (DiBiase et al., 2006; Veenedaal, 2014; Wikle & Fagin, 2014). There is a lack of consensus on updated competencies required to meet industry needs resulting from the fourth industrial revolution (Cann, 2016; Maynard, 2015; Plessis & van Nierkerk, 2013; Schwab, 2016a; Veenendaal, 2014). Without identifying future competency needs, organizations will not be ready to develop reskilling plans for the geospatial workforce (Meier, 2016; Schwab, 2016a).

Purpose of the Study

The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts shared their views based upon a predetermined list of categories and associated technical skills and knowledge required for geospatial professionals to perform their jobs successfully.

Research Questions

The primary research question and two subquestions posed for this study were as follows:

Research Question (RQ): How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?

Subquestion 1 (SQ 1): How does a panel of experts in the geospatial industry view the desirability of forward-looking technical competencies of geospatial professionals?

Subquestion 2 (SQ 2): How does a panel of experts in the geospatial industry view the practicability of forward-looking technical competencies of geospatial professionals?

Nature of the Study

Different investigators have focused on the fourth industrial revolution and the implications of the diffusion of disruptive new technologies such as 3D printing and augmented reality (Schwab, 2016a). Despite the awareness of leaders in the corporate, government, and educational sectors, no collaborative efforts have been made among industry experts to agree upon a current set of technical competencies needed to keep pace with the diffusion of advancing technologies (Schwab, 2016a; Veenendaal, 2014; Wikle & Fagin, 2014).

For this study, nonprobability, purposive sampling was used to constitute the expert panel, comprised of geospatial talent management and technology executives. Panelists were chosen with the use of criteria based upon a set of knowledge and experience indicators unique to the topics requiring expert opinion (Linstone & Turoff, 2002; von der Gracht, 2008). For the study, the criteria to identify experts included (a) 10 or more years of working experience in the geospatial field of which at least 5 years of experience were gained in a geospatial industry in an executive or management role, or at least 5 or more years of experience were gained in geospatial talent management

encompassing the strategy and implementation for employee hiring and development; (b) holding at least a bachelor's degree in GIS or a related field; and (c) possession of at least one of the existing geospatial professional certifications (e.g., Geographic Information Systems Professional [GISP], Esri Authorized Desktop Professional [EADP], ASPRS [American Society for Photogrammetry and Remote Sensing] Mapping Scientist, or other).

Panelists were identified in cooperation with owners of LinkedIn professional forums, leadership of the Geographic Information Systems Certification Institute (GISCI), and the use of snowball sampling (i.e., recommendations for panel membership made by existing contacts) as a contingent recruitment strategy. The sampling frame was estimated to cover more than 10,000 professionals, based on an assessment of LinkedIn contacts and GISCI members who meet panel inclusion criteria.

Panel sizes can vary in Delphi studies from as few as 10 members to several hundred members (Linstone & Turoff, 2002; von der Gracht, 2008). For this study, 24 experts formed the panel. Twenty-five was believed to be a good sample size for obtaining saturation of judgment among experts concerning forward-looking solutions (see Hasson, Keeney, & McKenna, 2000; von der Gracht, 2008). Ludwig (1997) stated that most Delphi studies used a sample of between 15 and 20 panelists (p. 2). Twenty-five was the desired number of participants for this study to allow for sufficiency of panel size while accounting for potential attrition of panel members (Hsu & Sanford, 2007), and 24 was the final number participants.

The study is classified as qualitative research because initial data collection drew upon the subjective opinions of experts (see Skulmoski**,** Hartman, & Krahn, 2007). The Delphi design is appropriate for identifying consensus among a panel of experts by methodically obtaining anonymous opinions from the experts in their prequalified areas of knowledge (Linstone & Turoff, 2002; von der Gracht, 2008). The modified Delphi research design encompassed three rounds of data collection and analysis for identifying viewpoints and the potential for consensus among the panel of experts of forward-looking desirable and practicable technical competencies of geospatial professionals. All surveys were administered to the panel members via secure, online survey tools.

The use of traditional, open-ended first-round questions of classical Delphi was bypassed in favor of using selected technical competencies from the existing competency list from the GIS&T BOK. In Round 1 of this study, panelists were invited to modify or add to the technical competencies on the original list, as a final updated list still does not exist. This change in protocol constituted the modified Delphi (Linstone & Turoff, 2002; Skulmoski et al., 2007).

The final list of competencies from Round 1 was converted to Likert-type competency statements for inclusion in the Round 2 survey instrument. The panelists then evaluated each competency statement, or item, using scales for desirability and practicability, based on criteria developed by Linstone and Turoff (2002). In Rounds 2 and 3, descriptive statistics were used to evaluate the ratings the panelists provided for desirability and practicability for each of the Likert-type competency statements, as well as overall confidence. In Round 3, panelists were provided with a final list of those

forward-looking technical competencies that are deemed by the panelists to be desirable and practicable. Panelists were asked in Round 3 to review these results by using a 5-point Likert scale to rate their confidence in the overall results of the study. These ratings were used as self-reported measures of credibility and confirmability of the trustworthiness of the results of the study (Lincoln & Guba, 1985; Linstone & Turoff, 2002; von der Gracht, 2008).

Conceptual Framework

The fourth industrial revolution will result in rapid change and require rapid responses to talent management; it will systematically affect the entire geospatial industry (Schwab, 2016a). The conceptual framework for this study included the concept of talent management from talent management theory and the concept of systems thinking from systems theory.

Talent Management Theory

Although there is no single researcher credited with the development of a talent management theory, Miner (1973) contributed to the theory's origins with a focus on the outcomes of talent recruitment measured by managerial success (Ariss, Cascio, & Paauwe, 2014; Miner, 1973). The practice of talent management evolved to include developing existing talent as well as recruiting new talent with the assumption that maximizing employees' talents is a major source of an organization's competitive advantage (Ariss et al., 2014). With the growth of the HR profession and globalization of business during the last 40+ years, talent management theories are more tightly linked to HR management practices with the goal of improving business performance (Ariss et al.,

2014). The goal of identifying viewpoints and potential for a consensus related to the forward-looking desirable and practicable technical competencies of geospatial professionals was aligned with the concept of talent management and the tenets of talent management theory.

Systems Theory

The grand-scale adaptation to a set of competencies for geospatial talent management represents a major system change, which can be explained through the work of von Bertalanffy (1969). Systems theory was originally proposed by von Bertalanffy, a biologist, in 1928. In 1951, he extended the original idea in that a system could be subdivided into individual components, analyzed as independent entities, followed by the components linearly added to describe the system's totality (Mele, Pels, & Polese, 2017; von Bertalanffy, 1969). Ackoff (1962, 2004) was another major contributor to systems thinking and systems theory. He posited that organizations should be viewed as systems to manage change and that management should utilize holistic and synthetic thinking rather than reductionist and analytical thinking. Systems theory was applied to understanding the convergence of various emerging technologies, as well as to how geospatial organizations, viewed as management systems, should respond to rapid industry changes and address resulting skills gaps.

The concept of systems thinking derived from systems theory applied to this research study because the wide-scale acceptance of a consensus-based competency list is a significant system change. Senge (2006) described systems-thinking organizations as "decentralized, nonhierarchical organizations dedicated to the well-being and growth of

employees as well as to success" (p. 15). Meadows (2008) defined a system as something that is more than the sum of its parts, consisting of "an interconnected set of elements that is coherently organized in a way that achieves something" (p. 11). Meadows posited that a system must consist of three things: (a) elements, (b) interconnections, and (c) function or purpose. Both Senge (2006) and Meadows (2008) discussed systems thinking as a different way to look at things; an alternative perspective that includes the elements, cause and effect relationships, and how things influence each other. Systems thinking considers cause-and-effect relationships and allows for the process of multiple-scenario analysis. It is also important to consider how systems thinking fits into the chaos and complexity experienced in today's organizations and how this way of thinking has moved individuals and organizations away from traditional ways of thinking. A thorough explanation of the concepts of both talent management and systems thinking and their logical connections to this study is provided in Chapter 2.

Definition of Terms

This section contains terms and acronyms with unique meanings in the context of this study.

Competency: An important skill or knowledge that is needed to do a job (Hoffman, 1999). In this study, competencies will be the basis for the Delphi survey rounds, with a list of desirable and practicable forward-looking geospatial technical competencies as the result.

Fourth industrial revolution: A major technological revolution that exploits the convergence of many emerging technologies for digital transformation such as artificial

intelligence and the connecting of devices, machine components, and nearly anything with a power switch to the Internet for data exchange and collection (AbuMezied, 2017; Maynard, 2015). In this study, the fourth industrial revolution is a driving force for attempting to develop a list of desirable and practicable forward-looking geospatial technical competencies.

Geographic Information Science and Technology Body of Knowledge (GIS&T BOK): In this study, the GIS&T BOK (DiBiase et al., 2006) was used as the starting point for the Round 1 survey.

Geographic Information Systems (GIS): GIS is the organized activity (typically computer/technology-based) by which people measure geographic phenomena, represent these measures, operate upon the representations, and transform representations (Chrisman, 1999). A GIS system is designed to capture, store, analyze, manipulate, represent, and manage geographic data and related attribution (Esri, 2019). In this study, *GIS* is referenced as a competency, as well as a term that is interchangeable with *geospatial*.

Geospatial talent management (GTM) expert: A GTM expert has geospatial talent management, technical, and professional experience (in the United States) and meets the minimum criteria for panel participation set forth in Chapter 3.

Geospatial technology: The geospatial industry is composed of organizations that rely on geospatial technology as a foundation for their core business practices. Geospatial technology is GIS-related technology that can be applied across many different fields, including but not limited to the environment, agriculture, government, defense and

intelligence, engineering, transportation, real estate, and more (Kumar, 2015). In this study, geospatial technology is used in reference to geospatial technical competencies.

Internet of Things (IoT): A term used to identify the concept of the digital connectivity of various kinds of devices and the coexistence of their technologies in a chosen interconnection platform (Atzor, Iera, & Morabito, 2017).

Taxonomy: A system for naming and organizing things into groups that share similar qualities (Rich, 1992). In this study, a taxonomy was used to organize a list of competencies.

Assumptions

An assumption is defined as that which is considered true or mostly plausible by those reading the study related to the research design, population, statistical tests, or other restrictions placed upon the scope of the study (Marshall & Rossman, 2016). This study included several important assumptions. First, there was the assumption that each panel member had the knowledge and experience required to provide honest and knowledgeable feedback during the survey process. Second, there was the assumption that panelists responded accurately and honestly to the self-reporting validity part of the survey and that they met the criteria set forth for panel participation. Third, the questions used in the Round 1 survey were finalized, based on the most relevant and forward-looking technical competencies in the GIS&T BOK, which currently is the most relevant list used by employers and educators. Open-ended responses to the survey were based on the participants' understanding of the fourth industrial revolution and future trends in the geospatial industry. Another important assumption was that although I had experience

with GIS and geospatial technical competencies, the potential for inherent bias was controlled by the nature of the research design. There was also the assumption that the literature reviewed in Chapter 2 had reached saturation.

Additionally, there was the assumption that any technical competencies added by the panel members accounted for all the forward-looking geospatial technical competencies. The panel expert criteria established for the study should have ensured that participants had the proper knowledge and experience to be included on the panel. For this study, the criteria to identify experts included (a) 10 or more years of working experience in the geospatial field of which at least 5 years of experience were gained in a geospatial industry in an executive or management role, or at least 5 or more years of experience were gained in geospatial talent management encompassing the strategy and implementation for employee hiring and development; (b) holding at least a bachelor's degree in GIS or a related field; and (c) possession of at least one of the existing geospatial professional certifications (e.g., GISP, Esri EADP, ASPRS Mapping Scientist, or other).

Scope and Delimitations

Geospatial technology can be applied to countless fields and industries, and identifying every possible desired competency is a complex problem that cannot be addressed in a single study. Defining the scope of a study allows for delimited boundaries, making the study more manageable and practical (Simon & Goes, 2013). Delimitations are defined as the definitions of the controllable boundaries and scope limits a researcher sets on the study to keep the study manageable (Yin, 2014). There

were several delimitations to consider in this study. This study's scope was delimited to identifying forward-looking desirable and practicable technical competencies of the general geospatial industry. The study was delimited to technical competencies to maintain an attainable level of complexity in data collection and analysis. The scales used for desirability and practicability, as well as the number of survey rounds conducted were also delimitations. The assessment and measurements used to define a consensus from the data was a delimitation, as was the amount of controlled feedback provided to, requested by, and shared with the panel of experts. Another delimitation of the study was that panel experts were based in the United States. Most potential expert panel members were in the United States and belonged to the organizations that were contacted for sampling purposes. However, geospatial organizations and professionals outside the United States could find the study applicable. The transferability of this study was based on the alignment of the expertise of the panelists with the needs of those who may read the study. Because Delphi studies use a purposeful sampling strategy, an opportunity exists for transferability based on the inclusion criteria of the panelists and description of the phenomenon under study (Brady, 2015). The survey administration tool, SurveyMonkey, ensured consistency in how the panelists took the survey. The resulting consensus-based list of technical competencies can be used as a starting point for future research, when geospatial technical competencies need to be reviewed and updated once again.

Limitations

Limitations are defined as restrictions on the study that cannot be reasonably dismissed; they may be considered potential weaknesses in a study that are out of the researcher's control due to factors such as limited funding and statistical model constraints (Marshall & Rossman, 2016). One limitation of this study was the anonymity and accountability upon which the study was structured. There was a possibility that the anonymous nature of the study may have resulted in a lack of accountability, which could have impacted the progress of the study (see Vernon, 2009). If panel members did not take the study seriously, the accuracy and rigor of their responses may have been affected (Vernon, 2009). The study was also limited by any unverified self-reported expertise of the panelists, as well as any bias they may have held.

Another limitation to consider was that due to anonymity, there was not any face-to-face communication between the panel members, resulting in a lack of potential debate. Because the participant portion of the study was conducted online, there was no opportunity for expert interactions. The lack of debate may have concealed reasons for conflicting expert responses (see Vernon, 2009). The study was also limited to the willingness of panelists to share their explanations for ratings and the quality of those explanations.

There were also limitations concerning the Delphi design in general. First, the study topic could have proven to be too complex, so that only a weakened consensus was possible, if a consensus was possible at all (see Avella, 2016). This was unlikely to occur in this study, because of the nature of the expert panel and because so many organizations

have used the GIS&T BOK (see DiBiase et al., 2006). Second, the competencies could have been too general for a nuanced consensus. Third, von der Gracht (2008) shared, from experience, that in a small set of instances (less than 5%), there was the possibility that the expertise and performance of an individual expert may outweigh that of the rest of the panel with the result that the performance of the rest of the panel is less effective overall.

Significance

IT-related employers, which include geospatial organizations, have reported the highest talent shortages since 2007, moving from ranking ninth in 2007 to second in 2015 (Orlikowski & Lozinak, 2016). The need for digitally competent employees is expected to increase more than twofold by the year 2021 (Geissbauer et al., 2016). A competency gap exists between the current geospatial workforce and future industry needs because the focus has been on what is needed now, and the industry is always playing "catch up" (Cann, 2016; Meier, 2016; Wikle & Fagin, 2014).

Schwab (2016b) stated in the human capital report for the World Economic Forum that educational, private, and government sectors must come together to develop workplace readiness of human capital. The ability to achieve consensus is hampered by accelerated changes in geospatial technologies (Cann, 2016; Schwab, 2016b; Wikle & Fagin, 2014); inconsistent job titles (Wikle & Fagin, 2014); uncertainty of future organizational needs (Cann, 2016; Meier, 2016; Schwab, 2016b; Wikle & Fagin, 2014); and variations in expectations for management responsibilities, which evolve as the geospatial field grows (Mathews & Wikle, 2016; Wikle, 2016).

Positive social change may result from this study based on the adoption of the potential recommendations of the expert panel. The technical competencies identified in this study may impact government policies and strategies that can help preserve national security and promote economic growth and global diplomacy. Failure to update geospatial technical competencies could have an adverse impact on promoting social change, should there be an increase in the technological obsolescence of the nation's security infrastructure and, ultimately, diminished national power (Kadtke & Wells, 2014).

Summary

This chapter contained an overview of the research proposal, with the goal of introducing and informing readers about its contents. The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals. Technical competencies were classified into categories of skills and knowledge required for geospatial professionals successfully to perform their jobs. This chapter included the background, objective, and rationale for choosing the topic, research methods, and design. The chapter began with a description of the background and rationale for choosing the topic of geospatial industry leaders being ill-prepared to manage rapid technological change due to an outdated list of geospatial technical competencies. The research problem was developed and presented, a gap in the literature was identified, and the research questions were formulated. A conceptual framework, based on integrating systems theory and talent management theory, was

presented. The rationale for selecting a qualitative approach and modified Delphi technique was summarized. Definitions of critical terms were included, as well as assumptions, delimitations, and limitations that determined the scope and nature of the study. The significance of the study for practitioners and industry leaders, as well as potential implications for positive social change, were explained.

The next chapter is a review of the existing literature, which formed the basis for the research study. Chapter 2 includes the search strategy used to identify and verify relevant resources and a review and synthesis of the literature related to key concepts of the study, the conceptual framework, and the research methods. A gap in literature is described at the end of the chapter, supporting further justification of the significance of conducting this study. Chapter 2 ends with a chapter summary and transition to Chapter 3.

Chapter 2: Literature Review

This chapter contains a review of existing literature related to the research problem. The general management problem examined in this study is the convergence of emerging technologies and the resulting rapid changes (Schwab, 2016a) that are outpacing the ability of geospatial industry leaders to maintain a properly skilled workforce (Meier, 2016; Veenedal, 2014; Wikle & Fagin, 2014). The specific management problem for this study is that leaders of geospatial organizations use an outdated set of technical competencies, codified in 2006, which makes industry leaders ill-prepared to manage rapid technological change (DiBiase et al., 2006; Veenedal, 2014; Wikle & Fagin, 2014). The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals.

Although the authors of several recent resources and studies discussed the desired geospatial technical competencies of organizations in the industry as it currently stands, there was little mention of forecasted competency needs for the future (Craig & Wikle, 2016; Malhotra, Kantor, & Vlahovic, 2018; Pendyala & Vijayan, 2018; Ricker & Thatcher, 2017; Wikle, 2016). Forward-looking geospatial technical competencies were rarely discussed in the literature, and no consensus-based list of these types of competencies currently exists. This gap in the literature has added to the persistence of the specific management problem.

The remainder of Chapter 2 begins with a description of the search strategy used to identify relevant sources for the literature review. Next is a review of the literature that provided the basis for the conceptual framework for the study. This section also contains the justification for using systems theory and talent management theory as the basis for the conceptual framework. Then, the current literature related to the problem statement is reviewed. The focus of this section is to establish the relevance of the problem based on what is known or not known in the existing literature; hence, identification of the gap in the existing literature. A secondary purpose of the literature review is to demonstrate credibility of the Round 1 survey instrument for data collection by establishing the precedence in the literature for the items included in the survey. The next section contains an overview of current methodological literature. The chapter ends with a summary of the gap in the literature, conclusions, and a transition to Chapter 3.

Literature Search Strategy

The relevant historical literature for this study includes sources from varied disciplines, including management, systems theory, talent management, geospatial sciences, and information technology (IT). This literature review is largely focused on the relevant literature published since 2015, including literature related to the concepts used to develop the framework for this study. Also included is a discussion of some literature prior to 2015, providing a historical context for the study. The methodological literature is also reviewed.

The first searches for relevant literature were conducted using multiple databases from the Walden University library and the Google Scholar search engine. Specific

databases used for the search included ABI/INFORM Complete, Business Source Complete, EBSCOHost, and ProQuest. The databases and search engines were checked with the following key terms: *geospatial competency, geospatial certification, fourth industrial revolution, systems theory, systems thinking, talent management theory, geospatial industry future, Delphi technique, workforce reskilling,* and *geospatial trends.* The references sections of articles found while searching the literature were also used to acquire additional relevant sources for the review. The search results were constrained by the conditions of publication date and peer-reviewed articles. However, some articles were included as necessary, even though they were not from peer-reviewed sources. The literature was limited to publication dates of 2015 or later; however, some resources published before 2015 were used because of their value to the review from an historical, methodological, or framework perspective. See Table 1 for a classification of the resources used for the literature review by key search term and date of publication.

Table 1

Reviewed Resources: Classification and Year of Publication

Key Search Term	2019	2018	2017	2016	2015	Prior	Total
Geospatial competency	3	2	5	6	3	6	25
Geospatial certification	3	2	2	2	1	3	13
Fourth industrial revolution	1	4	5	4	3	2	19
Industry 4.0	2	3	4	3	1	4	17
Geospatial industry future	4	2	3	3	2	6	18
Geospatial trends	0	3	2	3	2	7	17
Workforce reskilling	1	2	3	3	2	7	19
Total	14	18	24	24	14	35	128
Percentage of total	11%	14%	19%	19%	11%	26%	

Table 1 shows a breakdown of the resources I initially scanned for the literature review. Germinal works, germinal methodology, and thought-leader resources are not included in Table 1. The resources considered for the literature review were short-listed from the initially reviewed resources by evaluating the titles and abstracts to examine the relevance of each resource to the study and its framework. The peer-reviewed status of the resources included in this review were checked against Ulrich's (2018) periodical directory. The literature gathered from my search included peer-reviewed articles, reports, and studies from credible geospatial organizations and associations that related to the discussion of the industry classification of competencies and several relevant books and periodicals. I continued the searches until all the resources related to the key terms and sources published since 2015 had been examined for relevance to this review. All the short-listed resources were examined, annotated, and synthesized to create the literature review.

Conceptual Framework Literature

Talent Management Theory

Although no single researcher is credited with the development of talent management theory, Miner (1973) contributed to the theory's origins, with a focus on the outcomes of talent recruitment measured by managerial success (Ariss et al., 2014; Miner, 1973). The concept and practice of talent management evolved from talent management theory to include developing existing talent, as well as recruiting new talent, with the assumption that maximizing employees' talents was a major source of an organization's competitive advantage (Ariss et al., 2014). With the growth of the HR

profession and globalization of business over the past 40+ years, talent management is more tightly linked to HR management practices with the goal of improving business performance (Ariss et al., 2014).

Talent management theory has attracted increased attention in recent years from managerial practice, as well as from academic research, and its definition has since evolved from a summary of a broad range of HR practices to a more strategic concept (Claussen, Grohsjean, Luger, & Probst, 2013; Collings & Mellahi, 2009). Modern talent management theory describes the identification of key positions in an organization, as well as the development of a talent pool, to fill key positions (Collings & Mellahi, 2009). Deery and Jago (2015) conducted an examination of employee-turnover literature to underpin a discussion of successful talent management. The findings showed that a work-life balance was a key factor in employee satisfaction and retention. The concept of talent management encompasses not just employee satisfaction and retention but also management of the talent pool, which includes knowing what technical competencies are desired for various positions and having plans in place for training and reskilling existing employees, as well as hiring new employees. In other words, talent management is an organization's ability to attract, select, develop, and retain key employees. Deery and Jago (2015) did not examine employee training and reskilling (i.e., development) as factors in their research.

Additional considerations regarding the concept of talent management are generational challenges and individual expectations. As technology and HR practices have changed and advanced over the years, so have generational expectations. Festing

and Schafer (2014) conducted research to further enhance the concept of talent management. They posited that individual perspectives on talent management is under-researched and that the preferences, needs, and expectations of talented individuals should also be managed. Individual perspective should be a consideration when hiring new employees, as well as when training and reskilling existing employees. Generational differences can present major challenges for organizations as they strive to be a desirable employer for younger talent, while also retaining the knowledge and competencies of older, more seasoned employees (Festing & Schafer, 2014). Perhaps the most important finding presented in the literature review conducted by Festing and Schafer was that given the current demographics and shortages of skilled labor across the globe (Ward, 2011), now it is even more important to retain existing talent within organizations. This finding suggests that organizations will have to develop training and reskilling plans for existing talent to manage changes resulting from rapid technological advances.

Talent management also has implications related to the fourth industrial revolution. Karacay (2018) stated that, with the automation of processes in businesses and the emergence of new technologies and business models, organizations will have new digital skills requirements for the workforce. Karacay (2018) also posited that creating a future workforce involves reskilling current employees through training, redesigning work processes, and attracting and developing new talent. Berger and Frey (2016) showed in their study that employees with routine work tasks prior to automation were later required to perform more analytical and interactive tasks, after the implementation of more advanced technologies. Whysall, Owtram, and Brittain (2019)

conducted a study that focused on the talent management challenges of Industry 4.0. The authors found a significant gap between the capabilities of the current workforce and the rapidly changing requirements of their roles. Their findings supported the need for more effective approaches to the concept of talent management, leading to the evolution of talent management theory and practice. These studies have potential implications for talent management in the geospatial industry, as knowing what technical competencies to train and reskill for is a key component in preparing existing employees for the future. Karacay (2018), Berger and Frey (2016), and Whysall et al. (2019) discussed the significant changes happening in the workplace due to the implementation of new technologies and automated processes and agreed that there is a gap between current workforce capabilities and future industry needs. Addressing these needs will require more effective approaches to talent management, such as training and reskilling current employees and attracting and developing new talent (Berger & Frey, 2016; Karacay, 2018; Whysall et al., 2019).

Systems Theory

The grand-scale adaptation to a consensus-based competency list for geospatial talent management is a significant system change (von Bertalanffy, 1969). The fourth industrial revolution will result in rapid changes and require rapid responses to talent management, which will systemically affect the entire geospatial industry (Schwab, 2016a). The conceptual framework of this study was based on the concept of systems thinking from systems theory, in addition to talent management from talent management theory. Systems theory was originally proposed by von Bertalanffy, a biologist, in 1928.

In 1951, he extended the idea in that a system could be subdivided into individual components and analyzed as independent entities, and those components could be linearly added to describe the system's totality (von Bertalanffy, 1969; Mele et al., 2017). Ackoff (1962, 2004) was another major contributor to systems thinking and systems theory. Ackoff posited that organizations should be viewed as systems to manage change and that management should utilize holistic and synthetic thinking rather than reductionist and analytical thinking.

Cox, Elen, and Steegen (2018) authored an article about assessing systems thinking in geography. They defined systems thinking as viewing the interconnections among the parts or variables of a system in order to understand the whole system and considered it a necessary capability of geospatial employees. In geography and the geospatial industry, there is a focus on complex geospatial relationships, often between humans and the environment, that is better understood through the lens of systems theory. Jo (2018) conducted research on "geospatial thinking," or the understanding of the relationship between geography and the use of spatial concepts, tools, and reasoning for problem solving and decision making. Geospatial thinking can be considered a part of the systems thinking approach to understanding and analyzing spatial relationships, an integral skill of geospatial professionals (Cox et al., 2018; Jo, 2018). Geospatial organizations can be viewed and analyzed as systems, and technological advancements and talent management methods can be evaluated in terms of systems thinking. A systems thinking approach may help these organizations to more effectively implement

the appropriate strategies needed to manage rapid and significant change (Ackoff, 2004; Cox et al., 2018; Jo, 2018; Mele et al., 2017; Schwab, 2016a; von Bertalanffy, 1969).

Systems thinking considers management as a unified system of parts that are interrelated, where managerial decisions are made from the perspective of the whole organization rather than from smaller components (i.e., departments or individuals) (Kitana, 2016). Systems theory can be applied to understanding the convergence of various emerging technologies, as well as to how geospatial organizations, viewed as management systems, should respond to rapid industry changes and address the resulting skills gaps. The concept of systems thinking, combined with the concept of talent management, was an applicable approach to this study. Systems thinking was applicable to change management for organizations overall, and talent management was applicable to individual talent management and competency development.

Review of the Literature

Historic Context

GIS was first used by Tomlinson in 1968. Before that, GIS was an unnamed innovation that developed out of the Laboratory for Computer Graphics at the Harvard Graduate School of Design, starting in 1964. Much of the work done in the early years of the lab consisted of computer mapping and modeling tools but soon extended into spatial analysis. There are two contributors to the lab's early research and the resulting innovations - Steinitz and Dangermond. As reported by Waldheim (2011), today, Dangermond is the founder and CEO of Esri, the world's leading GIS software vendor

and one of the top GIS companies for the development of geospatial tools and techniques used in spatial analysis, mapping, and design and planning decisions.

As GIS technology and its applications have grown during the last 50 years, so has the demand for skilled geospatial employees. Several studies have been conducted to create a list of core competencies for geospatial employees, resulting mainly in the GIS&T BOK (DiBiase et al., 2006), and the GTCM (Gaudet et al., 2003). Although these competency lists and models have been used for hiring and developing job descriptions and titles in the geospatial industry, they have not been officially updated since their creation. The results are outdated lists that do not reflect changes in the technology and its applications, including a comprehensive selection of current and future needs of employers. Keeping up with technological advances and changes in the industry is vital for geospatial hiring managers, and the industry should have a competency list that reflects current needs as well as what needs are anticipated for the future. A consensus-based list that is both current and forward-looking does not exist, thus supporting the need for this study.

Geospatial Industry Background

Influence and applications of geospatial technology. The term *GIS* was first used by Tomlinson in 1968, but geospatial technology began to emerge into its own field in the 1980s and 1990s as computers became faster, more powerful, efficient, and more affordable. The launch of new satellites and the integration of remote sensing technology further enhanced the capabilities of geospatial technology and broadened its applications (Waldheim, 2011). Today, geospatial technology has grown to become a tool used across

many different fields, not just mapping and geography. Some applicable fields include the environment, agriculture, transportation, real estate, engineering, planning, design, policy and decision making, building information management, aeronautical engineering, meteorology, crime analysis, disaster management, and health and resource management, among many others.

Professionalism and certifications. A list of technical competencies could possibly be assembled based on professional organizations and requirements for certain geospatial certifications, but the problem here is that there are many such organizations and requirements, and they all have their own standards and methodologies. Mulaku (2013) conducted a literature review combined with personal experience to explore GIS certification and global trends in certification. While some countries do offer GIS certifications, many do not. The author explored some of the advantages and disadvantages of certification and made some arguments for requiring certification in the GIS profession, as well as arguments for why certification could cause more issues than it resolves. The most important finding in Mulaku's (2013) literature review was that "the presence of a strong GIS professional association greatly assists in the development of a program for such certification, and that the lack of such an association makes it difficult to succeed" (p. 347). Existing competency lists were created by task forces, assembled by several professional organizations. The study is limited because it consists only of a literature review and does not use a quantitative or qualitative approach to start addressing the gaps uncovered through the literature review. The author concluded that

failure to develop certification standards may result in countless organizations offering certifications that will not be credible or recognized in the industry.

Wikle and Fagin (2014) used a quasi-Delphi approach to collect and analyze survey data obtained from 197 employers and 121 educators across the United States to determine the most important hard and soft skills needed for entry-level GIS employees. The researchers stated that, while technical skills are important, other "soft" skills such as working in teams or through self-sufficiency are also important. They found that educators and employers tended to rate the importance of technical competencies in a similar way, but there were major differences in the ratings for soft skills. There were also differences in ratings regarding education in general; educators placed more emphasis on internships, and employers placed more emphasis on certificates. The results of the study indicated that a lack of consensus existed among educators and employers, meaning that they were not in agreement in terms of preparing entry-level GIS employees to enter the workforce. The study included a literature review, as well as background and definition information relevant to this study. The Wikle and Fagin (2014) study is limited by its focus on entry-level employees, but it does outlines core technical competencies of geospatial professionals. Their study could be expanded to include similar research to reach a consensus on skill requirements for employees at the professional level. This study aimed to do just that, but it also considered forward-looking technical competencies based on industry trends of the future of geospatial technology applications.

Cotton (2013) examined the purpose, benefits, and downfalls of professional certifications. Specifically, he compared the existing national project management

standards and certification with those implemented by the federal government. One of the key points of his study was to create internal certifications to fit the needs of different organizations. While these are interesting ideas, it also makes sense to look at certification in terms of professional experience combined with core knowledge to develop a current and forward-looking list of technical competencies.

Obermeyer and Somers (2014) presented the Geographic Information Systems Professional (GISP) certification and its importance to geospatial professionals. They discussed the characteristics of a profession in general, which includes a unique body of knowledge (GIS&T BOK), professional organizations, shared language (GIS and related terminology), a professional culture, and a code of ethics. During the last 15+ years, there has been a growing interest in GIS certification for several reasons. First, GIS certification can help protect the public and the geospatial information the public consumes. Second, other certified or licensed professions (e.g., engineering, surveying, and others) have passed laws for professionals that work with public data, and there is the idea that GIS should be included. Third, there is a desire among geospatial professionals for professional identity, which certification and licensing can help to provide (Obermeyer & Somers, 2014).

Wikle (2016) conducted a study in which he evaluated current geospatial professional certifications, as well as the backgrounds and job titles of registered GISPs. The researcher emphasized the importance of including a competency-based exam in addition to a professional experience portfolio to qualify for certification, but he also noted a disconnect between higher education curricula and exam content. Much of the

exam content in the existing certifications was based on technical skills and knowledge gained through experience in the workplace. He concluded that, for geospatial certifications to remain relevant in the geospatial industry, the certification exams and requirements will need to reflect the current and future qualities and skills desired by employers. Wikle's findings support the need to determine the current and future competency needs of geospatial organizations.

There was a general understanding among researchers about the importance of GIS certification for professional identity of geospatial professionals (Cotton, 2013; Mulaku, 2013; Obermeyer & Somers, 2014; Wikle, 2006; Wikle & Fagin, 2014). It should be noted that a large part of geospatial professional certification is developed from a body of knowledge. The core competencies of the geospatial industry, published in 2006 as GIS&T BOK (DiBiase et al., 2006), formed the basis of the GISP certification core technical exam and served as the foundation for developing the task statements and job tier assignments for the GISP certification portfolio (Obermeyer & Somers, 2014). Using the competency list from the 2006 GIS&T BOK to develop a core technical exam for certification has worked for the last 10+ years, but future competency needs should also be considered to keep the certification relevant.

The case has been made for the importance of technical and professional certifications in the geospatial industry. However, no consensus exists on what should be used to develop the standards for certifications, and several different certifications are currently in use. There is not a single industry standard for any technical or professional geospatial certification available. Cotton (2013) recognized that some certifications have

been developed to fit individual needs of organizations, but he argued for the need of an overall certification in terms of professional experience and core knowledge. The GISP certification consists of an experience portfolio and core technical knowledge exam (Obermeyer & Somers, 2014; Wikle, 2016), where the competencies tested are based on the GIS&T BOK of 2006 (DiBiase et al., 2006). Wikle and Fagin (2014) determined a lack of consensus among employers and educators about the most important geospatial competencies desired, using a quasi-Delphi methodology, a completely different approach to the task force methodology used to develop the GIS&T BOK (DiBiase et al., 2006). Where the authors do agree is that possessing a geospatial technical or professional certification is important to employers and employees, but the lack of certification standards across the industry may result in the existence of multiple certifications, causing them not to be very credible (Cotton, 2013; DiBiase et al., 2006; Mulaku, 2013; Obermeyer & Somers, 2014; Wikle, 2016; Wikle & Fagin, 2014).

Geospatial Competencies

Gaudet et al. (2003) discussed the GTCM, which addressed the core skills and knowledge needed by those looking to work in the geospatial field. The GTCM came to be as a response to the growing number of skilled employees needed to fill vacancies in the emerging GIS job market. Gaudet et. al. (2003) stated:

> Given the lack of agreement on GIS as a profession, the most appropriate academic program to prepare those who would work in this "profession," and the absence of recognized standards or industry certification, it is no surprise that

> organizations equipped with increased geospatial technology capabilities for decision support are questioning the kind of people to hire (p. 22).

Gaudet et al. (2003) conducted a short literature review regarding competency models and their importance. The research method of their study was a quasi-Delphi approach, which included several phases of data collection and analysis, including a literature review, survey, and focus groups. The results of their research provided them with the geospatial competencies that these focus groups deemed to be the most important, and a one-sentence industry definition was developed as part of the consensus among the focus groups. Competencies were divided into four categories: technical, business, analytical, and interpersonal. The fact that the geospatial industry continues to evolve over time was a limitation to this study, and the GTCM is now also outdated.

Albrecht (2015) focused on the fact that a systemic approach in support of a GIS project management program has been lacking since the field began to explode in the 1990s. The researcher offered a range of research questions as well as the beginning efforts needed to study GIS management practices that will help develop a body of knowledge (BOK) that could be used in accreditation of programs and certification of GIS project/program managers. An important point made in this book chapter was a reference made to the widening gaps between BOKs as technology advances, academic programs emerge, and certifications are added by vendors and user group organizations. Additionally, there have been new standards adapted by various public and private organizations, but nothing has been standardized or made uniform throughout the profession. This book chapter is particularly meaningful for GIS management

professionals and promotes the concept that a specialized program management BOK and certification are needed. A clear opportunity exists for further research on this topic, as there are hundreds of organizations currently conducting assessments that will provide the foundation for a BOK for GIS program management.

Niezgoda et al. (2014) addressed the issue of inconsistency in stream restoration projects due to the lack of definitive training requirements, design procedures, and monitoring protocols. These inconsistencies were often found to result in excessive costs, poor results, and ultimately failed projects. The authors discussed how prior research has shown that a BOK is necessary when a profession advances to ensure adequacy of training and educational programs and curricula, leading to the desired competency of individual professionals. Such BOKs have been developed for many professions over the years such as project management, surveying, and engineering. They posited that a BOK should also exist for stream restoration professionals; thus, they completed research that included a review of existing research, practitioner surveys, educational programs, and demographic information to offer suggestions for core concepts that should be included in a BOK for stream restoration professionals. The BOK could be used as the basis for national certification programs. While this was not based on a true Delphi method, the authors did use several different approaches to data collection and analysis, and they synthesized those approaches to create an outline for a BOK and basis for certification. The research could be improved with a true Delphi study rather than a single practitioner survey.

Plessis and van Nierkerk (2013) discussed the lack of existing literature that identifies detailed inconsistencies and commonalties among competency requirements for GIS. Addressing this gap in literature could assist in developing a framework that incorporates regional and international GIS curriculum guidelines. The researchers examined three sets of competency guidelines, both qualitatively and quantitatively, to identify commonalities and differences. Important themes were also identified in this research. The researchers concluded that, based on the results, a new competency set was needed best to serve the GIS industry. However, a consolidated or consensus-based list still does not exist.

Johnson (2019) emphasized the importance of defining the knowledge and skills needed by geospatial professionals in the 21st century. She explained that the growing use of geospatial technology across countless workforce domains, technological and analytical advancements, and the assessment of big data in real time have made the quest for understanding these knowledge areas and skills that much more complex and important to the industry. She posited that early efforts to identify competencies included work to support recognition of geospatial technology as its own distinct profession rather than another tool used by professionals. Johnson outlined the history of efforts to develop competency lists and how the lists have been used by employers and in academia, but she did not provide an updated list of competencies or a strategy for including forward-looking competencies in future lists.

Jo (2019), Plessis and van Nierkerk (2013), Niezgoda et al. (2014), and Albrecht (2015) agreed that a BOK was necessary to outline core competencies, but that there was

a widening gap between the BOK and the competency needs arising from technological advances in the industry. They all stressed the importance of and need for a current and relevant competency list but did not provide a new list in their studies. These authors' conclusions and findings supported the need for this study, due to the lack of a current and relevant list.

GIS&T BOK. The GIS&T BOK (DiBiase et al., 2006) was the source used to develop the Round 1 survey instrument for this study. This BOK was the result of a task force effort, initiated by the University Consortium for Geographic Information Science (UN-GIS) in the late 1990s as an effort to address educational challenges in the geospatial field; it has also been used to define the core competencies expected of geospatial employees across many geospatial organizations since its release in 2006 (Ahearn et al., 2013; DiBiase et al., 2006). Actual frameworks for the implementation of the BOK in both academia and the workplace have been limited (Unwin, Tate, Foote, & DiBiase 2011), but the GIS&T BOK is still considered a landmark accomplishment in the geospatial industry and viewed as a solid foundation looking forward (Ahearn et al., 2013; Rip, 2008).

Current needs in the industry. According to the GIS&T BOK (DiBiase et al., 2006), 10 major categories are considered core geospatial competency areas. Seven technical competency categories were chosen from this list and used to develop the Round 1 survey instrument for this study (see Appendices A and B). The 10 main categories from the BOK follow. *Analytical Methods* encompasses a variety of operations with the objective of using geospatial data to derive analytical results, including first

order (environmental) and second order (interaction) effects using data-driven, and model-driven approaches. *Cartography and Visualization* focuses on the visual display of geographic information, addressing the complex issues involved in visual thinking and communication of geospatial data and geospatial analysis results. *Design Aspects* encompasses the proper design of geospatial applications, models, and databases, as well as the validation and verification of design activities. The focus of this category is trained on the design of applications and databases for specific needs. *Conceptual Foundations* is grounded in spatial thinking, with the aim to recognize, identify, and appreciate spatial, spatiotemporal, and semantic components of the geographic environment in preparation for modeling the geographic environment using data and analysis. *Data Modeling* is the representation of formalized spatial and spatiotemporal reality using data models and their transition to data structures used in computation environments (i.e., within a GIS) including discrete, continuous, dynamic, and probabilistic. *Data Manipulation* involves understanding how nonanalytical manipulations are necessary to accommodate the analytical power of GIS and how changes in projection, grid systems, data forms, and formats happen during the modeling process for which GIS was designed. *Geocomputation* emphasizes the research, development, and application of computationally intensive approaches to the study of complex spatial-temporal problems, as well as an understanding of machine learning and simulation research. *Geospatial Data* focuses on the understanding of location and attributes of phenomena at or near the Earth's surface and on the manner of collection and analysis of this information and properties of geospatial and attribute data. *GIS&T and Society* focuses on understanding

how GIS&T serves society, including its potential benefits and impacts, while considering economic, political, ideological, legal, ethical, and personal factors. *Organizational and Institutional Aspects* considers the management of GIS and its hardware, software, data, and the workforce in private and public organizations (DiBiase et al., 2006).

Ahearn et al. (2013) developed a conceptual model for a re-engineered GIS&T BOK that included a three-layer system with a proposed BOK ontology as the foundation, a server layer, and a service application layer, all to be used interactively in a Web application or online environment. While this may be helpful from an organizational and data storage standpoint, their conceptual model did not address revisiting the core competencies represented in the GIS&T BOK to address current and future industry needs. Gaudet et al. (2003) evaluated the Geospatial Workforce Development Center's (GWDC) GTCM as a response to the increased need for skilled geospatial workers at the time. The GTCM identified the roles, competencies, and outputs necessary in the geospatial technology industry at that time. The GTCM has historically been used to define job titles and descriptions and was also intended to improve employee recruitment and selection, manage current employee performance, and design training and educational programs. The GWDC used a four-phase research method that included a literature review and focus group participation to develop the GTCM. The GTCM continues to be used by organizations today, although it was created more than 15 years ago.

In 2018, an official update was made to the GTCM, but very little changes were made to the original version aside from simplification and rewording of competency definitions (Directions Magazine, 2018). When comparing competency lists from the GTCM and the GIS&T BOK, inconsistencies are apparent, furthering the points that (a) there has been a lack of consensus and (b) the lists do not reflect future needs. The inconsistencies between the GTCM and the BOK regarding the most important geospatial technical competencies can be seen in Appendix B. Wikle (2016) also noted how the lack of consensus on geospatial competencies desired in geospatial professionals creates challenges for higher education programs and the new geospatial workforce, which institutions of higher learning are helping to shape. Potential new hires are entering the workforce without the skills and knowledge desired by geospatial employers (Huynh & Hall, 2019). To have a consensus-based list of forward-looking desirable and practicable competencies could help educators and organizations find common ground regarding expectations for new geospatial graduates.

Wikle and Fagin (2014) evaluated the hard and soft skills needed to prepare GIS professionals from the standpoints of both employers and educators. For this study, the competencies most desired by employers are included in the literature review. The results of the employer surveys yielded the following hard and soft skills/competencies as the most important, where the first eight are technical and the remaining are nontechnical. The competencies include data editing; GIS analysis; ability to create and edit tables, charts, and reports; working with projections and georeferencing; cartography and graphic design; database management; data querying; ability to work with aerial and

remote sensing imagery; problem solving; critical thinking; flexibility and adaptability; working in a team environment; working independently; and time management and multitasking (2014). It should be noted that Wikle and Fagin's (2014) study showed that geospatial employers and educators did have similar perceptions concerning the importance of the hard and soft skills currently needed by GIS professionals, but the integration of soft skills into the curriculum is challenging, compared to the development of those skills through workplace experience (Craig & Wikle, 2016; Rooney et al., 2006). A comparison of these competencies with those of the BOK and other competency lists can be found in Appendix B.

Solem et al. (2008) compared the skills of professional geographers to the needs of organizations across relevant sectors of the U.S. workforce. A series of focus groups was conducted, followed by the development of two surveys, to explore the extent of specific skills performed by geographers in various positions as well as the value of and anticipated demand from employers for those skills. The resulting technical competencies included cartography (designing paper and digital maps); GIS (using GIS to digitally manage and analyze spatial data); photogrammetry (using aerial stereo imagery and remote sensing data to produce planimetric and topographic data and maps); remote sensing (understanding methods for acquiring data about an object without physical contact); field methods (understanding methods of field data collection); and spatial statistics (using quantitative methods to process spatial data to explore patterns, trends, and spatial relationships) (Solem et al., 2008). While these competencies are certainly part of the geospatial field, they are more generalized than what is listed in the GIS&T

BOK (DiBiase et al., 2006) because the study focused on geographers, rather than geospatial professionals whose work applies across many disciplines. There is some overlap with the GTCM (Gaudet et al., 2003) as well, as shown in Appendix B, but comparing the various competency lists reveals an apparent lack of consensus.

Hong (2015) conducted a study in which he collected GIS job advertisements from three different GIS job websites in the United States and grouped them into five categories: analyst, programmer/developer/engineer, specialist, technician, and other (coordinator, manager, scientist, and more). He compiled a list of technical skills and their definitions, as well as general skills, using coding in NVivo software. These skills included analysis and modeling (image interpretation, data analysis, database development, geocomputation, geospatial modeling, data mining, network analysis, and spatial statistics); cartography and visualization (map design, map production, and web mapping); data processing and data management (data acquisition, data manipulation, data quality, georeferencing/datum/projections, and metadata); software and application development (database query, design/customization, programming, system architecture and user interface, web/mobile application development); analytical skills (creative thinking, critical thinking, and problem solving); management skills (planning/organizing, project management, and time management); and personal and social skills (communication, interpersonal skills, and independence) (Hong, 2015). The results of Hong's (2015) study seem to be the most current representation of the technical and general skills looked for by geospatial employers. However, there are some limitations to Hong's study to consider. Only three online sources were used to collect

job advertisements, which resulted in just 946 advertisements after removing duplicates. Additionally, no feedback, data, or input were collected directly from any geospatial employers or existing employees for analysis.

When comparing Hong's (2015) results with those of Gaudet et al. (2003) and DiBiase et al. (2006), there were a few overlaps, but also some clear differences, which are most likely attributable to the time gap in the studies, as shown in Appendix B. The findings from these studies also showed some important soft skills that should be considered as core competencies for geospatial professionals. These soft skills can be challenging to measure and assess and can often be difficult to teach or train. Rather, these skills depend on experience, personality, and practice. The importance of technical (hard) skills combined with soft skills should not be undermined, especially in the wake of the fourth industrial revolution (Craig & Wikle, 2016; Gaudet et al., 2003; Hong, 2015; Rooney et al., 2006; Wikle, 2016; Wikle & Fagin, 2014). Creativity, ingenuity, and innovation will be invaluable skills to possess during this time of rapid technological evolution. Thus, the focus of this study remained on desirable and practicable forward-looking geospatial technical competencies.

Fourth Industrial Revolution

The world is at the beginning of the fourth industrial revolution, a major technological revolution that exploits the convergence of many emerging technologies for digital transformation such as artificial intelligence and the connecting of devices, machine components, and nearly anything with a power switch to the Internet for data exchange and collection (AbuMezied, 2017; Maynard, 2015). This revolution is

characterized by "a fusion of technologies that are blurring the line between physical, digital, and biological spheres" (Park, 2016, p. 1), and it is progressing at an exponential rather than a linear pace, which is quite different from prior industrial revolutions, according to Park (2016). The possibility exists that the fourth industrial revolution will result in increased levels of inequality, so awareness of changes and how to prepare for them in the wake of the fourth industrial revolution is important (Chung & Kim, 2016). Paradigm shifts will occur in individual lives as well as in society due to the convergence of various technologies across countless fields and industries (Schwab, 2016a). Researchers and authors seem to agree that the impact of the fourth industrial revolution will be tremendous, not just on *how* or *why* people do things, but also on *who* they are (Chung and Kim, 2016; Maynard, 2015; Park, 2016; Schwab 2016a).

Future trends and needs in the geospatial industry. The fourth industrial revolution is changing how people work, live, and relate to each other (Maynard, 2015; Schwab, 2016a). Although the dynamics and complexities of global markets in the fourth industrial revolution are largely unknown, the preparation of a comprehensive and integrated response to rapid, technological change has been underway since 2010 by public and private-sector organizations such as academia, the government, and society (Schwab, 2016a). The geospatial industry is no exception as GIS technology is essential for national security and informed decision making among many types of organizations (Salkin, 2005). Geospatial professionals provide the tools, technologies, and services to support informed decision making by organizational leaders based on geographic data (Boston Consulting Group, 2012). While there are several existing lists of competencies

that attempt to address the current needs of the industry, a lack of consensus still exists on what those competencies are. Furthermore, the lists are outdated and, more importantly, do not account for future needs of employers, thus, supporting the need for this study.

The United Nations Global Geospatial Information Management (UN-GGIM, 2015) published a 5-to-10-year vision for future trends in geospatial information management, recognizing that the most significant changes in the industry will come from combing and linking multiple technologies and policies, rather than from a single technology. The report stated that increased global urbanization will result in more focus being placed on urban environments, with the "integration of smart technologies and efficient governance models, [leading to a] focus on citizen services, better land management, and sustainability of resources" (p. 5). Currently, one observes an increasing tendency to combine data from multiple sources, including statistics, geospatial information, satellite data, big data, and crowd-sourced data, among others (Schwab, 2016a; UN-GGIM, 2015). This tendency, combined with intelligent information-processing technologies such as the "internet of things," artificial intelligence, machine learning, and the human-oriented architecture of the Internet, results in the need for an updated list of forward-looking technical competencies to anticipate and address the future needs of geospatial employers (UN-GGIM, 2015). The UN-GGIM's 2015 report cited several specific trends in the geospatial industry, including smart cities and the internet of things; artificial intelligence and big data; indoor positioning and mapping; integrating statistical and geospatial information; technical advancements shaping the future direction of data creation, maintenance, and

management; legal and policy developments; assessing skills requirements and training mechanisms; changing roles of private and nongovernmental sectors in the industry; and the role of governments in geospatial data provision and management (Meier, 2016; UN-GGIM, 2015).

Jiang (2015) had a different perspective about the future of geospatial technology. He focused on geospatial analysis requiring a different way of thinking, stating that geospatial analysis is "very much dominated by a Gaussian way of thinking, which assumes that things in the world can be characterized by a well-defined mean, i.e., things are more or less similar in size" (p. 1). Malhotraet al. (2018) and Ricker and Thatcher (2017) also acknowledged how the geospatial industry was rapidly changing as the world changed, and the authors discussed approaches to future geospatial workforce development. The positions of these authors aligned with the idea that geospatial technology was rapidly changing, in large part due to the fourth industrial revolution, and that these changes required a different way of thinking (Malhotra et al., 2018; Maynard, 2015; Meier, 2016; Ricker & Thatcher, 2017; Schwab, 2016a; UN-GGIM, 2015). Hence, future trends should be considered when examining desirable forward-looking geospatial technical competencies in addition to methods of analysis and their parameters.

Planning for Future Needs

Managing talent shortages. Geospatial professionals provide the tools, technologies, and services to support informed decision making by organizational leaders based on geographic data (Boston Consulting Group, 2012). As high rates of geospatial job growth (upwards of 29%) are expected through 2024 (U.S. Department of Labor,

2014), human resource managers are questioning the competencies, or the requirements and knowledge needed by employees to be successfully reskilled for the digital transformation of the workplace (Wikle & Fagin, 2014). The convergence of emerging technologies and the resulting rapid changes (Schwab, 2016a) are outpacing the ability of geospatial industry leaders to maintain a properly skilled workforce (Meier, 2016; Veenedaal, 2014; Wikle & Fagin, 2014). Talent deficits in the geospatial industry pose increased risks to national security (Foster & Mayfield, 2016; Salkin, 2005; Veenedaal, 2014; Wikle & Fagin, 2014). The defense and intelligence sectors of the geospatial field are being affected by these deficits, as the need for digitally competent employees is expected to increase more than twofold by the year 2021 (Geissbauer et al., 2016).

In 2005, the U.S. Department of Labor projected a 35%-per-annum growth rate in the geospatial workforce. Although the actual growth rate has been closer to 29%, the geospatial industry is still considered a "high growth industry," and there is concern that employment needs are not being fully met, with 87% of geospatial employers reporting difficulties filling positions that require geospatial competencies (Roiste, 2014). The geospatial talent shortage is not just a problem in the United States. Although there are some countries that seems to have enough talent such as the United Kingdom, leading geospatial technology countries such the United States, Australia, and New Zealand continue to experience talent deficits. Roiste (2014) stated that a greater awareness of the geospatial industry may improve enrollment in geospatial higher education programs, leading to more potential employees. Roiste also stated that reskilling current employees is an option for building capacity, including in-house training, vendor training, continuing

education, and conference attendance. Obtaining certifications is another way for employees to improve their skills and knowledge (Roiste, 2014).

Training and reskilling employees. Oeldenberger and Khaled (2012) proposed a plan to implement a new approach to geospatial training and education in North Africa that could be implemented anywhere. The plan included formal education, classroom and online instruction, practical skills training, mentorships, management education, GIS awareness activities, and seminars. They also outlined the financing options for the proposed plan and discussed professional certification opportunities and their role in the proposed training plan. These ideas could be used to develop other training and reskilling plans in geospatial organizations. However, to maximize training and reskilling efforts best to meet the current and future needs of the industry, an updated competency list would necessarily be a key factor in developing those training plans. As demonstrated earlier in this chapter and shown in Appendix B, there is a lack of consensus regarding what should be included on that competency list (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Wikle & Fagin, 2014).

Mirzoev, Moore, Pryzbysz, Taylor, and Centeno (2015) examined GIS as a job growth area for IT professionals. Almost all organizations have IT staff, including geospatial organizations. Their study examined job postings for four different GIS positions on various online job posting boards. The authors found that, while noting some similar requirements, there were many inconsistencies among the job postings for same-titled positions. Their findings highlighted the need for the geospatial industry to set standards for requirements and education for each position. IT professionals could better

fill some of the GIS job openings if the requirements for the positions were clearer and more consistent (Mirzoev et al., 2015). This further supports the need for an updated set of technical competencies. Additionally, because IT professionals may already possess some of the desired skills of geospatial professionals, they are a potential talent pool for training and reskilling.

Dymon (2016) elaborated on the three main types of GIS users in organizations: (a) users with specific and defined tasks, keeping existing procedures in place, (b) users who have some of their task defined but use GIS for analysis, and (c) users who must define tasks and work requirements and design new applications to solve complex problems. When developing training and reskilling programs, organizations should consider the types of GIS employees that will participate and the level of upskilling that is needed. Financial factors should also be considered, and organizations may need to get creative to reduce training costs. Dymon also concluded that there is a "need to integrate geographical knowledge and concepts with the new technology for the anticipated future acceleration and proliferation of GIS applications to materialize" (p. 7). Organizations, professional societies, and universities should continue to provide training and professional seminars to existing and potential employees to increase awareness of current and future GIS applications, many of which have not yet been considered (Dymon, 2016).

Pendyala and Vijayan (2018) emphasized the need to develop and update training programs in remote sensing and geospatial applications to meet needs and requirements more effectively. Their study took place in India, where they evaluated existing training

programs administered by various departments of the Indian Space Research Organization (ISRO). The researchers also evaluated the feedback received by participants at the end of the training courses. They concluded that geospatial and remote-sensing training programs should be updated and changed to meet current and future needs. These training programs could be enhanced using online courses and e-learning modules, as well as the adoption of a multilevel training approach using guided instruction and self-paced learning. While Pendyala and Vijayan (2018), Dymon (2016), Mirzoev et al. (2015), and Oeldenberger and Khaled (2012) maintained the position of necessary training and reskilling programs for geospatial employees, they also focused on different methods, considerations, and constraints in their studies.

Not many relevant articles or studies were found specific to reskilling geospatial employees, but the existing literature showed a general understanding of the need to address future industry needs with existing employees and potential new hires. This information, combined with the articles regarding talent shortages and future trends in the geospatial industry, supports the need for training and reskilling programs in geospatial organizations. Organizations can look to utilize existing geospatial employees, as well as employees in a related field such as IT. Reskilling existing employees may be a faster, more cost-efficient way to meet talent needs than going through the process and costs of recruiting and hiring new talent (Dymon, 2017; Karacay, 2018; Mirzoev et al., 2015; Oeldenberger & Khaled, 2012; Whysall et al., 2019).

Methodology Literature

Delphi Technique

The Delphi technique has been used in many studies that focused on competency development, particularly in the health care and education fields. This methodology has proven to be useful in reaching consensus on competencies (Cao, Cai, & Chang, 2019; Hughes, Atkinson, Brown, Jenkins & Ahmed, 2018; Johnson & Traynor, 2018; Tognetto, Michelazzo, Ricciardi, Frederici, & Boccia, 2019). A specific search of Delphi studies related to competency development since 2018 in Google Scholar resulted in 177 articles and publications. Another specific search for Delphi studies related to talent management since 2018 yielded 136 results, covering a variety of workforce domains. The abundance of existing Delphi studies for competency development and talent management further enhances the case for using a Delphi method in this study.

Habibi, Sarafrazi, and Izadyar (2014) provided a theoretical framework for the Delphi technique in qualitative research. Their work is important because it addresses the lack of a clear theoretical framework for using the Delphi technique. Delphi became a popular academic research approach in the 1990s after it evolved from military and economic planning uses. Despite its various applications across qualitative research in many different industries over time, four main features remain unchanged in the Delphi technique: anonymity, iteration, controlled feedback, and statistical group response. In 1975, Linstone and Turoff defined the Delphi technique as a method that enables the structuring of an effective group communication process for the purpose of dealing with a complex problem. Its main purpose is to acquire a reliable consensus among a group of

experts concerning their opinions through a series of questionnaires and controlled feedback.

Habibi et al. (2014) examined previous research as well as existing Delphi studies to develop the theoretical framework using a comparative study. The overall framework for Delphi studies consists of six steps, where multiple iterations of several steps may be necessary. In terms of the size of the group of experts needed, there is no set number, but many previous studies have shown that a group of approximately 10 experts works well, if the group members have varying specialties. This method can use sequential or snowball sampling, which is considered nonprobability sampling. Additionally, after criteria/items are determined, it has been shown that a 7-point Likert scale is ideal in that it results in stronger correlations in *t* tests (Diefenbach, Weinstein, & O'Reilly, 1993). Descriptive statistics are then used to determine criteria that do not meet a minimum mean (5 or 4 in the 7-point scale), which are removed. Kendall's coefficient of concordance (Kendall's W) is used to measure the level of consensus using mean rank and standard deviation. This coefficient is used to determine if more rounds are needed in the Delphi process. Similar methods were used in this study. While examining the existing literature for purposes of this study, no Delphi studies were found that directly related to geospatial core technical competencies.

A review of various Delphi studies showed that there is no universal rating scale used in every study to identify participant viewpoints and the potential for consensus. Many types of rating scales are used in Delphi studies to develop consensus among expert panelists (Linstone & Turoff, 2002). This study used a 5-point Likert scale. The

dimensions of desirability, feasibility (practicability), and confidence can be used when a predetermined list of items is used in the first survey round and when additional feedback is prompted from the panelists. These three dimensions were introduced in Policy Delphi studies and used to assess the range of differing opinions (Linstone & Turoff, 2002). Next, they were used in Classical Delphi designs (Heitner, Kahn, & Sherman, 2013), and they are appropriate for this study. Desirability and practicability were used to assess and score each competency item, while confidence scores were used as self-assessment tools by the panel experts (Linstone & Turoff, 2002).

Geospatial Competency Model Development

A search for a systemic review, literature review, or critical review regarding how geospatial technical competencies have been studied methodologically did not yield highly relevant results. However, several publications exist in which the researchers used different methods to assess, compare, and categorize geospatial competencies, both technical and nontechnical. A review of these publications and their methodologies and results follows.

The GIS&T BOK, developed by DiBiase et al. (2006) was the result of a task force effort initiated by the UN-GIS in the late 1990s as an effort to address educational challenges in the geospatial field. It was used to define the core competencies expected of geospatial employees across many geospatial organizations since its release in 2006 (Ahearn et al., 2013; DiBiase et al., 2006). Actual frameworks for the implementation of the BOK in both academia and the workplace have been limited (Unwin et al., 2011), but the GIS&T BOK is still considered a landmark accomplishment in the geospatial industry

(Ahearn et al., 2013; Rip, 2008). The BOK is the source used to develop the Round 1 survey of this study. Technical competencies from the BOK are listed and categorized in Appendix B.

Gaudet et al. (2003) evaluated the GTCM, which addressed the core skills and knowledge needed by those looking to work in the geospatial field. They used a quasi-Delphi approach that included four phases of data collection and analysis. The study also included a literature review, survey, and focus groups. A short literature review was provided by the researchers regarding competency models and their importance. The results of the research provided the researchers with the geospatial competencies that the focus groups had deemed to be the most important. A one-sentence industry definition was developed as part of the consensus among the focus groups. The overlap of technical competencies with the BOK is shown in Appendix B. The 2018 update of the GTCM, when compared with the 2003 GTCM, shows very little real change and is also overlapping with the competencies of the BOK in Appendix B.

Wikle and Fagin (2014) conducted research regarding the hard and soft skills needed to prepare GIS professionals from the standpoints of both employers and educators. For this study, the competencies most desired by employers and educators were determined by Internet-based surveys, in which survey items were determined through a short literature review. The statistical Mann-Whitney and chi-squared tests were used to compare the perceived importance of hard and soft skills between employers and educators. A list of the most important and desirable hard and soft skills was developed based on the results of the surveys and statistical analyses. The technical

competencies resulting from this study are compared with Hong (2015), Solem et al. (2008), and Gaudet et al. (2003) in Appendix B.

Solem et al. (2008) compared the skills of professional geographers to the needs of organizations across relevant sectors of the U.S. workforce. A series of focus groups was conducted, followed by the development of two surveys, to explore the extent of specific skills performed by geographers in various positions as well as the value of and anticipated demand from employers for those skills. The results of the study showed an emphasis on general professional competencies (soft skills) such as time management and computer literacy. Several technical competencies were on the list of high importance, including field data methods, interdisciplinary applications, and spatial thinking. While these competencies are certainly part of the geospatial field, they are more generalized than what is listed in the GIS&T BOK (DiBiase et al., 2006) because the study focused on geographers, rather than on geospatial professionals whose work applies across many disciplines. This study showed some overlap of desired competencies with those of DiBiase et al. (2006), Hong (2015), and Gaudet et al. (2003), as well as the updated GTCM of 2018 (Directions Magazine, 2018), as demonstrated in Appendix B.

Hong (2015) conducted a qualitative study using GIS job advertisements from three different GIS job websites in the United States as the data sources and grouped the jobs into five categories: analyst, programmer/developer/engineer, specialist, technician, and other (coordinator, manager, scientist, and others). He compiled a list of technical skills and their definitions, as well as general skills by coding the advertisement data in

NVivo software. His study also included a general comparison of geospatial competencies determined by DiBiase et al. (2006), Gaudet et al. (2003), and Solem et al. (2008). There are limitations to Hong's study to consider as well. Only three online sources were used to collect job advertisements, which resulted in 946 advertisements after removing duplicates. Additionally, no feedback, data, or input were collected directly from any geospatial employers or existing employees for analysis. When comparing Hong's (2015) results with those of Gaudet et al. (2003), Solem et al. (2008), and DiBiase et al. (2006), there are overlaps, but also clear differences most likely attributable to the time gap between the studies, as well as differences in the research methods used and their associated limitations. The findings from these studies showed that there were not only important geospatial technical competencies, but also important soft skills that needed to be considered as core competencies for geospatial professionals.

Summary of Gaps in the Literature

A review of the literature revealed several key points. First, there is a clear lack of consensus regarding required geospatial technical competencies, even though there have been several studies conducted to develop a competency model. There was some overlap between the competency lists, but there were also clear differences, as shown in Appendix B. Second. Recent studies were lacking regarding the updating of geospatial technical competencies. The GIS&T BOK has not been officially updated since 2006 (DiBiase et al., 2006), and the 2003 GTCM was officially updated at the end of 2018, but with little changes aside from the rewording of competency definitions (Directions Magazine, 2018; Gaudet et al., 2003). Solem et al. (2008), Wikle and Fagin (2014), and

Hong (2015) published studies that employed different methodologies to try to create an updated list of geospatial technical competencies. Their results showed a lack of consensus related to the desired geospatial technical competencies as well. Appendix B outlines the seven technical competency categories, which are Analytical Methods, Cartography and Visualization, Design Aspects, Data Modeling, Data Manipulation, Geocomputation, and Geospatial Data. There are 46 competencies within these seven categories. As shown in Appendix B, there was agreement among DiBiase et al. (2006), Gaudet et al. (2003), Hong (2015), Solem et al. (2008), and Wikle and Fagin (2014) on just five of the 46 competencies listed. Comparing the competency lists developed by all the authors shown in Appendix B pointed out the lack of consensus regarding which competencies are most important. The methodologies used by these authors are all different as well. Third, there existed a gap in the literature regarding which forward-looking geospatial technical competencies should be included on the list. Future trends in the industry were discussed, but no current studies were available in which this information was used to define additional geospatial technical competencies. This study aimed to close these gaps in the literature.

Conclusions

The review of the literature in this chapter showed that, although several recent resources and studies have been published in which the authors discussed the desired geospatial technical competencies of organizations in the industry as it currently stands, there was little mention of forecasted competency needs for the future. Forward-looking geospatial technical competencies were rarely discussed in the literature, and no

consensus-based list of these types of competencies currently exists. This gap in the literature has added to the persistence of a specific management problem. The review of the literature showed that the geospatial industry continues to experience high rates of job growth each year, and that there is a geospatial talent shortage in the United States. There are opportunities to address the talent shortage by improving awareness about the industry and its applications across many fields, improving the relationships between organizations and academia better to develop relevant curricula and internship programs, and reskilling and training the current workforce to meet current and future talent needs.

In Chapter 3, I present the research methods used for this study. The use of a qualitative method, particularly a modified Delphi technique, is justified. The chapter also covers the role of the researcher, participant selection, instrumentation, issues of trustworthiness, and data collection and analysis.

Chapter 3: Research Method

The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals. The resulting list of competencies consisted of technical competencies classified into categories of skills and knowledge required for geospatial professionals to perform their jobs successfully. Panelists were experts in geospatial talent management (GTM). A GTM expert was defined as someone who had geospatial talent management as well as technical and professional experience (in the United States) and met the minimum criteria set forth later in this chapter.

The need for digitally competent employees is expected to increase more than twofold by the year 2021 (Geissbauer et al., 2016). A competency gap exists between the current geospatial workforce and future industry needs because the focus has been on what is needed now, which locks the industry into always playing "catch up" (Cann, 2016; Meier, 2016; Wikle & Fagin, 2014). The results of this modified Delphi study are intended to help close this competency gap. There is potential for positive social change, based on the adoption of the potential competency recommendations of the panel of experts. The findings from this study may impact government policies and strategies that can help preserve national security and promote economic growth and global diplomacy.

This chapter contains sections regarding the research methods for this study. These sections include descriptions of the research design and rationale, population and participant selection strategy, data collection instruments, method of data collection, and

data analysis strategy. Chapter 3 also contains descriptions of the role of the researcher, the relationship between researcher and participants, measures for protecting the confidentiality and privacy of study participants, ethical concerns, and the trustworthiness of the study. The chapter concludes with summary and transition to Chapter 4.

Research Design and Rationale

Qualitative Method

Although the consensus-based measures for determining which geospatial technical competencies were the most desirable and practicable were based upon the calculation of quantitative descriptive statistics, the method for the study was considered qualitative. The study was classified as qualitative research because initial data collection drew upon existing literature and open-ended input based on the subjective opinions of experts (see Skulmoski et al., 2007). With one research question and two subquestions, the purpose of this study was to address the specific problem identified in Chapter 1, namely, that leaders of geospatial organizations are using an outdated set of competencies, codified in 2006, which makes industry leaders ill-prepared to manage rapid technological change (DiBiase et al., 2006; Veenendal, 2014; Wikle & Fagin, 2014). Currently, a lack of consensus exists on updated competencies, required to meet industry needs resulting from the fourth industrial revolution (Cann, 2016; Maynard, 2015; Plessis & van Nierkerk, 2013; Schwab, 2016a; Veenendal, 2014). The primary research question and two subquestions were as follows:

Research Question (RQ): How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?

Subquestion 1 (SQ 1): How does a panel of experts in the geospatial industry view the desirability of forward-looking technical competencies of geospatial professionals?

Subquestion 2 (SQ 2): How does a panel of experts in the geospatial industry view the practicability of forward-looking technical competencies of geospatial professionals?

This qualitative study resulted in a consensus-based list of geospatial technical competencies that are desirable, practicable, and forward-looking, which could replace the outdated competency list of 2006.

Delphi Design

The qualitative method encompassed several choices for research design. The nature of a research study and its research questions supported the use of a specific methodology. The choice of the research design was determined by elements such as purpose, research questions, and desired outcomes of the study. The research study employed a Modified Delphi design. When the knowledge about forward-looking solutions to a complex problem or phenomenon is incomplete, a Delphi design is useful (Skulmoski et al., 2007). Delphi designs are also useful for problems that cannot be precisely analyzed and would benefit from the subjective judgments of experts (Skulmoski et al., 2007) such as geospatial industry experts in this study. This study

resulted in consensus-based opinions among experts as to the forward-looking desirable and practicable technical competencies needed by geospatial professionals.

A modified Delphi design is a variation of the Classic Delphi design. Classic Delphi uses open-ended questions and a series of survey rounds that enable expert panelists to build consensus (Skulmoski et al., 2007). Classic Delphi designs are distinguished by four characteristics: (a) anonymity, (b) iteration, (c) controlled feedback, and (d) statistical group response. First, the anonymity of Delphi participants is guaranteed, allowing participants to participate freely and offer their opinions without interference from other panelists (Skulmoski et al., 2007). Delphi studies feature multiple rounds of iterative questioning (Vernon, 2009). During Round 1 of Classic Delphi, panelists' solution-based responses are collated and reported back to the panel in subsequent rounds. Previous viewpoints can then be amended by panelists individually, based on the resulting collective opinion (Vernon, 2009). Responses are aggregated for descriptive statistical analysis and interpretation, and a consensus of expert opinions may be identified through controlled feedback and subsequent rounds of questioning (Skulmoski et al., 2007; Vernon, 2009).

Modified Delphi studies are adapted from any of the data collection and reduction components of a Classic Delphi study to meet specific needs (Skulmoski et al., 2007). For this modified Delphi study, similarities to a Classic Delphi study included multiple rounds with expert panelists and the goal of reaching a consensus (see Custer, Joseph, & Stewart, 1999). The key difference in methodology between a Classic Delphi and this modified Delphi study was the approach to Round 1. For this study, panelists were

provided with a list of preselected items, collected from the existing competency list of 2006, during Round 1. Panelists were also invited to add additional technical competencies to the list or adjust the description of the existing technical competencies. This modification to the Round 1 data collection process had the potential to reduce panelist drop-out rates. The time needed to validate an existing list of items was much shorter when compared to writing open-ended, narrative responses (Custer et al., 1999).

Role of the Researcher

A qualitative researcher can play many different roles, including teacher, observer, interviewer, consultant, interpreter, and advocate, among others. In traditional qualitative studies, the researcher often functions as an instrument of data collection as well. In the Delphi research design, the role of the researcher is more specifically focused on two types of roles: planner and facilitator (Avella, 2016). When panels are carefully designed and executed, there tends to be minimal risk of researcher bias due to the researcher's primary tasks of planning, coordinating, and recording (Avella, 2016). In this study, I did not participate in any of the survey rounds as a panel member. I planned the study, including recruiting the expert panel and evaluating potential panel members against the minimum panel criteria, as well as establishing communication methods and procedures. It is important to note that the back-and-forth communication between myself and the panelists contributed to internal process auditing (see Avella, 2016). The modified Delphi study was conducted using professional online networking groups, e-mail, and Internet-based surveys; communication was conducted primarily through e-mail as well. Personal relationships between myself and the participants were not

anticipated, but the potential existed for professional relationships. There were not any power-based supervisory relationships to consider for this study.

Methodology

Participant Selection

Delphi research is purposefully designed for a high inclusion of expertise where the sampling frame is a panel of experts (von der Gracht, 2008). Nonprobability, purposive sampling was used to constitute the expert panel, comprised of geospatial talent management and technology executives. Panelists self-selected using criteria based upon a set of knowledge and experience indicators unique to the topics requiring expert opinion (Linstone & Turoff, 2002; von der Gracht, 2008). For this study, the criteria to identify experts included (a) ten or more years of working experience in the geospatial field of which at least 5 years of experience were gained in a geospatial industry in an executive or management role, or at least 5 or more years of experience were gained in geospatial talent management encompassing the strategy and implementation for employee hiring and development, (b) holding at least a bachelor's degree in GIS or a related field, and (c) possession of at least one of the existing geospatial professional certifications (e.g., GISP, Esri EADP, ASPRS Mapping Scientist, or other). The sampling frame was conceptually aligned with the purpose of the study, which was to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. Panelists were recruited from GISCI and LinkedIn, with required permissions, as well as through snowball sampling strategies as needed.

In any qualitative design, sampling is an important consideration, as internal and external validity of the study depend on the suitability of the sample as related to goals of the research (Uprichard, 2013). Quantitative methods generally require larger, random sample sizes, whereas qualitative methods focus on relatively smaller samples, which are usually purposefully selected to suit a specific objective (Patton, 2015). Panel sizes can vary in Delphi studies from as few as 10 to several hundred (Linstone & Turoff, 2002; von der Gracht, 2008). For this study, 24 experts formed the panel. Twenty-five was believed to be a good sample size for obtaining saturation of judgment among experts concerning forward-looking solutions (Hasson et al., 2000; von der Gracht, 2008), and 24 was the final number of panelists. Ludwig (1997) stated that most Delphi studies used sample sizes between 15 and 20 panelists (p. 2). Twenty-five was the desired number of panelists chosen for this study to comply with most Delphi study sample sizes and to represent an attainable and manageable sample size, while anticipating a potential attrition rate of approximately 20% of the expert panel (see Bardecki, 1984).

Participants for this study were those who meet the selection criteria and were willing to participate. Any contact with potential participants occurred only after approval from the Institutional Review Board (IRB) of Walden University was obtained. The next steps in selecting and recruiting participants were obtaining written permission from the key geospatial group administrators at LinkedIn and joining groups, posting the study announcement (see Appendix E), and contacting members with public profile information as needed. Next, potential participants self-selected and chose to participate in the study. Those participants were asked to complete the informed consent form before

they could begin the Round 1 survey. It was estimated that there were more than 9,000 GISCI members with GISP certification in the United States and more than 97,000 members of several LinkedIn groups with geospatial experience. Referrals from participants and the researcher's contact network, known as snowball sampling, were included as a contingent sampling strategy if an insufficient number of panelists was recruited through the primary sampling strategy.

Recruitment

A search was conducted in LinkedIn, a professional online networking website, for professional geospatial groups. While there were many specialized group results, there were several more general geospatial groups with many members. Four specific groups were targeted for this study: GIS, Mapping, and GeoTech Professionals (52,517 members); GIS Professionals and Networking (28,207 members); GIS Professionals (16,944 members); and GISCI GISPs (3,168 members). The maximum total number of potential participants from these four LinkedIn groups was 100,836 members. While there may have been some overlap of membership among these groups, the total membership size was large enough to be useful for maintaining anonymity among the survey participants. Using the conservative assumption of a 0.5%-member recruitment response rate (504 members), there should have been more than enough potential participants ready to meet the target sample size of 25 and cover potential attrition.

The group owners of the four targeted LinkedIn groups were contacted through the LinkedIn messaging feature to request to be added to the group and obtain permission (Appendix C) to post the study announcement (Appendix E). The permission request

contained the necessary information about the study, as well as assurances of confidentiality and anonymity of the participants. Written permissions from group owners were obtained via e-mail or LinkedIn message.

Data collection and recruitment of participants began only after the Walden University IRB approved the proposal for the study. Once approval was received from the IRB and the LinkedIn group owners, the study announcement was posted to each group from which permission has been obtained. The study announcement gave all the required information about the study, including purpose, researcher contact information, self-selection criteria, start date, study duration and activities, overview of data collection protocols, and information on anonymity. The study announcement also contained a link to the Round 1 survey in SurveyMonkey. Once a potential participant used the link to the Round 1 survey, the self-selection criteria page appeared. Potential participants were required to read through the criteria and choose to either agree or disagree that they met the criteria. If they disagreed, the survey terminated. If they agreed, they were taken to the next page, which was the informed consent. If they chose to disagree, the survey terminated. If participants agreed to the terms and conditions of the informed consent, they were taken to the Round 1 survey where they began providing feedback to the 55 items in the survey. With such a large pool of potential participants in the four LinkedIn groups and in GISCI, no difficulty was anticipated in recruiting the necessary sample size. However, a secondary recruitment strategy was to use snowball sampling to obtain the desired sample size if necessary.

Potential participants were informed of the voluntary nature of the study in the study announcement and the informed consent form. No monetary benefits were provided. Participants' rights to dismiss participation in the study or withdraw from the study at any time were outlined in the informed consent form, as well as withdrawal procedures, anonymity, confidentiality, and data security (including participant data, data storage, e-mail communication, and more). All data collected from the participants through the surveys, as well as all communications between the researcher and participants, was kept confidential and secure by the researcher. There was anonymity among the participants, but the nature of data collection protocols and methodology required that I communicate with individual participants as needed; thus, complete anonymity between participants and the researcher was not possible.

Instrumentation

Day and Bobeva (2005) detailed a Delphi model with iterative stages of differentiated instrumentation, data collection, and data analysis procedures. Demonstrating the sequential and iterative nature of instrumentation creation and administration, data collection, and data analysis can provide clear protocols for conducting, monitoring, controlling, and demonstrating research quality (Day & Bobeva, 2005). Delphi studies are designed as an expert group process to achieve a consensus through an anonymous, iterative, written process, where panelists may provide their expert opinions in each round (von der Gracht, 2008). Several survey instruments specifically designed to answer the research question and subquestions were utilized in this study.

All surveys were administered to the panel members via SurveyMonkey. SurveyMonkey is a secure online survey tool. Participants provided initial feedback about the existing GIS&T BOK technical competencies in Round 1. Participants then completed two more iterative rounds of survey to address the desirability and practicability of the technical competencies.

Field test. Prior to starting actual data collection, a draft of the Round 1 survey was sent to three experts with either subject matter experience or some expertise in conducting a Delphi study. These experts reviewed the instrument and provided feedback relating to the Delphi data collection method. For this study, the Round 1 data collection strategy served as a traditional field test in that experts were asked to modify, revise, and add new items to the existing technical competency list provided in Round 1. For this study, participants in the field test were asked to comment on the clarity and relevance of the survey instructions, as well as comprehensibility of the instructions and survey questions. A successful field test can identify any potential confusion or ambiguity, allowing for the modification of the survey instrument before Round 1 begins. Protocols for data collection and analysis for each survey round follow in the section on Data Collection and Analysis.

Data Collection and Analysis

Because there was an existing set of technical competencies from 2006, data collection for Round 1 differed from the Classical Delphi design. Panelists were asked to review, modify, and add any new items to the list of technical competencies provided in Round 1 (see Appendix A), which they deemed relevant, along with their rationale. The

final list of technical competencies resulting from Round 1 was then be converted to Likert-type items for inclusion in the Round 2 survey instrument. The panelists evaluated each item using scales for desirability and practicability, based on criteria developed by Linstone and Turoff (2002). A total of four rounds of survey was planned, but three were utilized. The first two rounds were based upon consensus-identifying and data collection and analysis protocols; the last round consisted of validation of the final set of panelist viewpoints.

In Round 2, descriptive statistics were used to evaluate the ratings panelists provide for tendencies toward consensus as to the desirability and practicability of each of the Likert-type competency statements. In Round 3, panelists were asked to review the final set of consensus-based competencies deemed desirable and practicable. Using a 5-point Likert scale, panelists rated their confidence in the overall results of the study. This Round 3 rating was used as a self-reported measure of the credibility and confirmability of the trustworthiness of the results of the study (Lincoln & Guba, 1985; Linstone & Turoff, 2002; von der Gracht, 2008).

Round 1. Round 1 solicited responses from panel experts as to potential changes to the technical competencies listed in the Round 1 survey instrument, administered via SurveyMonkey. Panelists were provided the GIS&T BOK selected list of technical competencies with a brief description of each competency. Panelists were also able to add one or more new technical competencies along with their rationale for doing so. Panelists were also be given the opportunity to suggest edits or revisions to the existing technical

competencies and descriptions. Participants were asked to complete their responses within one week.

Round 2. Round 2 began with the revised list of survey items based upon the results of Round 1. The Round 2 survey was to be administered on the SurveyMonkey platform. Participants were asked to rate each competency's desirability and practicability. Five-point Likert scale items, based on the 4-point scales developed by Linstone and Turoff (1975), were used in this study, allowing the participants to numerically rate their responses for desirability and practicability for each item. The 5-point scale used in this study is a modification of the Linstone and Turoff scales in which participants can choose a neutral option if they have no opinion about an item one way or the other; they will not be forced to make a judgment leaning toward *in favor of* or *against* an item (Decieux, Mergener, Sischka, & Neufang, 2015). *Desirability* refers to a competency being advantageous, worthy of pursuit, and mitigating harm (Linstone & Turoff, 2002). Practicability (also called *feasibility* by Linstone and Turoff) refers to the ability to execute the job duty with minimal difficulty (Linstone & Turoff, 2002). The scales for each item range from 1 to 5, with 1 = *Very Undesirable* (or *Very Impractical*), 2 = *Undesirable* (or *Impractical*), 3 = *Neither Desirable nor Undesirable* (or *Neither Practicable nor Impractical*), 4 = *Desirable* (or *Practicable*), and 5 = *Very Desirable* (or *Very Practicable*). Panelists could provide comments on any items and were encouraged to provide a rationale when scoring any items as a 1 or 2. This information was used to inform the process of interpreting the data results.

For any item to move on to Round 3, 70% of the panelists had to rate each item separately as *desirable* and *practicable* (score of 4 or 5). This percentage reflects a tendency toward consensus (Masko, Eckert, Caldwell, & Clarkson, 2011). For any items not meeting the 70% threshold, a secondary calculation was used to determine if the item should pass to the next round. Any remaining items with a median score of 3.5 or greater moved to the next round, as the score most likely signified a tendency toward consensus. An item must have been rated both *desirable* and *practicable* to be advanced to the next round of item evaluation. Employing a primary and secondary filter in the data reduction process has been used in many other Delphi designs (Gevers, Kremers, De Vries, & Van Assema, 2014; Trevelyan & Robinson, 2015). Participants were given one week to respond to Round 2, with a reminder at the end of the week to complete the survey.

Round 3. At the start of Round 3, panelists received a list of the technical competencies from the Round 2 survey in matrix form. The list included aggregate panel data for the levels of consensus for desirability and practicability of technical competencies for all existing, revised, and additional technical competencies. Panleists were given the opportunity to provide comments regarding the list and ratings. Panelists were then asked to rate their overall confidence with the full list of items. Confidence ratings are used to assess the credibility of the findings of the study (Linstone & Turoff, 2002). Confidence ratings also indicate self-reported validity in a study. The ratings for the Linstone and Turoff confidence scale are 5 = *Certain* (low risk of being wrong), 4 = *Reliable* (some risk of being wrong), 3 = *Risky* (substantial risk of being wrong, 2 = *Neither Reliable nor Unreliable*, 1 = *Unreliable* (great risk of being wrong). Participants

will be given 1 week to respond to Round 4, with a reminder from the researcher at the end of the week to complete the survey. A response frequency of 70% or greater for the top two items (5 = *certain*, 4 = *reliable*) was an indicator of the self-reported credibility of the findings among the expert panelists.

Issues of Trustworthiness

There are no universally accepted criteria to assess the rigor of a qualitative study. Different scholars have suggested different criteria for qualitative research (Patton, 2015). Lincoln and Guba (1985) advanced the criteria for trustworthiness, which are now the most widely accepted tests of quality for qualitative research among scholars (Elo et al., 2014). The credibility, transferability, dependability, and conformability are the criteria prescribed by Lincoln and Guba (1985) for validating a qualitative study. Ethical concerns should also be addressed.

Credibility

Credibility in qualitative research is defined as the ability to understand the findings and interpretations, as well as the confidence in making decisions based on them (Zitomer & Goodwin, 2014). The credibility of this study was based on the ability of panelists to provide a confidence rating for each item, as well as the ability to provide comments on their Likert-scale ratings. Credibility was also based on the development of the Round 1 survey instrument, the field tests of the Round 1 instrument, and on allowing participants to confirm or modify their ratings and provide feedback in Round 3. The self-assessment of confidence levels of responses by panel members in Round 3 also bolstered credibility (see Linstone & Turoff, 2002).

Transferability

The transferability (or external validity) is defined as the possibility of applying the findings from the study to other similar situations (Houghton, Casey, Shaw, & Murphy, 2013). The transferability of the results of this study was based upon the alignment of the expertise of the panelists with the needs of those who may read the study. Because Delphi studies use a purposeful sampling strategy, the opportunity for transferability existed based on the criteria of the panelists and the description of the phenomenon under study (Brady, 2015). The survey administration tool SurveyMonkey ensured consistency in how the panelists took the survey. The resulting consensus-based list of technical competencies could potentially be used as a starting point for future research, when geospatial technical competencies need to be reviewed and updated once again. Additionally, the use of a purposeful sampling strategy in Delphi studies allowed for transferability based on the criteria of the participants as well as the description of the phenomenon (Brady, 2015),

Dependability

In a qualitative study, dependability means that a researcher can demonstrate the possibility of obtaining the same results by repeating the same research process, including data collection (Yin, 2014). Dependability of a study relies on the stability of the data (Houghton et al., 2013). Researcher bias was minimized in this study, which also contributed to its dependability. Proper documentation and record keeping for Delphi methods improves dependability, including information about data storage, questionnaire data, data collection and analysis, and software use (Fletcher & Marchildon, 2014).

Providing detailed instructions in the instrumentation as well as the research method also improved dependability. Because there was a single researcher collecting and analyzing the data, the study was more dependable.

Confirmability

Confirmability is defined as the neutrality and accuracy of qualitative data (Houghton et al., 2013). The quality of confirmability of research can be achieved by ensuring that the researcher's personal biases are not allowed to influence data collection or analysis. The role of the researcher in this Delphi designs minimized bias. Confirmability was evident in the detailed data reduction protocols documented in Chapter 3, in the section on Data Collection and Analysis.

Ethical Procedures

In this study, I collected information from human participants. Ensuring the participants' interests was necessary to protect them from any problems due to participating in the study or expressing their personal views. The focus was placed on ensuring the anonymity, confidentiality, and privacy of participants throughout the study. Before the study began, I informed the participants of their rights, including the right to withdraw from the study at any time. The core principles of ethical research are respect for persons, beneficence, and justice, which guided the processes of obtaining the informed consent, assessing the risks, and selecting the participants (Belmont Report, 1979). Participants were required to agree to the informed consent before beginning the Round 1 survey. The informed consent form provided important information to the participant, including criteria for self-selection, purpose of the study, procedures and

expected timelines for each round of survey, the voluntary nature of the study, risks and benefits of participating in the study, the fact that there is no compensation offered to participants, privacy protocols, contact information for the researcher, and the statement of consent. Contact with participants began only after the IRB of Walden University approved the research proposal. Permissions were obtained from the LinkedIn group owners and GISCI as named in Chapter 3, under Recruitment. Permissions and agreements were included in the IRB application packet. Once IRB approval was received (IRB approval number 09-18-19-0416428), LinkedIn group owners and GISCI were notified of the approvals and the corresponding approval numbers. Meeting the requirements for IRB approval ensured that the study complies with ethical standards set forth by Walden University and applicable U.S. regulations.

Anonymity among participants and confidentiality were upheld before, during, and after the study. All data collected was stored using password protection on a laptop computer, flash drive, and Microsoft OneDrive. Analysis reports were provided to participants throughout the survey process, with anonymity and confidentiality as a priority. The use of the online survey tool SurveyMonkey protected user anonymity by providing a unique identifier for each survey respondent, rather than disclosing any personal information. With anonymity between participants ensured, participants were likely to be more truthful and open in their responses. Only three people had access to the data in the password-protected storage locations: I, as the researcher; the chair of the dissertation committee; and the committee member. Only I, as the researcher, ever sew or had access to any identity-related information, which may include names and email

addresses. The data will be stored for a period of five years after Walden University fully approved the final dissertation document, which is a requirement of the University. After five years, the data will be permanently deleted, and the flash drive will be destroyed.

Summary

To address the rapid changes resulting from the convergence of emerging technologies and provide a relevant set of geospatial technical competencies, a consensus-identifying research method can be used. The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. Delphi was the chosen research method because the literature review in Chapter 2 revealed a lack of consensus regarding these technical competencies. The results of this study may be used to revise the list of core geospatial technical competencies being used by many organizations for hiring new personnel, as well as for reskilling the existing workforce. Throughout the study, ethical concerns were always at the forefront, and any potential issues were to be addressed immediately. Confidentiality and anonymity were considered throughout every aspect of the study to protect the participants. Data collection and data analysis procedures and protocols were documented and adhered to, to ensure the trustworthiness of the study. In Chapter 4, I discuss the results of the study, the research setting, and details for recruiting participants, the data collection, data analysis, and evidence of trustworthiness.

Chapter 4: Results

In Chapter 3, I presented the research methods for this study. The use of a qualitative method, particularly a modified Delphi technique, was justified. In Chapter 3, I also discussed the role of the researcher, participant selection, instrumentation, issues of trustworthiness, and data collection and analysis. In Chapter 4, I present details regarding the field test, research settings, demographics, details for recruiting participants, the data collection, data analysis, and evidence of trustworthiness, study results, and chapter summary.

The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts shared their views based upon a predetermined list of categories and associated technical skills and knowledge required for geospatial professionals to perform their jobs successfully. The primary research question and two subquestions posed for this study were as follows:

Research Question (RQ): How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?

Subquestion 1 (SQ 1): How does a panel of experts in the geospatial industry view the desirability of forward-looking technical competencies of geospatial professionals?

Subquestion 2 (SQ 2): How does a panel of experts in the geospatial industry view the practicability of forward-looking technical competencies of geospatial professionals?

Field Test

A successful field test can identify any potential confusion or ambiguity, allowing for the modification of the survey instrument before Round 1 begins. Prior to the Walden University IRB submission and approval, and starting actual data collection, a draft of the Round 1 survey was sent to three experts with either subject matter experience or some expertise in conducting a Delphi study. The three experts also possessed a GISP certification. These experts reviewed the instrument and provided feedback relating to the Delphi data collection method. For this study, the Round 1 data collection strategy could have served as a traditional field test in that experts were asked to modify, revise, and add new items to the existing technical competency list provided in Round 1. Participants in this field test were asked to comment on the clarity and relevance of the survey instructions, as well as comprehensibility of the instructions and survey questions (see Appendix F).

The field test did not require IRB approval because they did not provide any actual data or responses to the survey questions. The field test participants only reviewed the instructions and survey instrument and provided feedback via email. The feedback I received from all three participants in the field test was positive, and no changes were needed based on that feedback. After the field test was completed, and all other

requirements were met for IRB submission, I submitted the IRB application to obtain approval from the IRB to begin my data collection and analysis.

Research Setting

Electronic surveys were administered through SurveyMonkey in an online environment. The nature of the data collected consisted of participant ratings of desirability and practicability of geospatial competencies. I did not observe any conditions, either personal or professional/organizational, that may have influenced the opinions and experiences of the panelists, because there were no in-person or direct interactions with any panelists. Due to the absence of observation, I did not have any knowledge of any factors or conditions that might influence how I interpret the results of the study.

Demographics

The expert panelists for this study self-selected to meet the following criteria: (a) ten or more years of working experience in the geospatial field of which at least 5 years of experience were gained in a geospatial industry in an executive or management role, or at least 5 or more years of experience were gained in geospatial talent management encompassing the strategy and implementation for employee hiring and development; (b) holding at least a bachelor's degree in GIS or a related field; and (c) possession of at least one of the existing geospatial professional certifications (e.g., GISP, Esri EADP, ASPRS Mapping Scientist, or other). No other demographic information was collected or recognized for this study, as it was not required.

Recruitment

A search was conducted in LinkedIn, a professional online networking website, for professional geospatial groups. While there were many specialized group results, there were several more general geospatial groups with many members. Four specific groups were targeted for this study: (a) GIS, Mapping, and GeoTech Professionals (52,517 members); (b) GIS Professionals and Networking (28,207 members); (c) GIS professionals (16,944 members); and (d) GISCI GISPs (3,168 members). The maximum total number of potential participants from these four LinkedIn groups was 100,836 members. While there was some overlap of membership among these groups, the total membership size was large enough to be useful for maintaining anonymity among the survey participants. Using the conservative assumption of a 0.5%-member recruitment response rate (504 members), there should have been more than enough potential participants ready to meet the target sample size of 25 and cover potential attrition.

The group owners of the four targeted LinkedIn groups were contacted through the LinkedIn messaging feature to request to be added to the group and obtain permission (see Appendix C) to post the study announcement (see Appendix E). The permission request contained the necessary information about the study, as well as assurances of confidentiality and anonymity of the participants. Written permission from group owners was obtained via e-mail or LinkedIn message. I also obtained a letter of cooperation from GISCI, who directly emailed the GISP contact list to help recruit participants (see Appendix D).

Data collection and recruitment of participants began only after the Walden University IRB approved the proposal for the study. Once approval was received from the IRB and the LinkedIn group owners, the study announcement was posted to each group from which permission has been obtained. The study announcement gave all the required information about the study, including purpose, researcher contact information, self-selection criteria, start date, study duration and activities, overview of data collection protocols, and information on anonymity. The study announcement also contained a link to the Round 1 survey in SurveyMonkey. Once a potential participant used the link to the Round 1 survey, the self-selection criteria page appeared. Potential participants were required to read through the criteria and choose to either agree or disagree that they met the criteria. If they disagreed, the survey terminated. If they agreed, they were taken to the next page, which was the informed consent. If they chose to disagree, the survey terminated. If participants agreed to the terms and conditions of the informed consent, they were taken to the Round 1 survey where they began providing feedback to the 55 items in the survey. With such a large pool of potential participants in the four LinkedIn groups, no difficulty was anticipated in recruiting the necessary sample size. A secondary recruitment strategy was to use snowball sampling to obtain the desired sample size but was not necessary.

Potential participants were informed of the voluntary nature of the study in the study announcement and the informed consent form. No monetary benefits were provided. Participants' rights to dismiss participation in the study or withdraw from the study at any time were outlined in the informed consent form, as well as withdrawal

procedures, anonymity, confidentiality, and data security (including participant data, data storage, e-mail communication, and more). All data collected from the participants through the surveys, as well as all communications between myself and the participants, were kept confidential and secure. There was anonymity among the participants, but the nature of data collection protocols and methodology required the researcher to communicate with individual participants as needed; thus, complete anonymity between participants and myself was not possible.

Data Collection and Analysis

Participation Overview

This study utilized a modified Delphi design, and consisted of three rounds of data collection, analysis, and results. This section consists of the data collection and analysis details. Table 2 shows the number of participants reached, the number of surveys completed, and the response rates for each round of data collection.

Table 2

Survey Response Rates

Round	Participants reached	Surveys completed	Response rate %
1	114	42	36.8
2	35	29	82.9
3	29	24	82.8

Throughout the three rounds of data collection and analysis, the panelist attrition rate was 80%. Sixty-five percent of the attrition occurred between Rounds 1 and 2. One hundred fourteen participants agreed to the informed consent and entered the Round 1 survey, but only 42 completed the whole survey. There were a few comments and email

communications from some participants that explained their preference to not participate once they were able to review the Round 1 survey. Seven participants emailed with the simple request to be removed from the study and future communications related to the study, without any explanation. Three other participants requested to be removed as well but provided the explanation that the study was not what they expected it to be and they changed their minds. An additional participant stated that the study was "too intellectual." An assumption that could further explain the high drop-off rate is the lengthiness of the Round 1 survey.

Table 3 contains the timelines for the data collection and analyses of each of the three rounds. The discussion of the study results appears in the Study Results section of this chapter.

Table 3

Data Collection and Analysis Timeline

	Survey Dates		Analysis Dates	
Round	Start	Finish	Start	Finish
1	9/24/2019	10/03/2019	10/03/2019	10/05/2019
2	10/08/2019	10/15/2019	10/15/2019	10/16/2019
3	10/21/2019	10/29/2019	10/29/2019	11/04/2019

Round 1

Data collection. The Round 1 survey began shortly after IRB approval was received, simultaneously with participant recruitment. All surveys were administered through the online tool SurveyMonkey. After IRB approval, the study announcement, which contained a link to the Round 1 survey, was posted to the four LinkedIn groups specified in Chapter 3. The partner organization, GISCI, also sent the study

announcement to its email distribution list. During the Round 1 data collection period of one week (Sept. 24, 2019 to Oct. 3, 2019), a total of 116 people entered the Round 1 survey on SurveyMonkey. SurveyMonkey is a secure, online survey tool that ensures the privacy and confidentiality of the data collected. Participants were able to complete the survey on a computer or mobile device and were given the opportunity to email me at any time with questions or clarifications. The informed consent required an 'I AGREE' selection in the survey in order to move on the survey questions. Participants were asked to provide their email addresses, which were seen only by me. The email addresses were used to send BCC email reminders to participants about completing the survey round, and to track and correlate individual responses and comments through all three rounds as necessary. The Round 1 survey consisted of the 46 technical competencies from the GIS&T BOK, and panelists were given the opportunity to modify the wording of those competencies and provide suggestions from new competencies that should be added.

Round 1 began on September 24, 2019. The study announcement with a link to the Round 1 survey was emailed to the GISCI email list of current GISPs. The study announcement was also posted on the approved LinkedIn group pages and the GISCI Facebook page. Of the 116 people that entered the survey, 114 self-selected and agreed to the informed consent, and 105 provided their email address. Approximately 60 people provided feedback on at least one item but did not fully complete the survey. Only 42 people completed the survey in its entirety. An email reminder was sent to everyone who provided an email address on October 1, 2019. I did not ask if they had completed the survey, I only reminded them that the survey would soon close and included the link to

the survey. Participants were also reminded of their right to withdraw from the study at any time. The survey was closed on October 3, 2019. There were not any unusual circumstances encountered during the Round 1 data collection. I would like to note that the partner organization was vital in the participant recruitment process. The direct email of my study announcement resulted in the initial recruitment of 112 of the 116 total people that entered the Round 1 survey.

Data analysis. Once the Round 1 survey closed, I began data analysis on October 3, 2019. I exported the Round 1 survey data in its entirety to an Excel spreadsheet (an XLS file) and removed individual response records with no comments. I created two copies of the data in the XLS format. The first file contained the raw data from SurveyMonkey, and the second file contained a transposed version of the data more suitable for data analysis. The Round 1 survey data is included in Appendix G. The data was saved to a secure folder on my laptop and later copied to an external USB drive and to Microsoft OneDrive for safe keeping. I reviewed each competency category and the comments provided by participants. From those comments, I developed 30 new items (competencies) that were suggested by the panelists for inclusion in the Round 2 survey instrument. There were also several suggestions for modifications to the wording of existing items, so those were also included. There were also six new items suggested at the end of the survey that were not specific to an existing category. These additions and modifications were included in the Round 2 survey instrument, which I developed during the week following the Round 1 data collection. The Round 2 instrument consisted of the original 46 technical competencies, some of which were revised based on panelist

comments from Round 1, and 30 new competencies that were based on panelists comments from Round 1. New competencies were based on the comments where the wording did not fit with any of the original technical competencies listed from the GIS&T BOK. Round 1 data analysis was completed on October 5, 2019. There were not any unusual circumstances encountered during the Round 1 data analysis.

Round 2

Data collection. I used the results of Round 1 to develop the Round 2 survey instrument (see Appendix H). While Round 1 consisted of open-ended questions allowing panelists to provide comments for each item, Round 2 consisted of Likert-type items where panelists could provide rationale and comments for their rating choices. The Round 2 survey consisted of 76 competency items for the panelists to review and rate. For each item, panelists were asked to rate the desirability and practicability on a 5-point Likert-type scale. There were two scales provided for each of the 76 items, in addition to a comment box for each item for panelists to include and comments or feedback. The scales for desirability were as follows: 1 = *Very Undesirable*, 2 = *Undesirable*, 3 = *Neither Desirable nor Undesirable*, 4 = *Desirable*, and 5 = *Very Desirable*. The scales for practicability were as follows: 1 = *Very Impractical*, 2 = *Impractical*, 3 = *Neither Practicable nor Impractical*, 4 = *Practicable*, and 5 = *Very Practicable*. The instructions for the Round 2 survey also included the definitions for desirable and practicable. Panelists were given the opportunity to provide rationale or comments related to any of the items, particularly those with ratings of 1 or 2 on either scale.

Round 2 data collection began on October 8, 2019 through SurveyMonkey. A blind carbon copy (BCC) email was sent from my Walden email account to the 42 participants who completed the Round 1 survey in its entirety. The email addresses came from the data collected in SurveyMonkey. The email contained a link to the Round 2 survey and stated that the survey would close in one week, on October 15, 2019. I reminder email was sent vis BCC email from my Walden email account on October 13, 2019, two days before the survey was set to close. I closed the survey on October 15, 2019 as planned and received a total of 29 completed responses. There were not any unusual circumstances encountered during the Round 2 data collection.

Data analysis. Data analysis for Round 2 began on October 15, 2019. I exported the Round 2 survey data in its entirety to an Excel spreadsheet (an XLS file) and created two copies of the data in the XLS format. The first file contained the raw data from SurveyMonkey, and the second file contained a transposed version of the data more suitable for data analysis. All data files were saved to a secure folder on my laptop and later copied to an external USB drive and to Microsoft OneDrive for safe keeping.

Once the raw data was transposed to a more workable format, I used Excel formulas to calculate the median and frequency of each of the five scales for desirability and practicability. These values were stored in two columns for each of the competency items, so I calculated these statistics at the bottom of column. I then created two new rows to determine whether the criteria for consensus was met for each item. These criteria were that a) 70% or more rated the item with a score of 4 or 5 in both desirability and practicability and b) if the 70% threshold was not met, the item had a median score of

3.5 or higher in both desirability and practicability. I used values of 0 and 1 for these two rows for each item, where 1 represented the threshold being met and 0 represented the threshold not being met. This served as a double-check when I added up the total number of items that passed the criteria and were to be included in the Round 3 survey. An overview of this data is found in Appendix I.

The primary measure of 70% or more of participants providing a rating of 4 or 5 was established for the study because this percentage reflects a tendency toward consensus (Masko et al., 2011). For any items not meeting the 70% threshold, a secondary calculation was used to determine if the item should pass to the next round. Any remaining items with a median score of 3.5 or greater were also moved to the next round, as the score most likely signified a tendency toward consensus. Employing a primary and secondary filter in the data reduction process has been used in many other Delphi designs (Gevers et al., 2014; Trevelyan & Robinson, 2015), so it was appropriate to do the same in this study. The goal of this study is to develop a consensus-based list of current and forward-looking technical competencies, so all items meeting the criteria were included to be moved to Round 3. Data reduction was not a focus of this data collection and analysis. Of the 76 competencies included in the Round 2 survey, 41 met the primary measure for consensus. When the secondary measure was applied, an additional 13 competencies met the criteria. Using both measures resulted in 54 items that represented a tendency toward consensus by the expert panel and the removal of 20 items (26%) from the original list resulting from Round 1. These 54 items were added to the

Analysis Matrix (see Appendix J) for inclusion in Round 3 survey for further data collection and analysis.

The Analysis Matrix consisted of the list of all 76 competencies from Round 2 color coded by competency category. Four additional columns were included and were as follows: Desirable and Practicable (Column 1), Desirable and Impractical (Column 2), Undesirable and Impractical (Column 3), and Undesirable and Practical (Column 4). X's were placed for each competency in the appropriate columns, based on the statistics calculated in the Round 2 data analysis. 41 items were marked in Column 1, 13 items were marked in Column 2, 22 items were marked in Column 3, and zero (0) items were marked in Column 4. This matrix was included in Round 3 for panelists to review and provide further feedback.

I also used the Excel spreadsheet to analyze the comments and rationale statements provided by the expert panelists. The feedback was categorized into two types. Comments were general feedback provided by panelists who rated items with a 3, 4, or 5, and rationale statements were feedback from panelists who rated items with a 1 or 2. This feedback was evaluated from the Round 2 data results (see Appendix H). Round 2 data analysis was finished on October 15, 2019. There were not any unusual circumstances encountered during the Round 2 data analysis.

Round 3

Data collection. When this study was proposed, four rounds of survey data collection were planned. However, once data collection and analysis began, it was determined by my committee chair and me that combining Rounds 3 and 4 would be the

most efficient course of action and would help keep the attrition rate as low as possible moving from Round 2 to Round 3. Hence, the Round 3 survey instrument (see Appendix K) was developed based on the results of the Round 2 data analysis and included an item that measured the confidence ratings of panel members regarding the resulting competencies and their consensus-based ratings (see Appendix L). The Round 3 survey included the Analysis Matrix for panelists to review, as well as three open ended questions that provided the opportunity for panelists to provide feedback regarding a) changing the column number for any item in the matrix and include rationale, b) suggestions for what could be done to improve an item's rating from Column 2 (Desirable and Impractical) to Column 1 (Desirable and Practicable), and c) general comments related to items in Column 3 (Undesirable and Impractical). The final item in the Round 3 survey was a confidence rating for the overall results shown in the Analysis Matrix. Confidence ratings are used in Delphi studies to assess the credibility of the findings of the study (Linstone & Turoff, 2002). Confidence ratings also indicate self-reported validity in a study. The ratings for the Linstone and Turoff confidence scale used in the Round 3 survey item were *5 = Certain (low risk of being wrong), 4 = Reliable (some risk of being wrong), 3 = Risky (substantial risk of being wrong), 2 = Neither Reliable nor Unreliable, 1 = Unreliable (great risk of being wrong).*

Round 3 data collection began on October 21, 2019. I sent a BCC email from my Walden email account to the 29 panelists that fully completed the Round 2 survey. The email included a link to the Round 3 survey and an explanation for combining Rounds 3 and 4. The email also stated that the survey would close October 28,2019. I sent an email

reminder to panelists two days before the survey as set to close. Attempting to get as close to 25 completed responses as possible, I sent an additional reminder email on October 28, 2019 and left the survey open until October 29, 2019. I closed the Round 3 survey on this date and had 24 total completions. There were not any unusual circumstances encountered during the Round 3 data collection.

Data analysis. Round 3 data analysis began on October 29, 2019. I exported the Round 3 survey data in its entirety to an Excel spreadsheet (an XLS file) and created two copies of the data in the XLS format. The first file contained the raw data from SurveyMonkey, and the second file contained a transposed version of the data more suitable for data analysis. All data files were saved to a secure folder on my laptop and later copied to an external USB drive and to Microsoft OneDrive for safe keeping.

I evaluated the comments collected in Round 3 (see Appendix L). Each comment was linked to an individual panelist and was cross-referenced to the ratings that panelists provided in Round 2 for any items included in the comment. An analysis of these comments revealed that no changes were necessary to the overall ratings (Column numbers) of any items in the Analysis Matrix, as there were no significant changes to the medians or frequencies of any of the item ratings. However, there were several comments that warrant further discussion, which are included in the Study Results section of this chapter. The final item in the Round 3 survey was the confidence rating in the overall results (Analysis Matrix). These ratings were included the Excel spreadsheet, and I used Excel formulas to quantify the Likert-type scale frequencies. A response frequency of 70% or greater for the top two items (5 = *certain* and 4 = *reliable*) were used as an

indicator of the self-reported credibility of the findings among the expert panelists. Data analysis for Round 3 ended on November 4, 2019. There were not any unusual circumstances encountered during the Round 3 data collection.

Evidence of Trustworthiness

Credibility

Credibility in qualitative research is defined as the ability to understand the findings and interpretations, as well as the confidence in making decisions based on them (Zitomer & Goodwin, 2014). The credibility of this study was based on the ability of panelists to provide a confidence rating for each item, as well as the ability to provide comments on their Likert-scale ratings. Credibility was also based on the development of the Round 1 survey instrument, the field tests of the Round 1 instrument, and on allowing participants to confirm or modify their ratings and provide feedback in Round 3. The self-assessment of confidence levels of responses by panel members included in Round 3 also bolstered credibility (Linstone & Turoff, 2002).

The strategies described above were applied in this study to ensure credibility. The procedures outlined in the study allowed participants to provide feedback the list of technical competencies from the GIS&T BOK in Round 1. I modified and revised the existing items and added new competency items list based on participant feedback. Participants were comments and rationale for their ratings of items in Round 2 and had the opportunity to review the overall ratings in Round 3 and provide additional feedback. The study protocol also enabled the expert panel to rate their confidence level in the final list of technical competencies and their overall ratings as shown in the Analysis Matrix.

The percentage of panelists who chose one of the two highest confidence ratings (4 = Reliable and 5 = Certain) was 87.5, meaning 87.5% of the expert panel indicated that they have confidence in the overall truth of the study findings.

Transferability

The transferability (or external validity) is defined as the possibility of applying the findings from the study to other similar situations (Houghton et al., 2013). The transferability of the results of this study was based upon the alignment of the expertise of the panelists with the needs of those who may read the study. Because Delphi studies use a purposeful sampling strategy, the opportunity for transferability existed based on the criteria of the panelists and the description of the phenomenon under study (Brady, 2015). The survey administration tool SurveyMonkey ensured consistency in how the panelists take the survey. Additionally, the use of a purposeful sampling strategy in Delphi studies allowed for transferability based on the criteria of the participants as well as the description of the phenomenon (Brady, 2015).

I provided thorough overview of the study phenomenon as well as a detailed description of what was involved in the fieldwork. These details enable readers to have a better understanding of the study, which allows them to compare their own situations to the situation being investigated in this study and make inferences of transferability (Lincoln &Guba, 1975). In the literature review, I evaluated various studies and articles that addressed the need for an updated geospatial competency list using different methodologies. The findings of those studies can be compared to the findings of the expert panel to gauge transferability (Hasson & Kenney, 2011). The resulting consensus-

based list of technical competencies can potentially be used as a starting point for future research, when geospatial technical competencies need revision and updates once again.

Dependability

In a qualitative study, dependability means that a researcher can demonstrate the possibility of obtaining the same results by repeating the same research process, including data collection (Yin, 2014). Dependability of a study relies on the stability of the data (Houghton et al., 2013). Researcher bias was minimized in this study, which also contributed to its dependability. Proper documentation and record keeping for Delphi methods improved dependability, including information about data storage, questionnaire data, data collection and analysis, and software use (Fletcher & Marchildon, 2014). Providing detailed instructions in the instrumentation as well as the research method also improved dependability. Because there was a single researcher collecting and analyzing the data, the study was more dependable. I was the only researcher in this study, and I completed the following tasks: a) storing raw data, b) providing detailed instructions in each survey instrument, c) explaining data collection and analysis procedures, questionnaire data, and software use, and d) presenting the findings of each round.

Confirmability

Confirmability is defined as the neutrality and accuracy of qualitative data (Houghton et al., 2013). The quality of confirmability of research was achieved by ensuring that the researcher's personal biases are not allowed to influence data collection or analysis. The role of the researcher in Delphi designs minimized bias. Confirmability was evident in the detailed data reduction protocols documented in the section on Data

Collection and Analysis in this chapter. Additionally, the audit trail for this study can be attributed to the conformability of the study findings.

Study Results

This modified Delphi study consisted of three rounds of data collection, analyses, and results. This section contains the results of each of the three rounds, with the goal of building a consensus among a panel of experts as to the desirability and practicability of forward-looking technical geospatial competencies of geospatial professionals. The data reduction results of the categories and technical competency items for each round are show in Figure 1.

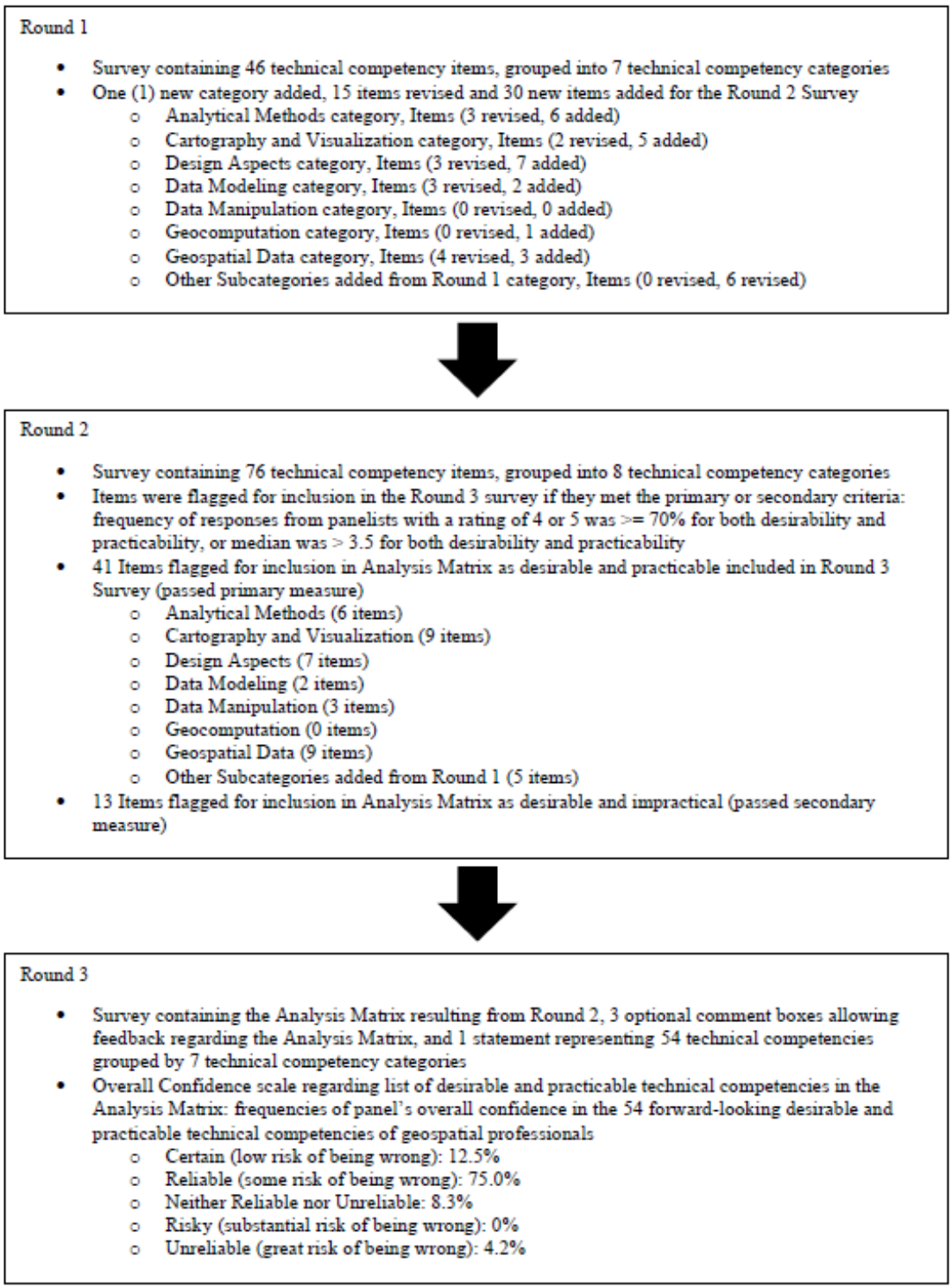


Figure 1. Data reduction results.

Round 1

The panel of experts revised 15 items and added 30 new items to the technical geospatial competency list based on the comments they provided in the Round 1 survey (see Appendix G). There were several comments for different items in the Round 1 survey as to panelists' preference to an item, such as agree, disagree, etc., but these types of responses were not considered pertinent to the results of Round 1. Panelists were asked to provide suggestions for modifications to any of the competency items they felt were necessary. One panelist continually commented "No suggestion" and another provided the comment of "No modification" for several items. Other panelists provided more substantial comments, such as "Maybe not the most appropriate space but: understanding of data type (integer vs decimal for example) and how this [a]ffects measuring phenomena" and "I would remove the on-line aspects from this category and create an entirely new one." The opinions provided by panelists regarding their preference or relevance did not have any effect on the items and whether their inclusion in Round 2.

Panelists generated 15 total revised items in five of the seven original technical competency categories and provided 30 total new items in six of the seven original technical competency categories. The common technical categories for revisions and additions were Analytical Methods, Cartography and Visualization, Design Aspects, Data Modeling, and Geospatial Data. There were several additions that did not readily fit into one of the existing categories, so they were placed into an eight category for Round 2. Tables 4 and 5 include the 15 revised items and the 30 new items resulting from Round 1, respectively.

Table 4

Revised Items Resulting from Round 1 Comments

Technical category	Original competency item	Revised competency item
Analytical Methods	Basic Analytical Operations	Basic Analytical Operations and Methods
	Surface Analysis	Surface Analysis and Derived Data Products
	Spatial Statistics	Spatial Statistics and Geostatistics
Cartography and Visualization	Map Production	Digital and Physical Map Production
	Map Use and Evaluation	Visual Map and Data Interpretation
Design Aspects		
	Database Design	Database Design, Modeling, and Standardization
	Application Design	Application Design and Evaluation
	System Implementation	System Implementation and Data Workflows
Data Modeling	Modeling 3D, Uncertain, and Temporal Models	Multi-dimensional, Uncertain, and Temporal Data Modeling
Geospatial Data	Earth Geometry	Geodesy and Earth Geometry
	Data Quality	Data Quality and Data Integrity
	Digitizing	Digitization and Vectorization
	Field Data Collection	Field Data Collection and Quality

Table 5

New Competency Items Resulting from Round 1 Comments

Technical category	New technical competency item
Analytical Methods	Raster Analysis
	Subsurface and AGL Analyses
	Spatio-temporal Modeling and Analysis
	Error Modeling
	Spatial Modeling and Analysis
	Forecasting
Cartography and Visualization	Dynamic Mapping
	Core Cartographic Principles
	Digital Integrations Mediums and Accessibility/ADA Compliance
	Web and Mobile Mapping and Response Design
	Web Cartography and Digital Mapping Principles
Design Aspects	GIS Project Workflows and Modeling
	Cloud Computing, Storage, and Retrieval
	Database Administration
	Database Management
	Enterprise System Design
	Basic Storage/Retrieval Structures and Infrastructure Scalability
	Data Organizations, Files Structures, and Workflows
	Relational Database Management Systems
	Big Data – Storage and Database Management
Data Modeling	Big Data Modeling and Analysis
	Geospatial File Types and Data Models
Geocomputation	Multi-scalar Data Sets
Geospatial Data	Linear Referencing
	UAS Data Collection
	Mobile Data Collection
Additional competencies	Metadata
	Ethical Considerations
	Data Integration
	Scripting and Automation
	Asset Management
	Machine Learning

Round 2

The Round 2 survey consisted of 76 total technical competency items. The panel reached the thresholds for consensus detailed in Chapter 3 for 41 of the 76 items. The Analysis Matrix (see Appendix J) was created to provide the panel an overview of all competency items, color-coded by category, and the determinations of desirability and practicability based on the results of Round 2. Appendix M contains the frequencies and medians of all the items. Six competency items met 100% frequency in the desirability rating, and none of the items met 100% in the frequency in the practicability rating. Only one item met 100% frequency in both ratings: Basic Analytical Operations and Methods. The six items that met 100% frequency in the desirability rating included:

- Basic Analytical Operations and Methods;
- Database Design, Modeling, and Standardization;
- Data Quality and Data Integrity;
- Map Projections;
- Georeferencing Systems; and
- Aerial Imagery and Photogrammetry.

The medians frequencies for all the competency items represented various depictions for established levels of consensus. There were 41 items that satisfied the primary measure for tendency toward consensus. There were 13 items that satisfied the secondary measure towards consensus. Of the 76 total items, 54 items met either the primary or secondary criteria. However, rather than have panelists rate these items again in a subsequent round, the Analysis Matrix was created in order to increase efficiency,

help simplify the next round, and retain study participants. This matrix provided the panel with an overview of all the competency items and how they were rated in terms of desirability and practicability. Forty-one of the items were rated both desirable and practicable, 13 items were rated desirable and impractical, and 22 items were rated undesirable and impractical based upon the primary measures of a tendency towards consensus. Table 6 consists of a summary of the 76 total items across the various depictions for establish levels for consensus. The abbreviations in the table are D=Desirability, Dm= Median of Desirability, P=Practicability, and Pm=Median of Practicability. The plus (+) and minus (-) indicate if the criterion was met (+) or not met (-) for each measure (D, Dm, P, and Pm).

Table 6

Summary of Depictions of Established Levels for Consensus

Depictions according to established levels of consensus	D+ Dm+ P+ Pm+	D+ Dm+ P- Pm+	D- Dm+ P+ Pm+	D- Dm+ P- Pm+	D+ Dm+ P- Pm-	D- Dm- P+ Pm+	D- Dm+ P- Pm-	D- Dm- P- Pm+	D- Dm- P- Pm-
Total	41	13	0	2	0	0	9	0	11

The primary measure of meeting established tendencies towards consensus for both desirability and practicability was the strictest filter used for determining consensus, and the items that passed this filter are reflected in the Analysis Matrix. This primary measure was used to ensure that the forward-looking technical competencies resulting from this study may be considered both desirable and practicable among various fields and professions in the geospatial industry. Table 7 consists of a summary of the 41 competencies that tend toward consensus using the primary measure.

Table 7

Consensus Competency Items Satisfying Frequency Measure

Technical category	Competency items from Round 2 Survey
Analytical Methods	Query Operations and Languages, Geometric Measures, Basic Analytical Operations and Methods, Data Mining, Network Analysis, Spatial Modeling and Analysis
Cartography and Visualization	Principles of Map Design, Dynamic Mapping, Core Cartographic Principles, Data Considerations, Graphic Representation Techniques, Web and Mobile Mapping and Responsive Design, Digital and Physical Map Production, Web Cartography and Digital Mapping Principles, Visual Map and Data Interpretation
Design Aspects	GIS Project Workflows and Modeling; Database Design, Modeling, and Standardization; Analysis Design; Database Administration; Database Management; Data Organization, File Structures, and Workflows; Relational Database Management Systems
Data Modeling	Vector and Object Data Models, Geospatial File Types and Data Models
Data Manipulation	Data Representation, Generalization and Aggregation, Transactional Management of Geospatial Data
Geospatial Data	Data Quality and Data Integrity, Datums, Map Projections, Land Surveying and GPS, Digitization and Vectorization, Field Data Collection and Quality, Aerial Imagery and Photogrammetry, Mobile Data Collection
Additional Competencies	Metadata, Ethical Considerations, Data Integration, Scripting and Automation, Asset Management

The competencies passing the secondary measure are listed in Table 8. They are also reflected in the Analysis Matrix as competencies that were considered desirable and impractical based on the primary measure.

Table 8

Consensus Competency Items Satisfying Median Measure

Technical category	Competency items from Round 2 Survey
Analytical Methods	Raster Analysis, Surface Analysis and Derived Data, Spatial Statistics and Geostatistics, Optimizations and Location-Allocation, Spatio-temporal Modeling and Analysis
Design Aspects	GIS&T System Design, Application Design and Evaluation, System Implementation and Data Workflows, Enterprise System Design, Basic Storage/Retrieval Structures and Infrastructure Scalability
Geospatial Data	Geodesy and Earth Geometry, Land Partitioning Systems, Linear Referencing, Satellite and Shipboard Remote Sensing, UAS Data Collection

There were 22 total competency items that did not meet the primary or secondary measures, as shown in Table 9. These items are included in the Analysis Matrix and rated as undesirable and impractical.

Table 9

Competency Items Rated Undesirable and Impractical

Technical category	Competency item(s) from Round 2 Survey
Analytical Methods	Subsurface and AGL Analyses, Spatial Regression and Econometrics, Error Modeling, Forecasting
Cartography and Visualization	Digital Integrative Mediums and Accessibility/ADA Compliance
Design Aspects	Cloud Computing, Storage, and Retrieval; Big Data – Storage and Database Management
Data Modeling	Tessellation Data Models; Multi-dimensional, Uncertain, and Temporal Data Modeling; Big Data Modeling and Analysis
Geocomputation	Emergence Computation, Computational Aspects of Geocomputing Cellular Automata (CA) Models, Heuristics, Genetic Algorithms (GA), Agent-based Models, Simulation Models, Data Uncertainty, Fuzzy Sets, Multi-scalar Data Sets
Additional Competencies	Machine Learning

For Round 2, the panelists' comments for the competency items are included in Appendix I. The survey instructions were to provide comments for those items that were rated undesirable and/or impractical. There were several panelists who included comments such as "This should be core knowledge," and "As our databases include more temporal information the importance of this will grow." These types of comments were more for support of a desirable and/or practicable rating. Additionally, there were many comments for items with ratings of undesirable and impractical. Panelists provided comments such as "Not a requirement, not typically used in our workflow/analysis tasks or projects," "Not used," "Don't know what this is,", "Out of scope with regards to maturity of organization," and "No strong use case for business analytics." For many of the items listed in Table 10, the comments seem to reflect that the items are overly

complex, no longer used/outdated, or are not typically used consistently. The 54 items that satisfied both the primary and secondary measures for a tendency towards consensus were included in the Analysis Matrix and moved forward to Round 3.

Round 3

As detailed earlier in the chapter, although Delphi studies typically consist of four or more rounds, this study combined the third and fourth rounds into one round, Round 3. Once data collection and analysis for this study began, it was determined by my committee chair and me that combining Rounds 3 and 4 would be the most efficient course of action and would help keep the attrition rate as low as possible moving from Round 2 to Round 3. Appendix L consists of the Round 3 data, including the comments provided by panelists regarding ways to improve items that were not primarily rated as both desirable and practicable, as well as the overall confidence scale for the results show in the Analysis Matrix. The ratings for the confidence scale were (a) 5 = Certain (low risk of being wrong), (b) 4 = Reliable (some risk of being wrong), (c) 3 = Neither reliable nor unreliable, (d) 2 = Risky (Substantial risk of being wrong), and (e) 1 = Uncertain (great risk of being wrong). The frequency percentages for the confidence ratings provided by the panelists were: (5) 12.5%, (4) 75%, (3) 8.3%, (2) 0%, and (1) 4.2%. The median rating was 4. Panelists were given the opportunity to provide comments for (a) changing the column for any items in the Analysis Matrix (see Appendix J), (b) ways to improve item ratings for items rated desirable and impractical so they become desirable and practicable, (c) general thoughts about items that were rated both undesirable and impractical, and (d) general thoughts about their overall confidence rating. These

comments are shown in Appendix L. The comments were evaluated and compared to the results of the Round 2 survey. The evaluation did not have any significant effects on or cause changes to the primary and secondary measures used to determine how items would be presented in the Analysis Matrix. One of the panelists commented that they would change their rating to Certain if they were able to upgrade the ratings of some items in the Analysis Matrix. Another panelist stated that "this survey needs to be grouped by industry or user roles in order to see which categories are relevant to the sector in which the might or might not be used." Another commented "the rating seems fair. Without knowing the range of GIS expertise across participants it may be hard to gauge how reliable the data is. That said the information is very telling about what [the] perceived importance of these topics [is]."

Summary

This chapter contained the results of a qualitative, modified Delphi study consisting of three rounds of data collection and analyses. The goal of the study and methodology was to answer the main research question (RQ): "How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?" There were also two subquestions: (SQ1) "How does a panel of experts in the geospatial industry view the desirability of forward-looking technical competencies of geospatial professionals? and (SQ2) "How does a panel of experts in the geospatial industry view the practicability of forward-looking technical competencies of geospatial professionals?"

Round 1 began with a survey that contained 46 technical competencies derived from the GIS&T BOK and grouped into seven categories. There were 42 total participants in Round 1 that completed the survey, and their comments resulted in 13 revised competency items and 30 new competency items. The results of Round 1 were used to develop the Round 2 survey instrument.

The Round 2 survey consisted of 76 total competency items grouped into eight categories. There were 29 completed surveys for Round 2. The data analysis resulted in 41 competencies passing the primary measure and 13 passing the secondary measure. All competency items were grouped by category and assigned one of four column ratings: (a) desirable and practicable, (b) desirable and impractical, (c) undesirable and practicable, or (d) undesirable and impractical. The Analysis Matrix (see Appendix J) was provided to the panelists in Round 3 as an overview of the Round 2 results.

The Round 3 survey contained the Analysis Matrix for the panelists to review the Round 2 results. Panelists were given the opportunity to provide comments regarding changing the rating (column) for any of the items, as well as ways to improve the impractical rating for items what were considered desirable. Round 3 also consisted of a confidence scale, where panelists were asked to provide a rating of their overall confidence in the results shown in the Analysis Matrix. Of the 24 panelists, 87.5% indicated a confidence rating of reliable or certain (a score of 4 or 5). Chapter 5 includes interpretations of findings and how they relate to the literature, limitations of the study, recommendations for further research, implications of the study, and conclusions.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this qualitative modified Delphi study was to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. Nonprobability, purposive sampling was used to constitute the expert panel, comprised of geospatial talent management and technology executives, for this study. Panelists were chosen with the use of criteria based upon a set of knowledge and experience indicators unique to the topics requiring expert opinion (see Linstone & Turoff, 2002; von der Gracht, 2008). The experts shared their views based upon a predetermined list of categories and associated technical competencies required for geospatial professionals to perform their jobs successfully. This study was conducted with the goal of contributing new knowledge to the geospatial industry regarding a consensus-based list of desirable and practicable forward-looking competencies. A review of existing literature supported the position that there is currently a lack of consensus regarding geospatial competencies.

When the knowledge about forward-looking solutions to a complex problem or phenomenon is incomplete, a Delphi design is useful (Skulmoski et al., 2007). Delphi designs are also useful for problems that cannot be precisely analyzed and would benefit from the subjective judgments of experts (Skulmoski et al., 2007) such as geospatial industry experts in this study. Hence, a qualitative modified Delph design was most appropriate for this study. The rationale for utilizing a Delphi design was to identify the opinions of an expert panel regarding the existing technical competency list, revise existing and add new competencies, and determine what, if any, consensus existed among

the panelists concerning the desirability and practicability of a final list of forward-looking competencies.

The results of this study consisted of a consensus-based list of 54 technical competencies grouped into seven categories. These categories included analytical methods, cartography and visualization, design aspects, data modeling, data manipulation, geospatial data, and new additional competencies (that were not categorized). Forty-one of the competencies passed the primary measure for consensus, and 13 passed the secondary measure. All 76 competencies from Round 2 were categorized and rated in the Analysis Matrix (see Appendix J), where the 54 consensus-based competencies were evident. Any major data reduction was unnecessary for this study because the goal was to build a comprehensive list. Ranking the competencies was not required, and both primary and secondary measures were used to determine which competencies should be included on the consensus-based list. Round 3 data results showed that 83% of the panelists had an overall confidence rating or certain or reliable. In this chapter, I present the interpretation of findings, limitations of the study, recommendations for further research, implications, and conclusions.

Interpretation of Findings

In this section, I focus on interpreting the results of the study, which comprise the consensus-based list of desirable and practicable forward-looking technical competencies of geospatial professionals. The main research question was: “How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?” In summary, the panel

started with 42 participants who completed the Round 1 survey and ended with 24 of those participants who completed through Round 3. Round 1 consisted of 46 technical competencies derived from the GIS&T BOK. Thirteen of those items were revised, and 30 new items were added. Round 2 consisted of the 76 original, revised, and additional competency items. After the Round 2 data analysis, 54 items remained. There were seven original categories, and by Round 3, one of those categories (Geocomputation) could be completely removed because none of the competency items passed the primary or secondary measures during data analysis. I discuss each technical category of competencies in this section. The remainder of the section consists of discussion of the results.

Analytical Methods

The analytical methods category consists of a total of 13 competencies. Four of those competencies did not pass the primary or secondary measures Three out of those four were additions resulting from Round 1, and one was and existing competency that panelists commented was now irrelevant and outdated. Many of the 13 remaining competencies are commonly considered core knowledge in the geospatial industry and are taught in higher education GIS programs and software-specific GIS courses (Shook et al., 2019). The original competency list used in Round 1 was derived from the GIS&T BOK and could be considered outdated, as it was released in 2006 (DiBiase et al., 2006). Considering that most of the competencies remained on the final list, the analytical methods category can be considered desirable and practicable. Although technology may change and improve over time and advance the processes of various analytical methods,

the core knowledge of those methods remains vital to geospatial professionals (Shook et al., 2019; USC University of Southern California, 2019.)

Cartography and Visualization

The final list of technical competencies consisted of nine items that passed the primary or secondary measure for consensus. Just one item did not pass, and that was an additional item suggested by a panelist regarding compliance and accessibility of digital mediums for disable persons. Most panelists thought this competency would "be nice" but that it was desirable or practicable. The remaining items consisted of an even mix of original and revised items with additional items. Although paper maps are still in use, digital maps have come to the forefront and preferred for use in geospatial applications (Adnams, 2017). That still means that cartographic principles are needed in the map design process. In the literature review, many of the original competencies in this category were agreed upon by most of the authors (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014). The new competencies added to this category are mainly focused on digital map production, mobile and web mapping applications, and web cartography.

Design Aspects

The design aspects category has 14 competencies that passed the measures for consensus and made it to the final list. These competencies are focused on topics such as database administration, design, and management; application design, GIS system design, workflows, and data organization. These competencies could be considered by many as higher level skills, or skills more applicable to an IT professional. I found in the literature

review that there was a lack of consensus regarding the importance of these types of competencies. The panelists evaluated these competencies using a forward-looking mindset and were able to come to a consensus that a majority are desirable and practicable for geospatial professionals.

Data Modeling and Data Manipulation

Only two competencies passed the required measures for consensus, and one of those was an addition. The remaining three competencies were deemed undesirable and impractical, and they included: tessellation data models; multi-dimensional, uncertain, and temporal data modeling; and big data modeling and analysis. These findings are somewhat contrary to what I found in the literature review. According to Maynard (2015) and Schwab (2016a), the fourth industrial revolution is changing how people work, live, and relate to each other, including the use of emerging technologies such as machine learning, big data, and artificial intelligence. Big data has been considered an important trend in the geospatial industry for several years (Schwab, 2016a; UN-GGIM, 2015). Tessellation data models can be considered part of the surface modeling competency, so they are no longer relevant on their own. There were three competencies in the data manipulation category, and all three remained in the final list. These were considered core knowledge by panelists, as noted in several comments provided in Round 2 (see Appendix J). However, there was a clear lack of consensus regarding these competencies in the literature review, with only two studies agreeing on their importance (DiBiase et al., 2006; Hong, 2015).

Geocomputation

In the literature review, only one study contained competencies in the geocomputation category (DiBiase et al., 2006). Geocomputation has been a tool used within GIS technology over the years, but the consensus among the panelists was that all these competencies were undesirable and impractical. Several panelists commented that these competencies are out of data and are no longer used. Banger (2010) authored an article in 2010 where he discussed how geocomputation has been replaced by broader terms such as spatial analysis and dynamic modeling in GIS, as a result of improved technologies and computing methods. Muenchow, Schratz, Bangs, and Brenning (2017) discussed the use of geocomputation in several software packages that can be used to enhance geospatial analysis, especially enhancing statistical analyses.

Geospatial Data

In the geospatial data category, 13 out of 14 competencies passed the measures for consensus. There were four revised items and three additional items added by the panel, all of which were included in the final list. The one competency that was deemed undesirable and impractical by the panel was satellite and shipboard remote sensing. In the literature review, there was consensus among three of the studies about geospatial competencies (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Solem et al., 2008). This is contrary to the findings in this study. There were a few comments about how this competency should be included in the final list during Round 3, but an evaluation of the statistics with a few responses changed in Round 2 for this item did not result in any changes to the rating given in Round 3 in the Analysis Matrix (see

Appendix J). Many recent studies have been conducted with the use of remote sensing technology and GIS (Ganasri & Ramesh, 2016; Jothibasu & Gunasekaran, 2017; Shimpi, Rokade, & Upasani, 2019) and it was also considered as trend in GIS that continues to grow in use and importance (Schwab, 2016a). There were not any meaningful comments from the panel that would help with understanding why this competency was not included in the final list. Many of the panelists considered other competencies in the category as core knowledge, as noted in the comments they provided in Round 2.

Other Additional Competencies

All the competencies in this category are new items that were added by the panelists in Round 1. They include metadata, ethical considerations, data integration, scripting and automation, asset management, and machine learning. Machine learning was the only competency that did not pass the measures for consensus for inclusion in the final competency list. Machine learning is an emerging technology that is part of defining the fourth industrial revolution (AbuMezied, 2017; Maynard, 2015) and was also considered a trend in the geospatial industry (Schwab, 2016a; UN-GGIM, 2015). Ethical considerations are not necessarily technical in nature, but the consequences of ignoring them could be severe on many levels (Apte et al., 2019). The panelists appeared to recognize this view as well and felt ethical considerations were important for geospatial professionals to understand. Metadata could tie in with ethical considerations in some cases, such as when data is misused or not credited as specified in the metadata file. Metadata is data about data, and it is important for geospatial professionals to understand the characteristics of their spatial data including its intended use, spatial extent, projection

information, use limitations, lineage, etc. (Cowen, 2016). Data integration, scripting and automation are also considered trends in the geospatial industry (Schwab, 2016a; UN-GGIM, 2015), which the panel deemed as desirable and practicable forward-looking competencies.

Summary

This section consists of the answers to the research question and two subquestions and the ways in which the findings of this study confirm, disconfirm, or extend knowledge in the discipline, as well as how the results compare the reviewed literature. The main research question was: "How does a panel of experts in the geospatial industry view the desirability and practicability of forward-looking technical competencies of geospatial professionals?" There were 54 items on the final list of technical competencies that met the primary or secondary measures of consensus. Forty-one items were categorized as desirable and practicable, as they met the primary measure of consensus, and were included in every category except geocomputation. Thirteen items were categorized as desirable and impractical. These thirteen items met the primary and secondary measures of consensus for desirability, but only the secondary measure for practicability. The 13 items consisted of competencies from the technical categories of analytical methods, design aspects, and geospatial data. Of the 54 total items, 21 were from the original competency list, 11 were revised, and 22 were new. Five of the new items were not part of the original categories and were grouped into a new category of "other," and included metadata, ethical considerations, data integration, scripting and automation, and asset management. The remaining new items consisted of competencies

from the technical categories of analytical methods, cartography and visualization, data modeling, and geospatial data.

The first subquestion was: “How does a panel of experts in the geospatial industry view the desirability of forward-looking technical competencies of geospatial professionals?” Specifically, the panelists viewed 54 out of the total 76 competencies as desirable based on both the primary and secondary measures. These 54 competencies consisted of 21 original, 11 revised, and 22 new items in every technical category except geocomputation. The second subquestion was: “How does a panel of experts in the geospatial industry view the practicability of forward-looking technical competencies of geospatial professionals?” Specifically, the panelists viewed 41 out of the 76 competencies as practicable based on the primary measure, and 13 more based on the secondary measure. The 41 competencies based on the primary measure consisted of 18 original, six revised, and 17 new items. The additional 13 items based on the secondary measure consisted of three original, five revised, and five new items in the categories of analytical methods, design aspects, and geospatial data.

A comparison of the resulting competency list of this study to the technical competencies and their associated citations in Appendix B resulted in 24 competencies (original and revised) on both lists, with agreement among at least three of the five previous competency model studies as discussed in the literature review (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014). These 24 competencies were included in the technical categories of analytical methods, cartography and visualization, data modeling, data manipulation,

and geospatial data. Fourteen of those 46 competencies in Appendix B were not included in the final list in the Analysis Matrix (see Appendix J), including all nine competencies in the geocomputation category. The remaining eight competencies in Appendix B that were included in the Analysis Matrix only shared one or two competency model study citations as discussed in the literature review (DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014). These items included competencies in the categories of data manipulation, analytical methods, and data modeling. Hence, there were 32 competencies (original or revised) from Appendix B and 22 new additional competencies that were included in the results of this study. Of the 22 new competencies, five were related to Hong's study (2015), and four were related to some of the future trends in the industry discussed in the literature review (Schwab, 2016a; UN-GGIM, 2015). The competencies related to Hong's (2015) study included raster analysis, metadata, scripting and automation, web cartography and digital mapping principles, and application design and evaluation. The competencies related to the discussion of Schwab (2016a) and UN-GGIM (2015) included web and mobile mapping and responsive design; spatial modeling and analysis; asset management; and cloud computing, storage and retrieval.

The results of this study could extend the knowledge in geospatial talent management. The final list of desirable and practicable technical competencies confirmed that approximately 69% of the items from the GIS&T BOK list are still relevant in every category except geocomputation, more than a decade after they were published. The results also disconfirmed the relevance of approximately 31% of the competencies from the GI&T BOK list in the categories of geocomputation, data modeling, and analytical

methods, which may be attributed to recent technological advancements and changes in the geospatial industry. The resulting competency list from this study included 22 new technical competencies that consisted of items related to recent changes in geospatial technology, as well as future trends, as identified in the Analysis Matrix.

Limitations of the Study

Limitations are defined as restrictions on the study that cannot be reasonably dismissed; they may be considered potential weaknesses in the study that are out of the researcher's control due to factors such as limited funding and statistical model constraints (Marshall & Rossman, 2016). One limitation of this study was the anonymity and accountability upon which the study was structured. There was a possibility that the anonymous nature of the study may have resulted in a lack of accountability, which could have impacted the progress of the study (Vernon, 2009). If panel members did not take the study seriously, the accuracy and rigor of their responses may have been affected (see Vernon, 2009). The study was also limited by any unverified self-reported expertise of the panelists, as well as any bias they may have held. A weakness of this study is that I did not confirm that panelists were honest about their qualifications when they self-selected to participate. I believed that panelists were truthful and did not have resources to complete background checks for each panelist.

Another limitation to consider is that due to anonymity, there was not any face-to-face communication between the panel members, resulting in a lack of potential debate. Because the participant portion of the study was conducted online, there was no opportunity for expert interactions. The lack of debate may have concealed reasons for

conflicting expert responses (Vernon, 2009). The study was also limited to the willingness of panelists to share their explanations for ratings and the quality of those explanations.

There were limitations concerning the qualitative Delphi design as well. Panelists could have been biased and working toward personal agendas or could have had subjective opinions. There were many items in the first and second rounds of data collection, and participants could have felt the survey was a burden and did not give their best effort when completing the survey. However, when evaluating the amount of time panelists spent through each round of survey and the comments that were provided, it is likely that a majority did not feel burdened.

Recommendations

Alternative Methodologies

This study focused on the opinions of an expert panel that met specific criteria but may also have had very different backgrounds and professional experience. Geospatial technology is used across numerous fields, and professionals in each field apply the technology in their own way. An opportunity for further research may be to conduct a study like this one in different career fields. This study could be mimicked across fields such as transportation, real estate, environment, planning, infrastructure, engineering, among others. Each field would likely result in specialized competency lists. There would likely be similarities among them, but there would also be clear differences that are specific to how geospatial technology is used in each field. Comparing the similarities

would yield a universal list of core technical competencies across many fields in the geospatial industry.

A follow-up Delphi study like this current study could be an option for future research as well. The resulting list from the study could be used a starting point for the Round 1 survey in a future Delphi study. The criteria for panel selection could be adjusted as well. I recommend that a study like this one be conducted every few years in order to maintain a current competency list that reflects trends in the industry. The list could be used to enhance technical exam development, assist academia in developing relevant curricula in geospatial education programs, and provide organizations with a resource to help them hire qualified candidates for geospatial-related positions.

There is the option of a generic qualitative study for further research. Further research could include an evaluation of the content of geospatial core technical exams as well as certification exams. Comparisons of these types of exams could yield additional competencies and provide further insight to what competencies are most important to various geospatial professional organizations and software companies. Hong's (2015) studied could also be expanded to evaluate larger numbers of geospatial job postings to help gauge what competencies are most relevant in geospatial organizations. However, in order to consider future trends and how they will affect desirable competencies, I recommend a Delphi study like this one. An expert panel would be able to evaluate current and future trends and provide input regarding future competency needs in the geospatial industry.

There is an option for exploratory case studies to provide supplemental research to this topic. Researchers could conduct case studies in geospatial organizations as well as academia in order to better discern how each views the importance of geospatial competencies. There seems to be a disconnect between them, and this type of research could improve collaboration. Researchers could also focus on collecting data from geospatial organizations related to their talent management by looking at their job descriptions, current employee resumes, and job postings. Additionally, I believe there is an opportunity to mimic this research methodology to determine the more desirable and practicable forward-looking non-technical skills of geospatial professionals. Research exists for soft skills in general, but there is room to add to the existing literature specific to the geospatial industry. These non-technical skills might include creativity, innovation, cross functional tea building, self-motivation, problem solving, etc.

Desirable and Impractical Technical Competencies

There were 13 competencies in the final list that passed the secondary measure for consensus with a median score of 3.5 or more in both desirability and practicability, but only passed the primary measure for desirability. While these were still included in the final competency list, there may be opportunities to improve how these competencies would be rated by a panel in the future. Panelists were asked to provide suggestions regarding how the practicability ratings might be improved. Comments included: “greater collaboration with computer sciences to develop more accessible tools for the geosciences,” “these are basic concepts that all GIS analy[sts] should have a grasp of – again send your technicians to a class,” “providing better examples of these tasks,” and,

A category will get scored lower because people are not familiar with its use related to their job. It seems that you need a category related to industry or job title/area/department of work in order to group or identify the trends or patterns that may exist in this research.

As I discussed in the previous section, this research could be conducted over various career fields related to GIS in order to compare and determine the common core technical competencies. GIS knowledge has evolved from a specific job skill to a tool that is used to enhance countless other types of jobs and duties. I agree with the panel that the ratings could be improved with more specific examples provided to the panel as well. The panel was given access to the GIS&T BOK as a resource for clarification of competencies, but examples may have also been helpful to them. I also agree with the panelist who said that some of these competencies should be core knowledge. Perhaps there is an opportunity here for organizations and academia to collaborate and ensure students are learning the most important skills to be able to enter the geospatial workforce as prepared for current and future industry needs as possible. In any case, I would recommend that technical competencies for geospatial professionals be evaluated over a specified interval, perhaps every five years as an example. This will help ensure the list stays current, relevant, and forward-looking.

Implications

Positive Social Change Implications

The results of this study may contribute to positive social change in a variety of ways. The technical competencies identified in this study may impact government

policies and strategies that can help preserve national security and promote economic growth and global diplomacy through more informed decision making. Failure to update geospatial technical competencies could have an adverse impact on promoting social change, should there be an increase in the technological obsolescence of the nation's security infrastructure and, ultimately, diminished national power (Kadtke & Wells, 2014). The potential for improved collaboration between organization talent managers and academia could have implications for positive social change. Geospatial graduates would be better prepared for the workforce and could possibly find jobs faster, reducing unemployment numbers. Organizations could benefit by having a qualified pool of talent that may require less training on the job, helping organizations save money, hence stimulating the economy.

Another implication of this study is that its outcomes may assist organizations not only with hiring strategies, but also training and reskilling programs for current employees. Such initiatives could have positive effects on employee satisfaction and retention rates and could help strengthen the competitiveness in the job market and could also reduce costs for employee replacement and new hire training (Alias, Roni, Merga, & Ismail, 2017; Iqbal, Guohao, & Akhtar, 2017;). Job satisfaction is a huge implication for positive social change at the individual level. There are countless seasoned geospatial professionals who want to remain in the industry, and training and reskilling programs could be an effective strategy to improve retention, satisfaction, and performance.

Methodological and Theoretical Implications

Although the dynamics and complexities of global markets in the fourth industrial revolution are largely unknown, it has become increasingly clear since 2010 that the preparation of a comprehensive and integrated response to rapid technological change is underway by public and private sector organizations such as academia, governments, and society (Schwab, 2016a). The geospatial industry is no exception, as GIS technology is essential for national security and informed decision making among many types of organizations (Foster & Mayfield, 2016; Salkin, 2005). Geospatial professionals provide the tools, technologies, and services to support informed decision making by organizational leaders based on geographic data (Boston Consulting Group, 2012). As high rates of geospatial job growth, upwards of 29%, are expected through 2024 (U.S. Department of Labor, 2014), talent managers are questioning the competencies needed by new hires as well as existing employees to be successfully prepared and reskilled for the digital transformation of the workplace (Wikle & Fagin, 2014). Without identifying future competency needs, organizations will not be ready to develop reskilling plans for the geospatial workforce (Meier, 2016; Schwab, 2016a).

This study was conducted to develop a consensus-based list of desirable and practicable forward-looking competencies of geospatial professionals. The resulting competency list from this study can be utilized by talent managers to develop reskilling and training programs for existing employees and help determine the appropriate qualifications desired of new hires. The Delphi design of this study helped to narrow the gap in the literature by providing scholars and practitioners with a consensus-based list of

technical competencies grouped into seven broader categories. The methodology could also be implemented for future updates to the research, or to other areas of study where the focus is to work toward a consensus.

The findings of this study reinforce that there has been a lack of consensus regarding the importance of geospatial competencies evident in the literature. The study's findings supported the conceptual framework for evaluating the existing competencies and adding new items to a technical competency list. Systems theory can be applied to understanding the convergence of various emerging technologies, as well as to how geospatial organizations, viewed as management systems, should respond to rapid industry changes and address the resulting skills gaps. The concept of systems thinking, combined with the concept of talent management, was an applicable approach to this study. Systems thinking was applicable to change management for organizations overall, and talent management was applicable to individual talent management and competency development. The implications for training and reskilling strategies and opportunities tie into talent management and systems theories. Another implication of the findings from this study is that a practitioner's knowledge and experience are vital in enhancing the literature because the expert panelists were able to suggest new competencies that passed the established levels of consensus.

Recommendations for Practice

A lack of consensus is evident in the industry regarding the desired geospatial technical competencies of organizations (Cann, 2016; DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Maynard, 2015; Plessis & van

Nierkerk, 2013; Schwab, 2016a; Solem et al., 2008; Veenendaal, 2014), as well as a lack of studies regarding the forecast of competency needs for the future (Meier, 2016; Schwab, 2016a). There is a gap in the literature regarding what kind of forward-looking geospatial technical competencies should be included on the list (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014). Future trends in the industry were discussed by scholars and practitioners, but there are no current studies that take into consideration future trends when defining additional geospatial technical competencies (DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Meier, 2016; Schwab, 2016a; Solem et al., 2008; Wikle & Fagin, 2014). In this study, I aimed to close some of these gaps in the literature and develop a forward-looking desirable and practicable technical competency list for geospatial professionals.

I recommend that geospatial talent managers utilize this list to evaluate current employees' skills and develop strategies for reskilling and training as needed in order to retain their current workforce and better prepare for technological advancements. I also recommend talent managers use this list to help draft job postings and filter resumes for potential new hires. This methodology can be used on a recurring basis to help maintain a relevant competency list as well. Organizations and academia should consider improving collaboration in order to better prepare new hires for the geospatial workforce. The results of this study could be used as resource for collaboration and strategy development between geospatial organizations and academia as well.

Conclusions

The lack of consensus regarding forward-looking desirable and practicable technical competencies in the geospatial industry is creating the potential for talent managers in geospatial organizations to lose good employees because of lost opportunities for training and reskilling. In the wake of the fourth industrial revolution, the convergence of emerging technologies and the resulting rapid changes are outpacing the ability of geospatial industry leaders to maintain a properly skilled workforce. Without identifying future competency needs, organizations will not be ready to develop reskilling and training plans for geospatial employees and new hires. The purpose of this study was to determine how a nationwide panel of experts in the geospatial industry viewed the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts shared their views based upon a predetermined list of categories and associated technical skills and knowledge required for geospatial professionals to perform their jobs successfully.

The expert panel revised 15 of the existing competencies and added 30 new ones in the early stages of data collection and analysis. The original list consisted of 46 technical competencies, and the final list consisted of 54 competencies, 20 of which were entirely new. The methodology employed in this study was successful in evaluating the opinions of experts regarding an outdated set of competencies and allowing them to provide suggestions of new, forward-looking and relevant competencies. The findings of the study can be used to help organizations better prepare its workforce for the rapid changes resulting from the fourth industrial revolution. The methodology used in this

study can also be utilized by other industries to evaluate and update their own competency lists.

References

AbuMezied, A. (2017). What role will education play in the fourth industrial revolution? *World Economic Forum*. Retrieved from https://www.weforum.org/agenda/2016/01/what-role-will-education-play-in-the-fourth-industrial-revolution/

Ackoff, R. L. (1962). *Scientific method: Optimizing applied research decisions.* New York, NY: John Wiley & Sons.

Ackoff, R. L. (2004). Transforming the systems movement. *The Systems Thinker, 15*(8), 2–5. Retrieved from https://thesystemsthinker.com/wp-content/uploads/pdfs

Adnams, W. (2017). *Digital maps vs. paper maps*. Retrieved from https://www.lovelljohns.com

Ahearn, S. C., Iker, I., Datta, R., DeMers, M. N., Plewe, B., & Skupin, A. (2013). Re-engineering the GIS&T Body of Knowledge. *International Journal of Geographic Science, 27*(11). doi:10.1080/13658816.2013.802324

Albrecht, J. (2015). Towards a theory of GIS project management. In W. Juhn & W. Onsrud (Eds.), *Advancing geographic information science: The past and the next 20 years*. Needham, MA: GSDI Association Press. Retrieved from https://academicworks.cuny.edu

Alias, N. E., Mat Roni, S., Merga, M. K., & Ismail, I. (2017). Rethinking of talent management practices as an employee retention strategy in emerging economy. In *The proceedings of 2nd Business Doctoral and Emerging Scholars Conference,*

At ECU Joondalup Campus Perth, Australia (pp. 144-151). Retrieved from https://www.researchgate.net

Apte, A., Ingole, V., Lele, P., Marsh, A., Bhattacharjee, T., Hirve, S., ... & Juvekar, S. (2019). Ethical considerations in the use of GPS-based movement tracking in health research–lessons from a care-seeking study in rural west India. *Journal of Global Health*, *9*(1), 1-7. doi: 10.7189/jogh.09.010323

Ariss, A. A., Cascio, W. F., & Paauwe, J. (2013). Talent management: Current theories and future research directions. *Journal of World Business*, *49*, 173–179. doi:10.1016/jwb.2013.11.001

Artz, M. (2009). Top five benefits of GIS. *GIS and Science.* Retrieved from http://gisandscience.com

Atzori, L., Iera, A., & Morabito, G. (2017). Understanding the internet of things: Definition, potentials, and societal role of a fast evolving paradigm. *Ad Hoc Networks*, *56*, 122–140. doi: 10.1016/j.adhoc.2016.12.004

Avella, J. R. (2016). Delphi panels: Research design, procedures, advantages, and challenges. *International Journal of Doctoral Studies, 11*, 305–321. Retrieved from http://www.informingscience.org

Bardecki, M. J. (1984). Participants' response to the Delphi method: An attitudinal perspective. *Technological Forecasting and Social Change, 25*(3), 281–292. doi:10.1016/0040-1625(84)90006-4

Belmont Report. (1979). *The Belmont Report: Ethical principles and guidelines for the protection of human subjects of research*. Office of Human Research Protections,

U.S. Department of Health & Human Services. Retrieved from http://www.hhs.gov

Berger, T., & Frey, C. B. (2016). Digitalization, jobs and convergence in Europe: Strategies for closing the skills gap. *Brüssel: Bericht im Auftrag der Europäischen Kommission.* Retrieved from https://www.oxfordmartin.ox.ac.uk

Boston Consulting Group. (2012). *Putting the U.S. geospatial services industry on the map*. Retrieved from http://www.ncge.org/files/documents/US-FullReport.pdf

Brady, S. R. (2015). Utilizing and adapting the Delphi method for use in qualitative research. *International Journal of Qualitative Methods, 14*(5), 1–6. doi:10.1177/1609406915621381

Cann, O. (2016). Five million jobs by 2020: The real challenge of the fourth industrial revolution. *World Economic Forum.* Retrieved from https://www.weforum.org/press

Cao, W., Cai, J., & Chang, C. (2019). Scale development for competencies among medical teachers on undergraduate education: A Delphi study from a top Chinese university. *Innovations in Education and Teaching International*, 1–11. doi: 10.1080/14703297.2019.1569545

Chrisman, N. R. (1999). What does GIS mean? *Transactions in GIS, 3*(2), 175–186. doi:10.111/1467-9671.00014

Chung, M., & Kim, J. (2016). The Internet information and technology research directions based on the fourth industrial revolution. *KSII Transactions on Internet and Information Systems, 10*(3), 1311–1320. doi:10.3837/tiis.2016.03.020

Claussen, J., Grohsjean, T., Luger, J., & Probst, G. (2014). Talent management and career development: What it takes to get promoted. *Journal of World Business, 49*, 236–244. doi:10.2139/ssrn.2326262

Collings, D. G., & Mellahi, K. (2009). Strategic talent management: A review and research agenda. *Human Resource Management Review, 19*(4), 304–313. doi:10.1016/j.hrmr.2009.04.001

Cotton, B. (2013). *Examining certification in project management.* Unpublished manuscript. Retrieved from https://funnelfiasco.com

Cowen, D. J. (2016). Geospatial Metadata. *International Encyclopedia of Geography: People, the Earth, Environment and Technology: People, the Earth, Environment and Technology*, 1-6. doi: 10.1002/9781118786352.wbieg0405

Cox, M., Elen, J., & Steegen, A. (2018). A test to measure students' systems thinking abilities in geography. *European Journal of Geography, 9*(1), 105–120.

Craig, T. R., & Wikle, T. A. (2016). Perceptions and practices: Employers, educators, and students on GIS internships. *Transactions in GIS*, *20*(6), 948–961. doi:10.1111/this.12201

Custer, R. L. S., Joseph A., Stewart, B. R. (1999). The modified Delphi technique: A rotational modification. *Journal of Vocational and Technical Education, 15*(2), 50–58. doi:10.21061/jcte.v15i2.702

Day, J., & Bobeva, M. (2005). A generic toolkit for the successful management of Delphi studies. *EJBRM, 3*(2), 103–116. Retrieved from http://citeseerx.ist.psu.edu

Decieux, J. P. P., Mergener, A., Sischka, P., & Neufang, K. (2015). Implementation of the forced answering option within online surveys: Do higher item response rates come at the expense of participation and answer quality? *Psihologija, 48*(4), 311–326. doi:10.2298/PSI1504311D

Deery, M., & Jago, L. (2015). Revisiting talent management, work-life balance and retention strategies. *International Journal of Contemporary Hospitality Management, 27*(3), 453–472. doi:10.1108/IJCHM-12-201-0538

DiBiase, D. (2012). Strengthening the GIS profession. *ArcNews, Summer 2012.* Retrieved from http://www.esri.com/

DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A. T., Plewe B., & Wentz, E. (2006). Geographic information science and technology body of knowledge. *Association of American Geographers*. doi:10.22224.gistbok

Diefenbach, M. A., Weinstein, N. D., & O'Reilly, J. (1993). Scales for assessing perceptions of health hazard susceptibility. *Health Education Research, 8*(2), 181–192. doi 10.1093/her/8.2.181

Directions Magazine. (2018) *The 2018 GTDM update: Significance and impact*. Retrieved from https://www.directionsmagazine.com

Dymon, U. J. (2016). *Professional training as a factor in the proliferation of GIS applications.* Retrieved from ProQuest.

Elo, S. (2014). Qualitative content analysis: A focus on trustworthiness. *Sage Open*, 1–10. https://doi.org/10.1177/2158244014522633

Esri. (2019). *What is GIS?* Retrieved from https://www.esri.com

Fagin, T., & Wikle, T. (2011). The instructor element of GIS instruction and U.S. colleges and universities. *Transactions in GIS, 15*(1), 1–15. doi:10.1111/j.1467-9671.2010.01238.x

Festing, M., & Schafer, L. (2014). Generational challenges to talent management: A framework for talent retention based on the psychological-contract perspective. *Journal of World Business, 49*, 262–271. doi:10.1016/j.jwb.2013.11.010

Fletcher, A. J., & Marchildon, G. P. (2014). Using the Delphi method for qualitative, participatory action research in health leadership. *International Journal of Qualitative Methods, 13*(1), 1–18. doi:10.1177/160940691401300101

Foster, D., & Mayfield, C. (2016). Geospatial resource integration in support of homeland defense and security. *International Journal of Applied Geospatial Research, 7*(4). doi:10.4018/IJAGR.201600105

Ganasri, B. P., & Ramesh, H. (2016). Assessment of soil erosion by RUSLE model using remote sensing and GIS-A case study of Nethravathi Basin. *Geoscience Frontiers, 7*(6), 953-961. doi: 0.1016/j.gsf.2015.10.007

Gaudet, C. H., Annulis, H. M., & Carr, J. C. (2003). Building the geospatial workforce. *URISA Journal, 15*(1), 21–30. Retrieved from http://citeseerx.ist.psu.edu

Geissbauer, R., Vedso, J., & Schrauf, S. (2016). A strategist's guide to industry 4.0. *Strategy and Business.* Retrieved from https://www.strategy-business.com

Gevers, D. W. M., Kremers, S. P. J., De Vries, N. K., & Van Assema, P. (2014). Clarifying concepts of food parenting practices. A Delphi study with an

application to snacking behavior. *Appetite*, *79*, 51–57. doi:10.1016/j.appet.2014.04.002

Habibi, A., Sarafrazi, A., & Izadyar, S. (2014). Delphi technique theoretical framework in qualitative research. *The International Journal of Engineering and Science, 3*(4), 8–13. Retrieved from http://files.figshare.com

Hasson, F., & Keeney, S. (2011). Enhancing rigour in the Delphi technique research. *Technological Forecasting and Social Change*, *78*(9), 1695–1704. doi:10.1016/j.techfore.2011.04.005

Hasson, F., Keeney, S., & McKenna, H. (2000). Research guidelines for the Delphi survey technique. *Journal of Advanced Nursing*, *32*, 1008–1015. doi:10.1046/j.1365-2648.2000.01567.x

Heitner, K. L., Kahn, A. E., & Sherman, K. C. (2013). Building consensus on defining success of diversity work in organizations. *Consulting Psychology Journal: Practice and Research*, *65*(1), 58–73. Retrieved from http://doi.org/10.1037/a0032593

Hoffmann, T. (1999). The meanings of competency. *Journal of European Industrial Training*, *23*(6), 275–286. doi:10.1108/03090599910284650

Hong, J. E. (2015). Identifying skill requirements for GIS positions: A content analysis of job advertisements. *Journal of Geography, 00*, 1–12. doi:10.1080.00221341.2015.1085588

Houghton, C., Casey, D., Shaw, D., & Murphy, K. (2013). Rigour in qualitative case-study research. *Nurse Researcher, 20*(4), 12–17. Retrieved from

www.nurseresearcher.co.uk

Hsu, C., & Sanford, B. A. (2007). Minimizing non-response in the Delphi process: How to respond to non-response. *Practical Assessment, Research & Evaluation*, 12*(17).* Retrieved from https://pareonline.net

Hughes, P. G., Atkinson, S. S., Brown, M. F., Jenkins, M. R., & Ahmed, R. A. (2018). Evaluation of technical competency in healthcare simulation (E-TeCHS) tool: A modified Delphi study. *BMJ Simulation and Technology Enhanced Learning*, 6(1), 15-21. doi: 10.1136/bmjstel-2018-000391

Hyunh, N. T., & Hall, G. B. (2019). Navigating employment prospects for new graduates in the geospatial sciences. In S. Balram & J. Boxall (Eds.), *GIScience teaching and learning perspectives: Advances in geographic information science* (pp. 145–169). Switzerland: Springer International.

Iqbal, S., Guohao, L., & Akhtar, S. (2017). Effects of job organizational culture, benefits, salary on job satisfaction ultimately affecting employee retention. *Review of Publication and Administration Management*, *5*(229), 2. doi: 10.4172/2315-7844.1000229

Jekel, T., Car, A., Strobl, J, & Griesebner, G. (Eds.; 2012). *GI Forum 2012: Geovisualization, Society, and Learning.* Berlin, Germany: Herbert Wichmann Verlag.

Jiang, B. (2015). Geospatial analysis requires a different way of thinking: The problem of spatial heterogeneity. *GeoJournal*, *80*(1), 1–13. doi: 10.1007/s10708-014-9537-y

Jo, I. (2018). Spatial thinking in secondary geography: A summary of research findings and recommendations for future research. *Boletim Paulista de Geografia, 99,* 200–212. Retrieved form https://pdfs.semanticscholar.org

Johnson A. (2019). Quest to define the knowledge and skills needed by geospatial professionals. In K. Koutsopoulos, R. de Miguel González, & K. Donert (Eds). *Geospatial challenges in the 21st century: Key challenges in geography* (pp. 271–288). (EUROGEO Book Series). Cham, Switzerland: Springer.

Johnson, C., & Traynor, A. P. (2018). Identifying student learning competencies for urban underserved practice using a Delphi process. *Currents in Pharmacy Teaching and Learning, 10*(6), 687–694. doi: 10.1016/j.cptl.2018.03.007

Jothibasu, A., Venkatesan, A., & Gunasekaran, S. (2017). Potential groundwater accumulations assessment in drought prone area using remote sensing and GIS technology. *International Journal of Advanced Remote Sensing and GIS, 6*(3), 2080-2087. doi: 10.23953/cloud.ijarsg.70

Kadtke, J., & Wells, L., II. (2014, Sep.). Policy challenges of accelerating technological change: Security policy and strategy implications of parallel scientific revolution. *Center for Technology and National Security Policy (CTNSP) National Defense University (NDU).* Retrieved from http://ctnsp.dodlive.mil

Karacay, G. (2018). Talent development for industry 4.0. In *Industry 4.0: Managing the digital transformation* (pp. 23–136). Switzerland: Springer International. doi:10.1007/978-3-19-57870_7

Kitana, A. (2016). Overview of the managerial thoughts and theories from the history: Classical management theory to modern management theory. *Indian Journal of Management Science*, *6*(1), 16. Retrieved from https://www.researchgate.net

Kumar, M. (2015). Defining the geospatial industry. *Geospatial World.* Retrieved from https://www.geospatialworld.net

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry*. Newbury Park, CA: SAGE.

Linstone, H. A., & Turoff, M. (2002). *The Delphi method: Techniques and applications.* Reading, MA: Addison-Wesley.

Ludwig, B. (1997). Predicting the future: Have you considered using the Delphi methodology? *Journal of Extension, 35*(5), 1–4. Retrieved from http://www.joe.org

Lukinbeal, C., & Monk, J. J. (2015). Master's in geographic information systems programs in the United States: Professional education in GIS and geography. *The Professional Geographer, 67*(3), 482–489. doi:10.1080/00330124.2014.983630

Malhotra, R., Kantor, C., & Vlahovic, G. (2018). Geospatial workforce development in a changing world: An HBCU focus. *Southeastern Geographer, 58*(1), 125–135. doi:10.1353/go.2018.0008

Marshall, C., & Rossman, G. B. (2016). *Designing qualitative research* (6th ed.). Thousand Oaks, CA: Sage.

Masko, M. L., Eckert, C. M., Caldwell, N. H., & Clarkson, P. J. (2011). Designing for resilience: Using a Delphi study to identify resilience issues for hospital designs in a changing climate. In *DS 68-5: Proceedings of the 18th International*

Conference on Engineering Design (ICED 11), Impacting Society through Engineering Design, Vol. 5: Design for X/Design to X, Lyngby/Copenhagen, Denmark, August 15-19, 2011. Retrieved from https://www.designsociety.org

Mathews, A., & Wikle, T. (2016). Assessing professional benefits of GIS certification. *Cartography and Geographic Information Science, 44*(5), 452–462. doi:10.1080/15230406.2016.1185742

Maynard, A. D. (2015). Navigating the fourth industrial revolution. *Nature Nanotechnology, 10*, 1005–1006. doi:10.1038/nnano.2015.286

Meadows, D. H. (2008). *Thinking in systems: A primer.* White River Junction, VT: Chelsea Green.

Meier, P. (2016). A 10-year vision: Future trends in geospatial information management. *iRevolutions*. Retrieved from https://irevolutions.org

Mele, C., Pels, J., & Polese, F. (2017). A brief review of systems theories and their management applications. *Service Science, 2*(1/2), 126–135. doi:10.1287/serv.2.1_2.126

Miner, J. B. (1973). Management consulting firm as a source of high-level managerial talent. *Academy of Management Journal, 16*(2), 253–264. doi:10.2307/255326

Mirzoev, T., Moore, A., Pryzbysz: B., Taylor, B., & Centeno, J. (2015). GIS as a job growth area for IT professionals. *World of Computer Science and Information Technology Journal (WCSIT), 5*(6), 98–111. Retrieved from http://www.wcsit.org

Muenchow, J., Schratz, P., Bangs, D., & Brenning, A. (2017). *Integrating R with GIS for innovative geocomputing – The examples of RQGIS and RSAGA.* Retrieved from https://ui.adsabs.harvard.edu

Mulaku, G. (2013). Professionalism in GIS: International aspects of the certification debate. *Journal of Geographic Information Systems, 5*, 347–353. doi:10.4236/jgis.2013.54033

Niezgoda, S., Wilcock, P., Baker, D., Mueller, J., Castro, J., Curran, J., . . . Shelds, F. (2014). Defining a stream restoration body of knowledge as a basis for national certification. *Journal of Hydraulic Engineering*, 123–136. doi:10.1061/(ASCE)HY.1943-7900.0000814

Obermeyer, N., & Somers, R. (2014). *GIS professional certification 2.0: Putting GIS to the test.* Retrieved from https://docs.lib.purdue.edu

Oeldenberger, S., & Khaled, K. B. (2012). The African geospatial services sciences institute (AGSI): A new approach to geospatial training in North Africa. *International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, 39*(B6), 45–51. doi 10.5194/isprsarchives-xxxix-b6-45-2012

Orlikowksi, C., & Lozinak, A. (2016). Skilled talent: It's at your fingertips. *Manpower Group.* Retrieved from http://www.manpowergroup.com

Park, H. A. (2016). Are we ready for the fourth industrial revolution? *IMIA Yearbook of Medical Informatics, 1,* 1–3. doi:10.15265/IY-2016-052

Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Thousand

Oaks, CA: Sage.

Pendyala, V., & Vijayan, D. (2018). Developing training programs in remote sensing and geospatial applications. *ISPRS Annals of the Photogrammetry, Remote Sensing, and Spatial Information Sciences, 4*(5), 1–6. doi: 10.5194/isprs-annals-iv-5-1-2018

Plessis, H., & van Nierkerk, A. (2013). A comparison of geographical information science competency requirements. *South African Journal of Geomatics, 2*(3), 206–217. Retrieved from https://www.researchgate.net

Rich, P. (1992). The organizational taxonomy: Definition and design. *Academy of Management Review, 17*(4), 758–781. Retrieved from https://www.researchgate.net

Ricker, B., & Thatcher, J. (2017). Evolving technology and shifting expectations: Cultivating pedagogy for a rapidly changing GIS landscape. *Journal of Geography in Higher Education, 41*(3), 368–382. doi:10.1080/03098265.2017.1315533

Rip, F. (2008). GIS&T body of knowledge: Basis for e-learning, certification, and curriculum planning? *11th AGILE International Conference on Geographic Information Science 2008.* Retrieved from https://agile-online.org

Roiste, M. (2014). Filling the gap: The geospatial skills shortage in New Zealand. *New Zealand Geographer*, *70*(3), 1793–189. doi 10.1111/nzg.12054

Rooney, P., Kneale, P., Gambibi, B., Keiffer, A., Vandrasek, B., & Gedye, S. (2006). Variations in international understandings of employability for geography.

Journal of Geography in Higher Education 30, 133–145. doi 10.1080/03098260500499766

Salkin, P. E. (2005). GIS in the age of homeland security: Accessing public information to ensure a sustainable environment. *William and Mary Environmental Law and Policy Review, 30*(1), 55–94. doi:10.1080/03098260500499766

Schwab, K. (2016a). The future of jobs: Employment, skills, and workforce strategy for the fourth industrial revolution. *World Economic Forum*. Retrieved from http://www3.weforum.org

Schwab, K. (2016b). The human capital report. *World Economic Forum*. Retrieved from http://reports.weforum.org

Senge, P. M. (2006). *The fifth discipline: The art & practice of learning organizations.* New York, NY: Doubleday.

Shimpi, S., Rokade, V. M., & Upasani, K. (2019). Application of Remote Sensing and GIS for Groundwater Potential Zonation: A Case Study of Bori-Chikli Watershed, Maharashtra, India. *Bulletin of Pure & Applied Sciences-Geology*, (1). Retrieved from https://www.researchgate.net

Shook, E., Bowlick, F. J., Kemp, K. K., Ahlqvist, O., Carbajeles-Dale, P., DiBiase, D., … Wang, S. (2019). Cyber literacy for GIScience: Toward formalizing geospatial computing education. *The Professional Geographer, 71*(2), 221-238. doi: 10.1080/00330124.2018.1518720

Simon, M. K., & Goes, J. (2013). *Assumptions, limitations, delimitations, and scope of the study*. Retrieved from http://www.dissertationrecipes.com

Skulmoski, G. J., Hartman, F. T., & Krahn, J. (2007). The Delphi method for graduate research. *Journal of Information Technology Education, 6*, 1–21. doi:10.28945/199.

Solem, M., Cheung, I., & Schlemper, M. B. (2008). Skills in professional geography: An assessment of workforce needs and expectations. *The Professional Geographer, 60*(3), 356–373. doi:10.1080/00301208020136 20

Tognetto, A., Michelazzo, M. B., Ricciardi, W., Federici, A., & Boccia, S. (2019). Core competencies in genetics for healthcare professionals: Results from a literature review and a Delphi method. *BMC Medical Education, 19*(1), 1-10. doi: 10.1186/s12909-019-1456-7

Trevelyan, E. G., & Robinson, N. (2015). Delphi methodology in health research: How to do it? *European Journal of Integrative Medicine*, *7*(4), 423–428. doi:10.1016/j.eujim.2015.07.002

UCGIS. (2017). *GIS&T body of knowledge*. Retrieved from http://www.ucgis.org

Ulrich. (2018). *Ulrichsweb: Global serials directory.* Serials solutions. Retrieved from http://ulrichsweb.serialssolutions.com

United Nations Global Geospatial Information Management. (UN-GGIM, 2015). *Future trends in geospatial information management: The five to ten year vision.* Retrieved from http://ggim.un.org

Unwin, D., Tate, N., Foote, K., & DiBiase, D. (2011). *Teaching geographic information science and technology in higher education.* Hoboken, NJ: John Wiley & Sons.

Uprichard, E. (2013). Sampling: Bridging probability and non-probability designs.

International Journal of Social Research Methodology, 16(1), 1–11. doi:10.1080/13645579.2011.633391

USC University of Southern California. (2019). *Top GIS technologies in 2020 and beyond.* Retrieved from: https://gis.usc.edu

U.S. Department of Labor, Bureau of Labor Statistics. (2014). *Occupational outlook handbook.* Retrieved from https://www.bls.gov

Veenendaal, B. (2014). Addressing the challenges of a quarter century of GIScience education: A flexible higher education curriculum framework. *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL*(6), 107–112. doi:10.3726/978-3-653-04632-8/20

Vernon, W. (2009). The Delphi technique: A review. *International Journal of Therapy and Rehabilitation, 16*(2), 69–76. doi:10.12968/ijtr.2009.16.2.38892

von Bertalanffy, L. (1969). *General system theory: Essays on its foundation and development.* New York, NY: George Braziller.

von der Gracht, H. A. (2008). *The future of logistics: Scenarios for 2025*. Berlin, Germany: Springer Science & Business Media.

Waldheim, C. (2011). The invention of GIS. *The Harvard Gazette.* Retrieved from https://news.harvard.edu

Ward, K. (2011). *The world in 2050: Quantifying the shift in the global economy.* London, England: HSBC.

Whysall, Z., Owtram, M., & Brittain, S. (2019). The new talent management challenges of industry 4.0. *Journal of Management Development.* doi: 10.1108/jmd-06-2018-0181

Wilson, J., & Goodchild, M. (2012). Rethinking spatial science education programs. *GI Forum 2012: Geovisualization, Society, and Learning*, 242–245. Retrieved from http://www.gispoint.de

Wikle, T. A. (2016). A look at GIS certification programs and their challenges for higher education. *Journal of the Urban and Regional Information Systems Association, 27*(1), 7–12. Retrieved from EBSCOHost

Wikle, T., & Fagin, T. (2014). Hard and soft skills in preparing GIS professionals: Comparing perceptions of employers and educators. *Transactions in GIS,* 1–12. doi:10.1111/tgis.12126

Yin, R. K. (2014). *Case study research: Design and methods* (5th ed.). Thousand Oaks, CA: Sage.

Zitomer, M. R., & Goodwin, D. (2014). Gauging the quality of qualitative research in adapted physical activity. *Adapted Physical Activity Quarterly, 31*(3), 193–218. doi: 10.1123/apaq.2013-0084

Appendix A: Round 1 Survey

Round 1 Survey to Address the Skills Gap of Geospatial Professionals in the Fourth Industrial Revolution

Welcome to the Round 1 Survey. In this survey, you are presented with the current **technical** core geospatial competency/knowledge area categories, descriptions, and subcategories selected from the GIS&T BOK. The official GIS&T BOK was published in 2006 by the American Association of Geographers and contains the core knowledge areas in the geospatial industry, which were determined by more than 70 geospatial educators, researchers, and practitioners. The BOK was meant to be a work in progress but has not been officially updated and re-published to keep up with technological advances and changing needs in the geospatial field. While there is a current online effort to update the BOK, the update is incomplete and relies on users to populate entries, much like the method used to update and populate Wikipedia entries. This study focuses on input from a vetted panel of experts, where quantitative statistics will be used to develop a consensus-based list of technical competencies over several rounds of survey and data collection.

Within each category, carefully read and consider each item (subcategory) as you go through the survey.

If you have a suggestion to modify or reword an existing item, or add a new item, please do so in the space provided after each item. Please do not include suggestions for removing items during this Round 1 survey. Please include your rationale for changes.

If you wish to add a main category, please do so in the space provided at the very end of the survey and include your rationale for doing so.

As you go through the survey, keep in mind what you believe are competencies that should be included to address current and future geospatial industry needs, based on our understanding of the rapid and forthcoming technological advances in the industry. The estimated time to complete this survey is approximately 30 minutes. You can pause your responses as needed and finish later. Upon completion, please click Submit.

If would like to refer to the GIS&T BOK publication, please use this link: http://www.aag.org/galleries/publications-files/gist_body_of_knowledge.pdf

1. Category AM: Analytical Methods
   Analytical Methods is a knowledge area that encompasses a variety of operations with the objective of using geospatial data to derive analytical results, including first order (environmental) and second order (interaction) effects using data-driven, and model-driven approaches. The following are subcategories/items included in Category AM:

2. Query Operations and Languages
   Please provide suggestions for modifications to this item, if any, in the space provided.

3. Geometric Measures
   Please provide suggestions for modifications to this item, if any, in the space provided.

4. Basic Analytical Operations
   Please provide suggestions for modifications to this item, if any, in the space provided.

5. Surface Analysis
   Please provide suggestions for modifications to this item, if any, in the space provided.

6. Spatial Statistics
   Please provide suggestions for modifications to this item, if any, in the space provided.

7. Spatial Regression and Econometrics
   Please provide suggestions for modifications to this item, if any, in the space provided.

8. Data Mining
   Please provide suggestions for modifications to this item, if any, in the space provided.

9. Network Analysis
   Please provide suggestions for modifications to this item, if any, in the space provided.

10. Optimization and Location-Allocation Modeling
    Please provide suggestions for modifications to this item, if any, in the space provided.

11. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

12. Category CV: Cartography and Visualization

Cartography and Visualization is a knowledge area the focuses on the visual display of geographic information, addressing the complex issues involved in visual thinking and communication of geospatial data and geospatial analysis results. The following are subcategories/items included in Category CV:

13. Principles of Map Design
    Please provide suggestions for modifications to this item, if any, in the space provided.

14. Data Considerations
    Please provide suggestions for modifications to this item, if any, in the space provided.

15. Graphics Representation Techniques
    Please provide suggestions for modifications to this item, if any, in the space provided.

16. Map Productions
    Please provide suggestions for modifications to this item, if any, in the space provided.

17. Map Use and Evaluation
    Please provide suggestions for modifications to this item, if any, in the space provided.

18. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

19. Category DA: Design Aspects
    Design Aspects is a knowledge area that encompasses the proper design of geospatial applications, models, and databases, as well as the validation and verification of design activities. The focus of this category is on the design of applications and databases for a particular need. The following are subcategories/items included in Category DA:

20. GIS&T System Design
    Please provide suggestions for modifications to this item, if any, in the space provided.

21. Database Design

Please provide suggestions for modifications to this item, if any, in the space provided.

22. Analysis Design
    Please provide suggestions for modifications to this item, if any, in the space provided.

23. Application Design
    Please provide suggestions for modifications to this item, if any, in the space provided.

24. System Implementation
    Please provide suggestions for modifications to this item, if any, in the space provided.

25. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

26. Category DM: Data Modeling
    Data Modeling is a knowledge area that deals with representation of formalized spatial and spatiotemporal reality through data models and the translation of these data models into data structures within a conceptualized environment such as a GIS. Examples of spatial data model types are discrete (object-based), continuous (location-based), dynamic, and probabilistic. The following are subcategories/items included in Category DM:

27. Basic Storage and Retrieval Structures
    Please provide suggestions for modifications to this item, if any, in the space provided.

28. Database Management Systems
    Please provide suggestions for modifications to this item, if any, in the space provided.

29. Tessellation Data Models
    Please provide suggestions for modifications to this item, if any, in the space provided.

30. Vector and Object Data Models
    Please provide suggestions for modifications to this item, if any, in the space provided.

31. Modeling 3D, Uncertain, and Temporal Models
    Please provide suggestions for modifications to this item, if any, in the space provided.

32. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

33. Category DN: Data Manipulation
    Data Manipulation is a knowledge area that encompasses the understanding of how non-analytical manipulations are necessary to accommodate the analytical power of GIS, and how changes in projection, grid systems, data forms, and formats happen during the modeling process for which GIS was designed. The following are subcategories/items included in Category DN:

34. Representation Transformation
    Please provide suggestions for modifications to this item, if any, in the space provided.

35. Generalization and Aggregation
    Please provide suggestions for modifications to this item, if any, in the space provided.

36. Transactional Management of Geospatial Data
    Please provide suggestions for modifications to this item, if any, in the space provided.

37. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

38. Category GC: Geocomputation
    Geocomputation is a knowledge area that emphasizes the research, development, and application of computationally intensive approaches to the study of complex spatial-temporal problems, as well as an understanding of machine learning and simulation research. The following are subcategories/items included in Category GC:

39. Emergence of Geocomputation
    Please provide suggestions for modifications to this item, if any, in the space provided.

40. Computational Aspects of Geocomputing Cellular Automata (CA) models
    Please provide suggestions for modifications to this item, if any, in the space provided.

41. Heuristics
    Please provide suggestions for modifications to this item, if any, in the space provided.

42. Genetic Algorithms (GA)
    Please provide suggestions for modifications to this item, if any, in the space provided.

43. Agent-based Models
    Please provide suggestions for modifications to this item, if any, in the space provided.

44. Simulation Models
    Please provide suggestions for modifications to this item, if any, in the space provided.

45. Uncertainty
    Please provide suggestions for modifications to this item, if any, in the space provided.

46. Fuzzy Sets
    Please provide suggestions for modifications to this item, if any, in the space provided.

47. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

48. Category GD: Geospatial Data
    Geospatial Data is a knowledge area that focuses on the understanding of location and attributes of phenomena at or near the Earth's surface, how this information is collected and analyzed, and properties of geospatial and attribute data. The following are subcategories/items included in Category GD:

49. Earth Geometry
    Please provide suggestions for modifications to this item, if any, in the space provided.

50. Land Partitioning System
    Please provide suggestions for modifications to this item, if any, in the space provided.

51. Data Quality
    Please provide suggestions for modifications to this item, if any, in the space provided.

52. Datums
    Please provide suggestions for modifications to this item, if any, in the space provided.

53. Map Projections
    Please provide suggestions for modifications to this item, if any, in the space provided.

54. Georeferencing Systems
    Please provide suggestions for modifications to this item, if any, in the space provided.

55. Land Surveying and GPS
    Please provide suggestions for modifications to this item, if any, in the space provided.

56. Digitizing
    Please provide suggestions for modifications to this item, if any, in the space provided.

57. Field Data Collection
    Please provide suggestions for modifications to this item, if any, in the space provided.

58. Aerial Imagery and Photogrammetry
    Please provide suggestions for modifications to this item, if any, in the space provided.

59. Satellite and Shipboard Remote Sensing
    Please provide suggestions for modifications to this item, if any, in the space provided.

60. If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

61. The space below is provided to you to include any other additions to this list of core competency/knowledge area Main Categories. If you have anything else to add, please include a category and description, as well your rationale (please use bullet points for multiple items).

Appendix B: Geospatial Competency Citation Table

Citation(s)	Technical Competency Category	Technical Competency
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Wikle & Fagin, 2014	Analytical Methods (AM)	Query Operations and Languages
DiBiase et al., 2006; Wikle & Fagin, 2014	Analytical Methods (AM)	Geometric Measures
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Wikle & Fagin, 2014	Analytical Methods (AM)	Basic Analytical Operations
DiBiase et al., 2006; Wikle & Fagin, 2014	Analytical Methods (AM)	Surface Analysis
DiBiase et al., 2006; Hong, 215; Solem et al., 2008	Analytical Methods (AM)	Spatial Statistics
DiBiase et al., 2006	Analytical Methods (AM)	Spatial Regression and Econometrics
DiBiase et al., 2006; Hong, 2015	Analytical Methods (AM)	Data Mining
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Analytical Methods (AM)	Network Analysis
DiBiase et al., 2006	Analytical Methods (AM)	Optimization and Location-Allocation Modeling
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Cartography and Visualization (CV)	Principles of Map Design

DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Cartography and Visualization (CV)	Data Considerations
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Cartography and Visualization (CV)	Graphic Representation Techniques
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Cartography and Visualization (CV)	Map Production
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Cartography and Visualization (CV)	Map Use and Evaluation
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Design Aspects (DA)	GIS&T System Design
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Design Aspects (DA)	Database Design
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Wikle & Fagin, 2014	Design Aspects (DA)	Analysis Design
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015	Design Aspects (DA)	Application Design
DiBiase et al., 2006; Hong, 2015	Design Aspects (DA)	System Implementation
DiBiase et al., 2006	Data Modeling (DM)	Basic Storage and Retrieval Structures

DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Data Modeling (DM)	Database Management Systems
DiBiase et al., 2006	Data Modeling (DM)	Tessellation Data Models
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Data Modeling (DM)	Vector and Object Data Models
DiBiase et al., 2006	Data Modeling (DM)	Modeling 3D, Uncertain, and Temporal Models
DiBiase et al., 2006; Hong, 2015	Data Manipulation (DN)	Representation Transformation
DiBiase et al., 2006; Hong, 2015	Data Manipulation (DN)	Generalization and Aggregation
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Data Manipulation (DN)	Transactional Management of Geospatial Data
DiBiase et al., 2006	Geocomputation (GC)	Emergence of Geocomputation
DiBiase et al., 2006	Geocomputation (GC)	Computational Aspects of Geocomputing Cellular Automata (CA) models
DiBiase et al., 2006	Geocomputation (GC)	Heuristics
DiBiase et al., 2006	Geocomputation (GC)	Genetic Algorithms (GA)
DiBiase et al., 2006	Geocomputation (GC)	Agent-based Models
DiBiase et al., 2006	Geocomputation (GC)	Simulation Models
DiBiase et al., 2006	Geocomputation (GC)	Uncertainty
DiBiase et al., 2006	Geocomputation (GC)	Fuzzy Sets
DiBiase et al., 2006; Wikle & Fagin, 2014	Geospatial Data (GD)	Earth Geometry
DiBiase et al., 2006	Geospatial Data (GD)	Land Partitioning Systems
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Data Quality

DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Datums
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Map Projections
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Georeferencing Systems
DiBiase et al., 2006; Wikle & Fagin, 2014	Geospatial Data (GD)	Land Surveying and GPS
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Digitizing
DiBiase et al., 2006; Hong, 2015; Wikle & Fagin, 2014	Geospatial Data (GD)	Field Data Collection
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Hong, 2015; Solem et al., 2008; Wikle & Fagin, 2014	Geospatial Data (GD)	Aerial Imagery and Photogrammetry
DiBiase et al., 2006; Directions Magazine, 2018; Gaudet et al., 2003; Solem et al., 2008	Geospatial Data (GD)	Satellite and Shipboard Remote Sensing

Appendix C: Permission Request to LinkedIn Group Owners

Dear Group Owner:

I, Shannon Doyle, am requesting permission to join your group and post my study announcement in hopes of recruiting talent manager experts in the geospatial industry to participate in my dissertation study. The purpose of this qualitative modified Delphi study is to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts will share their views based upon a pre-determined list of categories and associated technical skills and knowledge required for geospatial professionals to successfully perform their jobs. The expert opinions available in your group may help provide the geospatial industry with an updated list of the expected technical competencies of geospatial professionals that are considered practicable, desirable, and forward-looking. Participant confidentiality, as well as anonymity among the participants, will be maintained indefinitely. I hope you will grant me the privilege of posting the study announcement in your group with the permission to join as well. Thank you for your time.

Sincerely,

Shannon Doyle

Appendix D: Permission Request to GISCI

I, Shannon Doyle, am requesting permission to join your group and post my study announcement and contact GISPs with public profiles on your website, if necessary, in hopes of recruiting talent manager experts in the geospatial industry to participate in my dissertation study. The purpose of this qualitative modified Delphi study is to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts will share their views based upon a pre-determined list of categories and associated technical skills and knowledge required for geospatial professionals to successfully perform their jobs. The expert opinions available in your group may help provide the geospatial industry with an updated list of the expected technical competencies of geospatial professionals that are considered practicable, desirable, and forward-looking. Participant confidentiality, as well as anonymity among the participants, will be maintained indefinitely. I hope you will grant me the privilege of posting the study announcement in your group with the permission to join as well. I also hope to have permission to contact GISPs on the GISP public registry if needed. Thank you for your time.

Sincerely,

Shannon Doyle

Appendix E: Study Announcement

I, Shannon Doyle, am a PhD candidate in the School of Management at Walden University, and I'd like to invite you to participate in my research study. The purpose of this qualitative modified Delphi study is to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals. The experts will share their views based upon a pre-determined list of categories and associated technical skills and knowledge required for geospatial professionals to successfully perform their jobs.

Criteria to be a Participant:

You may qualify be a participant if you meet the following criteria:

1. Ten or more years of working experience in the geospatial field of which, (a) at least 5 years of experience in the geospatial industry in an executive or management role, or (b) at least 5 or more years of experience in geospatial talent management encompassing the strategy and implementation for employee hiring and development;
2. At least a bachelor's degree in GIS or related field; and
3. Possession of at least one of the existing geospatial professional certifications (such as GISP, Esri EADP, ASPRS Mapping Scientist, etc.).

Online Survey Format and Time Commitment:

Should you choose to participate, you will first be asked to agree that you self-select, and then asked to agree to the informed consent. You will then be asked to complete four (4) rounds of online survey via SurveyMonkey over eight (8) consecutive weeks. Each round

takes place over two (2) weeks with each week beginning on a Monday. Participants will complete the survey in odd-numbered weeks. Researcher data analysis of the previous week's data will occur during the even-numbered weeks. Round 1 survey will take approximately 30 minutes and Rounds 2-4 surveys will take approximately 15-20 minutes each. Round 1 occurs during Weeks 1 and 2, Round 2 occurs during Weeks 3 and 4, Round 3 occurs during Weeks 5 and 6, and Round 4 occurs during Weeks 7 and 8. Week 7 (Round 4) is the final week for participants. Your identity will be anonymous to all other individuals in the study and to me. You may withdraw from the study at any time without penalty. You may email me of your intention to withdrawal from the study or to ask any questions during the survey rounds.

Benefit of Study:

An expected benefit of the study includes a better understanding of the Delphi methodology. Another benefit is the potential positive impact on the geospatial industry by participating on a panel of experts to identify the potential for consensus regarding forward-looking desirable and practicable competencies in the geospatial industry.

How to Participate and Start Date

To agree to participate, follow the link provided in the study announcement to be taken to the self-select agreement and informed consent. You must agree that you self-select and meet the required criteria, and you then must agree to the informed consent. If you self-select, the researcher has accepted in good faith your eligibility, interest, and commitment for being a participant. If you agree to self-select and to the informed consent, you will be taken to the Round 1 survey and may begin at any time. You may also recruit and share

the survey link to other eligible individuals to participate in the study. An email will be sent to each individual participant regarding the start date one week in advance.

Please use the following SurveyMonkey link to take the Round 1 survey: https://www.surveymonkey.com/r/2PHLZBH. Thank you for taking the time to assist me in this important research. Please contact me via email at any time if you have any questions.

Sincerely,

Shannon Doyle

Appendix F: Field Test Request

Date

Hello,

I am Shannon Doyle, a doctoral student pursuing a PhD degree in Management at Walden University. For my doctoral dissertation, I am employing a modified Delphi research design. The purpose of my study is to determine how a nationwide panel of experts in the geospatial industry views the desirability and practicability of forward-looking technical competencies of geospatial professionals.

The targeted population for my study is defined by the following criteria:

(1) Ten or more years of working experience in the geospatial field of which,
    (a) at least 5 years of experience in the geospatial industry in an executive or management role, OR
    (b) at least 5 or more years of experience in geospatial talent management encompassing the strategy and implementation for employee hiring and development
(2) At least a bachelor's degree in GIS or related field
(3) Possession of at least one of the existing geospatial professional certifications (such as GISP, Esri EADP, ASPRS Mapping Scientist, etc.).

I am seeking your support for providing feedback as to the appropriateness of the questions being asked of the study participants, and how the questions are being asked in relation to the purpose of the study. I am also looking for feedback on the clarity of the survey instructions.

After reviewing questions for the survey, please respond to these four field test questions:

1. Are the participants likely to find any of the questions on the questionnaire (the nature of the question or specific wording) objectionable? If so, why? What changes would you recommend?

2. Were any of the questions on the questionnaire difficult to comprehend? If so, why? What changes would you recommend?

3. Was any part of the survey instructions difficult to comprehend? If so, why? What changes would you recommend?

4. Feel free to provide any additional thoughts about the questionnaire, which were not covered in questions 1 through 3, above.

For your review, the questions on the Round 1 survey are attached.

Should you choose to participate in this field test, please do not answer the interview questions intended for the study participants.

Thank you in advance for your time.

Respectfully,

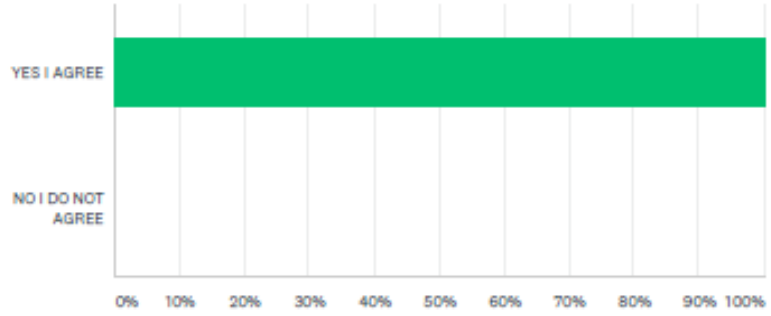
Shannon Doyle

Appendix G: Round 1 Data

Round 1 Survey - Delphi - Shannon Doyle

Q1 I agree to the terms and conditions set forth in the above Informed Consent. I also agree that I have self-selected myself to participate and that I meet all the criteria for participation set forth in the above informed consent.

Answered: 114 Skipped: 2



ANSWER CHOICES	RESPONSES	
YES I AGREE	100.00%	114
NO I DO NOT AGREE	0.00%	0
TOTAL		114

Q2 Please provide your email address. NOTE: All email addresses will be kept confidential and will only be seen by me. No personal identifiable information will be shared with anyone, and SurveyMonkey's privacy policy also ensures information will be kept confidential and private.

Answered: 105 Skipped: 11

Q3 Category AM: Analytical MethodsAnalytical Methods is a knowledge area that encompasses a variety of operations with the objective of using geospatial data to derive analytical results, including first-order (environmental) and second-order (interaction) effects using data-driven, and model-driven approaches. The following are subcategories/items included in Category AM:Query Operations and LanguagesPlease provide suggestions for modifications to this item, if any, in the space provided.

Round 1 Survey - Delphi - Shannon Doyle

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q4 Geometric MeasuresPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q5 Basic Analytical OperationsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	Basic analytical operations and methods	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM

Q6 Surface AnalysisPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 6 Skipped: 110

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Maybe not the most appropriate space but: understanding of data type (integer vs decimal for example) and how this effects measuring phenomena.	9/30/2019 12:15 PM
3	Term is very close to Spatial Analysis. Assume it means working with terrain modeling?	9/27/2019 11:56 AM
4	"surface analysis" is a broad term, I would suggest changing this to "raster analysis" as it is more directly correlated to GIS	9/27/2019 11:51 AM
5	Surface Analysis and derived data products	9/27/2019 9:15 AM
6	Basic Surface, Subsurface, and AGL Analyses	9/27/2019 9:01 AM

Q7 Spatial StatisticsPlease provide suggestions for modifications to this item, if any, in the space provided.

Round 1 Survey - Delphi - Shannon Doyle

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	Spatial statistics and geostatistics	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM

Q8 Spatial Regression and EconometricsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Do you mean Geostatistics, AM8 in the GIST BOK link you provided; or AM9, Spatial Regressesion and econnometrics? In comparing your questions and the BOK, I'm wondering why some are skipped?	9/27/2019 11:16 AM

Q9 Data MiningPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Nothing rally to add, only to suggest data mining doesn't need to just apply to "extremely large data sets".	9/30/2019 12:15 PM

Q10 Network AnalysisPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q11 Optimization and Location-Allocation ModelingPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	No modification	10/1/2019 8:48 AM

Q12 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

Answered: 6 Skipped: 110

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	It exists elsewhere, and in some of the categories, but I think "error modeling" ought to be a class unto itself, else explicit within all categories.	9/30/2019 12:15 PM
3	Category: Spatio-temporal modeling or analysis Rationale: • High demand for understanding spatial relationships/changes through time. • The temporal dimension adds additional complexity and requires specialized skillsets.	9/28/2019 8:56 AM
4	- Spatial Analysis - This would include any sort of spatial modeling, such as restriction or suitability analysis. - Raster Analysis - Manipulating and extracting data from raster data.	9/27/2019 11:56 AM
5	I believe Foundations category should not be excluded. It is nice to teach someone to fish, but it might help to know why and a bit of history of tackle types.	9/27/2019 11:04 AM
6	One thing that I find is a specialized talent is Forecasting. Which is a little of 8,10,and 11. But something highlighting Forecasting specifically might be useful.	9/27/2019 9:52 AM

Q13 Category CV: Cartography and VisualizationCartography and Visualization is a knowledge area the focuses on the visual display of geographic information, addressing the complex issues involved in visual thinking and communication of geospatial data and geospatial analysis results. The following are subcategories/items included in Category CV:Principles of Map DesignPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	how to design maps that are dynamic (ie the user can turn on/off layers and in a sense, create their own sense of the data) does not appear to be currently on the list.)	9/27/2019 11:16 AM
3	I would heavily consider reframing this topic to something like "Principles of Cartography and Map Design." Cartography is more of the core principles, whereas Map Design is consideration of who needs the end product and what their needs are. Cartography is the science and the art. Map Design is requirements gathering and workflow. Then again, perhaps Map Design on its own is fine and a new topic should be added, like Core Cartographic Principles.	9/27/2019 9:01 AM

Round 1 Survey - Delphi - Shannon Doyle

Q14 Data ConsiderationsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	see above.	9/27/2019 11:16 AM
3	This is a little vague.	9/27/2019 8:43 AM

Q15 Graphics Representation TechniquesPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 5 Skipped: 111

#	RESPONSES	DATE
1	I would remove the on-line aspects from this category and create an entirely new one.	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	Is missing a conversation on accessibility (color blindness, other visual impairments) and particularly for digital integrative mediums.	9/30/2019 12:15 PM
4	Web Mapping is specified but responsive design and mobile is not.	9/27/2019 11:16 AM
5	A section on color theory	9/27/2019 7:16 AM

Q16 Map ProductionsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Does there need to be a separate category for digital map production?	9/27/2019 11:16 AM

Q17 Map Use and EvaluationPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Round 1 Survey - Delphi - Shannon Doyle

Q18 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

Answered: 7 Skipped: 109

#	RESPONSES	DATE
1	Web cartography - I believe with the explosion of web mapping that this warrants separation from traditional manual design	10/3/2019 7:46 PM
2	Visual Map Interpretation Promote critical thinking skill during the map creation process, and when interpreting map content.	10/3/2019 12:50 PM
3	No suggestion	10/1/2019 8:48 AM
4	See comment for Q15. Accessibility considerations (considering that the product is the means for communication) may merit its on section.	9/30/2019 12:15 PM
5	Digital map production?	9/27/2019 11:16 AM
6	Again, foundations and history of Cartography is excluded. You can teach a monkey to use a tool, but there is so much more to Geography than plan tools. It is an art as much as science, especially when it comes to great Cartography. It is not all about which symbols to use and rinse and repeat, but the ever evolving field and how it changed through time as well.	9/27/2019 11:04 AM
7	Digital Mapping Principles; Mobile Mapping Applications; ADA Compliance (Physical and Digital)	9/27/2019 9:01 AM

Q19 Category DA: Design AspectsDesign Aspects is a knowledge area that encompasses the proper design of geospatial applications, models, and databases, as well as the validation and verification of design activities. The focus of this category is on the design of applications and databases for a particular need. The following are subcategories/items included in Category DA:GIS&T System DesignPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	I recommend changing this category name to something like "Work Flow and Modeling"	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	Defining a needed Project scope is quite important, so if included here, not needed as a separate category.	9/27/2019 11:04 AM

Q20 Database DesignPlease provide suggestions for modifications to this item, if any, in the space provided.

Round 1 Survey - Delphi - Shannon Doyle

Answered: 4 Skipped: 112

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	(maybe just my interpretation but) In my reading this category seems focused on traditional relational database management. If thinking for the future it may be worth some attention on other database models and practices that might be unique to them.	9/30/2019 12:15 PM
3	Database Design and Standardization - We work with many spatial data models and it is important that employees are familiar with standard business rules and workflows.	9/27/2019 11:56 AM
4	Database Modeling and Design	9/27/2019 9:47 AM

Q21 Analysis DesignPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q22 Application DesignPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	Application Design and Evaluation It is important that the application be tested, evaluated for performance and easy of use, ...	10/3/2019 12:50 PM
2	No suggestion	10/1/2019 8:48 AM
3	Section is light on user interface & user experience, and practices of designing to the intended user.	9/30/2019 12:15 PM

Q23 System ImplementationPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	This needs to include SaaS, DaaS & PaaS. There could be lumped under cloud computing sub-tasks.	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	System Implementation and Data Workflows - Having a consistent workflow that defines the migration and quality control rules is important.	9/27/2019 11:56 AM

Q24 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide additions and rationale in a bulleted list.

Answered: 5 Skipped: 111

#	RESPONSES	DATE
1	Database Administration The requirement for geospatial professionals to administer there own data is increasing. The need for a basic understanding of tasks such as indexing, versioning and space allocation is increasing.	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	Data Management if not included below as it relates to keeping data storage systems current with latest technology/updates or designing a DB to adapt to later updates.	9/30/2019 12:28 PM
4	Nothing can ruin a project and wonderful ideas in the real world as much as lousy budget and equipment. This can impact computational speed, staffing, scope, and should be elementary requirement for the design.	9/27/2019 11:04 AM
5	1 - ADA Compliance; 2 - Enterprise System Design. This would take into account cross-departmental (or organizational) goals, requirements, and decision trees.	9/27/2019 9:01 AM

Q25 Category DM: Data ModelingData Modeling is a knowledge area that deals with representation of formalized spatial and spatio-temporal reality through data models and the translation of these data models into data structures within a conceptualized environment such as a GIS. Examples of spatial data model types are discrete (object-based), continuous (location-based), dynamic, and probabilistic. The following are subcategories/items included in Category DM:Basic Storage and Retrieval StructuresPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Data Organization, File Structures, and Workflows	9/27/2019 11:56 AM
3	Scaleability of storage and retrieval infrastructure	9/27/2019 7:16 AM

Q26 Database Management SystemsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 4 Skipped: 112

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	you're missing some of the more modern dbms, specifically NoSQL databases for big data storage.	9/30/2019 12:15 PM
3	Spatial Data Modeling?	9/27/2019 11:56 AM
4	Relational Database Management Systems	9/27/2019 9:15 AM

Q27 Tessellation Data ModelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	Not sure how essential	10/1/2019 8:48 AM

Q28 Vector and Object Data ModelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestions	10/1/2019 8:48 AM

Q29 Modeling 3D, Uncertain, and Temporal ModelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Modeling 3D should be renamed to something like "Multi-dimensional Modeling" to account for 3D/4D engineering design, LiDAR, audio, BIM, as well as Augmented Reality (AR) and Virtual Reality (VR) use cases.	9/27/2019 9:01 AM

Q30 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

Answered: 5 Skipped: 111

#	RESPONSES	DATE
1	No additions	10/1/2019 8:48 AM
2	I feel like the whole section in general is missing basic competencies regarding data types and their appropriate usages.	9/30/2019 12:15 PM
3	Category: Big Data Modeling Rationale 1. Increased need to use spatial modeling with data that is high velocity, volume and variability.	9/28/2019 8:56 AM
4	Raster Analysis Spatial Analysis	9/27/2019 11:56 AM
5	So where does cloud storage and retrieval fit into this category? I'm only a novice in this area, so am not sure if this is where it should fit, or not. But currently it's not really mentioned at all - but it is widely popular and being implemented everywhere.	9/27/2019 11:16 AM

Q31 Category DN: Data ManipulationData Manipulation is a knowledge area that encompasses the understanding of how non-analytical manipulations are necessary to accommodate the analytical power of GIS, and how changes in projection, grid systems, data forms, and formats happen during the modeling process for which GIS was designed. The following are subcategories/items included in Category DN:Representation TransformationPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	This has the possibility of being unclear, since transformations are often used with projections. I think this means differences in data represented with lines, polygons, edges, points,etc.	9/27/2019 11:30 PM

Round 1 Survey - Delphi - Shannon Doyle

Q32 Generalization and AggregationPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q33 Transactional Management of Geospatial DataPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q34 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	Need to add file types, LAS, LAZ, DSM	10/3/2019 7:46 PM
2	No addition	10/1/2019 8:48 AM

Q35 Category GC: GeocomputationGeocomputation is a knowledge area that emphasizes the research, development, and application of computationally intensive approaches to the study of complex spatial-temporal problems, as well as an understanding of machine learning and simulation research. The following are subcategories/items included in Category GC:Emergence of GeocomputationPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 4 Skipped: 112

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	Recommend dropping	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	Definitely agree that this is a graduate level category; but recognition and awareness at a higher undergrad level could be appropriate.	9/27/2019 11:16 AM
4	Rename to "Principles of Geocomputation" but I think that "Spatial Computation" might be more accurate.	9/27/2019 9:01 AM

Q36 Computational Aspects of Geocomputing Cellular Automata (CA) modelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q37 HeuristicsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q38 Genetic Algorithms (GA)Please provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	I don't even know what these are?!	9/27/2019 11:30 PM

Q39 Agent-based ModelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q40 Simulation ModelsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q41 UncertaintyPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	Specifically data uncertainty	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM

Q42 Fuzzy SetsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q43 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for any changes made. Please provide modifications and rationale in a bulleted list.

Answered: 4 Skipped: 112

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	wow, i don't know what most of these items are	10/2/2019 7:49 PM
2	No additions	10/1/2019 8:48 AM
3	This is all upper level stuff; not to be considered core competencies.	9/27/2019 11:16 AM
4	New topic: Multi-scalar Data Sets	9/27/2019 9:01 AM

Q44 Category GD: Geospatial DataGeospatial Data is a knowledge area that focuses on the understanding of location and attributes of phenomena at or near the Earth's surface, how this information is collected and analyzed, and properties of geospatial and attribute data. The following are subcategories/items included in Category GD:Earth GeometryPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestionGlobalSat BT-821	10/1/2019 8:48 AM
2	Geodesy is the foundation of this subject	9/27/2019 7:16 AM

Q45 Land Partitioning SystemPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Would Linear Referencing fall in here? Linear Referencing Systems are becoming more prevalent as a way to categorize and organize spatial information. As the world moves to bigger data better referencing systems will be needed.	9/27/2019 9:52 AM
3	Land Partitioning Systems	9/27/2019 9:15 AM

Q46 Data QualityPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Data Quality and Data Integrity	9/27/2019 9:15 AM

Round 1 Survey - Delphi - Shannon Doyle

Q47 DatumsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q48 Map ProjectionsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q49 Georeferencing SystemsPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q50 Land Surveying and GPSPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 2 Skipped: 114

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	I question if this is critical as a core concept, but with land records delving into the legal ramifications and standards of differing document types	9/30/2019 12:15 PM

Q51 DigitizingPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Is tablet digitizing still a thing? Its purely historic in my world. Also, provide accommodations for automated vectorization outside of GIS tools, for latter ingestion into GIS (i.e. that vectorization can happen in CAD or other vector graphic technologies).	9/30/2019 12:15 PM
3	why is this not a core unit? It's how errors can be introduced, data invalidated, and rendered useless.	9/27/2019 11:16 AM

Q52 Field Data CollectionPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 4 Skipped: 112

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	If this section is meant to capture more than just physical phenomena (i.e. demographic, socio-economic, or anything more social) there needs to be competency in survey question design.	9/30/2019 12:15 PM
3	indication of quality measures? In our work, if the field collection doesn't follow procedures, the data is invalid. It's a core unit.	9/27/2019 11:16 AM
4	Is there duplication here with #50? GPS applies to both, but otherwise I see the distinction.	9/27/2019 8:43 AM

Q53 Aerial Imagery and PhotogrammetryPlease provide suggestions for modifications to this item, if any, in the space provided.

Answered: 1 Skipped: 115

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM

Q54 Satellite and Shipboard Remote Sensing Please provide suggestions for modifications to this item, if any, in the space provided.

Answered: 3 Skipped: 113

#	RESPONSES	DATE
1	No suggestion	10/1/2019 8:48 AM
2	Should UAS/drones be added to this?	9/27/2019 11:30 PM
3	not sure why this is considered core and field measurements are not?	9/27/2019 11:16 AM

Q55 If you have a suggestion to add a competency to this category, pleased do so in the space provided below, and state your rationale for

any changes made. Please provide modifications and rationale in a bulleted list.

Answered: 9 Skipped: 107

#	RESPONSES	DATE
1	UAS Data Collection This is a growing area of data collection with a host of systems and technology that warrants its own category. Mobile Data Collection (Vehicle based) same as above	10/3/2019 7:46 PM
2	No suggestion	10/1/2019 8:48 AM
3	Imagery Data Collection: as it relates to advising people who actually collect the data so that collection planning considers the data management system in which the data will be stored/accessed/analyzed.	9/30/2019 12:28 PM
4	Both the aerial Imagery & Satellite sensing categories should be combined. Minus a few nuances the topics overlap a good deal. Its all remote sensing after all.	9/30/2019 12:15 PM
5	The introduction to this category states "The USGS envisions a National Map..." That national map is a reality and relied on and contributed to by many state and local partners. Wording needs to be updated to indicate the new reality.	9/27/2019 11:16 AM
6	Metadata should not be excluded. It is very important, especially when more and more data is produced, with no information behind it. If anything it is not provided enough importance in current GIS training courses.	9/27/2019 11:04 AM
7	Perhaps consider adding a section that would account for pre-GIS data that comes from something like CAD/CADD, where the GIS user would not know if the CADD design was created in paperspace or modelspace. Not knowing that could have significant effects on a long-distance or wide-area project.	9/27/2019 9:01 AM
8	This last area is my specialty. It looks like you have covered the topics well. I assume by earth geometry you are referring to the geoid/spheroid types of discussions.	9/27/2019 8:43 AM
9	A section on small unmanned aerial systems for data capture.	9/27/2019 7:16 AM

Q56 The space below is provided to you to include any other additions to this list of core competency/knowledge area Main Categories. If you have anything else to add, please include a category and description, as well your rationale (please use bullet points for multiple items).

Answered: 6 Skipped: 110

Round 1 Survey - Delphi - Shannon Doyle

#	RESPONSES	DATE
1	Ethics Due to the nature of geospatial data, the ethical responsibility to understand the strengths and weaknesses of the data is critical to the decision-making aspects of the data. Remote Sensing Since this is categorized as geospatial, I believe a remote sensing category is required. With the advancements in UAS technology (especially sensors), geospatial professionals are increasingly responsible for producing data and products using traditional remote sensing techniques. Scripting Due to the nature of geospatial data processing, the ability to script and use work flow tools is increasing critical to the demands placed upon staff. Data Integration For lack of a better term, mash-ups. The knowledge of how to integrate real-time data in both web and desktop environments is required. This will be especially true as we progress from data collection to applications to integrations	10/3/2019 7:46 PM
2	No additions	10/1/2019 8:48 AM
3	I realize this list is meant to cover technical skill sets. Hopefully later surveys will cover non-technical skills. In my experience, there a very smart GIS pros that do not have a solid grasp of leadership and management principals: 1) as they relate to fostering and helping junior GIS pros to develop, 2) interpersonal skills as it relates to positive/negative feedback with supervisors, peers, and supervisees, 2) customer service skills as they relate to working with non-GIS colleagues to ensure that there is a back-and-forth component to developing, implementing, and managing GIS solutions & products.	9/30/2019 12:28 PM
4	There's more reliance on mobile, responsive design, and cloud than was previously indicated in the BOK. The core units of what is being measured and how, and how to determine quality are still valid and important. But you sometimes have non-GIS&T people coming in saying that mobile and cloud is the best - but is there a geographer on that team that can make sure that the quality is still good?	9/27/2019 11:16 AM
5	I do not know where this fits in yet, but I think it would be wise to add Asset Management somewhere into this list. There are some basic, core principles that should be captured on all infrastructure data sets that routinely are not.	9/27/2019 9:01 AM
6	xxx	9/24/2019 10:13 PM

Appendix H: Round 2 Survey

Round 2 Survey - Delphi Study - Shannon Doyle

Welcome to Round 2!

- Competencies reflect current and future geospatial industry needs,
- Estimated time to complete is approximately 20-30 minutes. The remaining rounds will take less time.
- You can pause your responses as needed and finish later. Upon completion, please click Submit.
- For reference: GIS&T BOK publication: http://www.aag.org/galleries/publications-files/gist_body_of_knowledge.pdf
- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable).

Round 2 Survey - Delphi Study - Shannon Doyle

Category AM: Analytical Methods

Analytical Methods is a knowledge area that encompasses a variety of operations with the objective of using geospatial data to derive analytical results, including first-order (environmental) and second-order (interaction) effects using data-driven, and model-driven approaches. The following are subcategories/items included in Category AM, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 1. Please confirm your email address used in the Round 1 survey. NOTE: All email addresses will be kept confidential and will only be seen by me. No personal identifiable information will be shared with anyone, and SurveyMonkey's privacy policy also ensures information will be kept confidential and private.

* 2. Please rate the Desirability and Practicability of subcategory: **Query Operations and Languages**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 3. Please rate the Desirability and Practicability of subcategory: **Geometric Measures**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 4. Please rate the Desirability and Practicability of subcategory: **Basic Analytical Opertations and Methods**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 5. Please rate the Desirability and Practicability of subcategory: **Raster Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 6. Please rate the Desirability and Practicability of subcategory: **Surface Analysis and Derived Data Products**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 7. Please rate the Desirability and Practicability of subcategory: **Subsurface and AGL Analyses**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 8. Please rate the Desirability and Practicability of subcategory: **Spatial Statistics and Geostatistics**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable

Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 9. Please rate the Desirability and Practicability of subcategory: **Spatial Regression and Econometrics**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 10. Please rate the Desirability and Practicability of subcategory: **Data Mining**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 11. Please rate the Desirability and Practicability of subcategory: **Network Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 12. Please rate the Desirability and Practicability of subcategory: **Optimization and Location-Allocation Modeling**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 13. Please rate the Desirability and Practicability of subcategory: **Spatio-temporal Modeling and Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 13. Please rate the Desirability and Practicability of subcategory: **Spatio-temporal Modeling and Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 14. Please rate the Desirability and Practicability of subcategory: **Error Modeling**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable

Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 15. Please rate the Desirability and Practicability of subcategory: **Spatial Modeling and Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 16. Please rate the Desirability and Practicability of subcategory: **Forecasting**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

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Round 2 Survey - Delphi Study - Shannon Doyle

Category CV: Cartography and Visualization

EDIT

Cartography and Visualization is a knowledge area the focuses on the visual display of geographic information, addressing the complex issues involved in v thinking and communication of geospatial data and geospatial analysis results. The following are subcategories/items included in Category CV, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 17. Please rate the Desirability and Practicability of subcategory: **Principles of Map Design**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 18. Please rate the Desirability and Practicability of subcategory: **Dynamic Mapping**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 19. Please rate the Desirability and Practicability of subcategory: **Core Cartographic Principles**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 20. Please rate the Desirability and Practicability of subcategory: **Data Considerations**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 21. Please rate the Desirability and Practicability of subcategory: **Graphic Representation Techniques**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 22. Please rate the Desirability and Practicability of subcategory: **Digital Integrative Mediums and Accesibility/ADA Compliance**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 23. Please rate the Desirability and Practicability of subcategory: **Web and Mobile Mapping and Responsive Design**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 24. Please rate the Desirability and Practicability of subcategory: **Digital and Physical Map Production**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 25. Please rate the Desirability and Practicability of subcategory: **Web Cartography and Digital Mapping Principles**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 26. Please rate the Desirability and Practicability of subcategory: **Visual Map and Data Interpretation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

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or Copy and paste questions

Round 2 Survey - Delphi Study - Shannon Doyle

Category DA: Design Aspects

Design Aspects is a knowledge area that encompasses the proper design of geospatial applications, models, and databases, as well as the validation and verification of design activities. The focus of this category is on the design of applications and databases for a particular need. The following are subcategories/items included in Category AM, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 27. Please rate the Desirability and Practicability of subcategory: **GIS&T System Design**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 28. Please rate the Desirability and Practicability of subcategory: **GIS Project Workflows and Modeling**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 29. Please rate the Desirability and Practicability of subcategory: **Database Design, Modeling, and Standardization**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 30. Please rate the Desirability and Practicability of subcategory: **Analysis Design**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable

Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 31. Please rate the Desirability and Practicability of subcategory: **Application Design and Evaluation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 32. Please rate the Desirability and Practicability of subcategory: **System Implementation and Data Workflows**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 33. Please rate the Desirability and Practicability of subcategory: **Cloud Computing, Storage, and Retrieval**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 34. Please rate the Desirability and Practicability of subcategory: **Database Administration**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 35. Please rate the Desirability and Practicability of subcategory: **Database Management**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 36. Please rate the Desirability and Practicability of subcategory: **Enterprise System Design**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 37. Please rate the Desirability and Practicability of subcategory: **Basic Storage/Retrieval Structures and Infrastructure Scalability**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable

Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 38. Please rate the Desirability and Practicability of subcategory: **Data Organization, File Structures, and Workflows**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 39. Please rate the Desirability and Practicability of subcategory: **Relational Database Management Systems**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 40. Please rate the Desirability and Practicability of subcategory: **Big Data - Storage and Database Management**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

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Category DM: Data Modeling

Data Modeling is a knowledge area that deals with representation of formalized spatial and spatio-temporal reality through data models and the translation of these data models into data structures within a conceptualized environment such as a GIS. Examples of spatial data model types are discrete (object-based), continuous (location-based), dynamic, and probabilistic. The following are subcategories/items included in Category DM, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 41. Please rate the Desirability and Practicability of subcategory: **Tessellation Data Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 42. Please rate the Desirability and Practicability of subcategory: **Vector and Object Data Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 43. Please rate the Desirability and Practicability of subcategory: **Multi-dimensional, Uncertain, and Temporal Data Modeling**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 44. Please rate the Desirability and Practicability of subcategory: **Big Data Modeling and Analysis**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 45. Please rate the Desirability and Practicability of subcategory: **Geospatial File Types and Data Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

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Category DN: Data Manipulation

Data Manipulation is a knowledge area that encompasses the understanding of how non-analytical manipulations are necessary to accommodate the analytical power of GIS, and how changes in projection, grid systems, data forms, and formats happen during the modeling process for which GIS was designed. The following are subcategories/items included in Category DN, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

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* 46. Please rate the Desirability and Practicability of subcategory: **Data Representation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 47. Please rate the Desirability and Practicability of subcategory: **Generalization and Aggregation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 48. Please rate the Desirability and Practicability of subcategory: **Transactional Management of Geospatial Data**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

NEW QUESTION

or Copy and paste questions

Round 2 Survey - Delphi Study - Shannon Doyle

Category GC: Geocomputation

Geocomputation is a knowledge area that emphasizes the research, development, and application of computationally intensive approaches to the study of complex spatial-temporal problems, as well as an understanding of machine learning and simulation research. The following are subcategories/items included in Category GC, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 49. Please rate the Desirability and Practicability of subcategory: **Emergence Computation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 50. Please rate the Desirability and Practicability of subcategory: **Computational Aspects of Geocomputing Cellular Automata (CA) Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 51. Please rate the Desirability and Practicability of subcategory: **Heuristics**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 52. Please rate the Desirability and Practicability of subcategory: **Genetic Algoritms (GA)**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable

Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 53. Please rate the Desirability and Practicability of subcategory: **Agent-based Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 54. Please rate the Desirability and Practicability of subcategory: **Simulation Models**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 55. Please rate the Desirability and Practicability of subcategory: **Data Uncertainty**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 56. Please rate the Desirability and Practicability of subcategory: **Fuzzy Sets**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 57. Please rate the Desirability and Practicability of subcategory: **Multi-scalar Data Sets**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

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Category GD: Geospatial Data

Geospatial Data is a knowledge area that focuses on the understanding of location and attributes of phenomena at or near the Earth's surface, how this information is collected and analyzed, and properties of geospatial and attribute data. The following are subcategories/items included in Category GD, as well as additions/modifications suggested by panel members.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 58. Please rate the Desirability and Practicability of subcategory: **Geodesy and Earth Geometry**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 59. Please rate the Desirability and Practicability of subcategory: **Land Partitioning Systems**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 60. Please rate the Desirability and Practicability of subcategory: **Linear Referencing**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 61. Please rate the Desirability and Practicability of subcategory: **Data Quality and Data Integrity**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 62. Please rate the Desirability and Practicability of subcategory: **Datums**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 63. Please rate the Desirability and Practicability of subcategory: **Map Projections**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 64. Please rate the Desirability and Practicability of subcategory: **Georeferencing Systems**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 65. Please rate the Desirability and Practicability of subcategory: **Land Surveying and GPS**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 66. Please rate the Desirability and Practicability of subcategory: **Digitization and Vectorization**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 67. Please rate the Desirability and Practicability of subcategory: **Field Data Collection and Quality**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 68. Please rate the Desirability and Practicability of subcategory: **Aerial Imagery and Photogrammetry**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 69. Please rate the Desirability and Practicability of subcategory: **Satellite and Shipboard Remote Sensing**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 70. Please rate the Desirability and Practicability of subcategory: **UAS Data Collection**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	◯	◯	◯	◯	◯
Practicability	◯	◯	◯	◯	◯

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 71. Please rate the Desirability and Practicability of subcategory: **Mobile Data Collection**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

NEW QUESTION

or Copy and paste questions

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Other Subcategories added from Round 1

The following are subcategories/items are additional items suggested by panel members that were not included under a main category.

- Please rate the Desirability and Practicability for each subcategory using the scales provided.
- Feel free to include a rationale for your selections (particularly with low ratings of 1 or 2) and provide comments if you would like.
- The scales for each item range from 1 to 5, with:

1 = Very Undesirable (or Very Impractical),
2 = Undesirable (or Impractical),
3 = Neither Desirable nor Undesirable (or Neither Practicable nor Impractical),
4 = Desirable (or Practicable),
5 = Very Desirable (or Very Practicable)

- **Desirability** refers to being advantageous, worthy of pursuit, and mitigating harm.
- **Practicability** (also called feasibility) refers to the ability to execute the job duty with minimal difficulty.

* 72. Please rate the Desirability and Practicability of subcategory: **Metadata**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 73. Please rate the Desirability and Practicability of subcategory: **Ethical Considerations**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 74. Please rate the Desirability and Practicability of subcategory: **Data Integration**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 75. Please rate the Desirability and Practicability of subcategory: **Scripting and Automation**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 76. Please rate the Desirability and Practicability of subcategory: **Asset Management**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

* 77. Please rate the Desirability and Practicability of subcategory: **Machine Learning**

	1 - Very Undesirable/Very Impractical	2 - Undesirable/Impractical	3 - Neither Desirable nor Undesirable/Neither Practicable nor Impractical	4 - Desirable/Practicable	5 - Very Desirable/Very Practicable
Desirability	○	○	○	○	○
Practicability	○	○	○	○	○

Use this space if you wish to provide rationale for choosing a rating of 1 or 2, or to provide general comments.

Appendix I: Round 2 Data

Q2 Please rate the Desirability and Practicability of subcategory: Query Operations and Languages

Answered: 34 Skipped: 0

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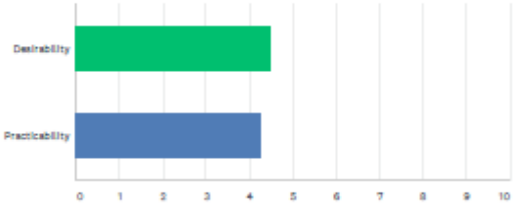


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	9.38% 3	31.25% 10	59.38% 19
Practicability	0.00% 0	5.88% 2	8.82% 3	38.24% 13	47.06% 16

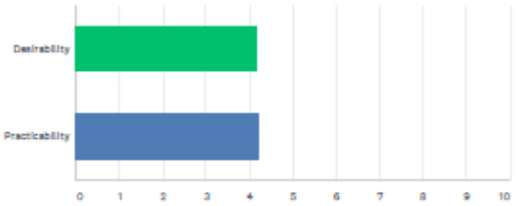
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.50	0.66
Practicability	2.00	5.00	4.00	4.26	0.85

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:45 PM
2	Important to be able to manipulate data layers via definition queries.	10/9/2019 5:00 PM

Q3 Please rate the Desirability and Practicability of subcategory: Geometric Measures

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	15.15% 5	51.52% 17	33.33% 11
Practicability	0.00% 0	2.94% 1	11.76% 4	47.06% 16	38.24% 13

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.18	0.67
Practicability	2.00	5.00	4.00	4.21	0.76

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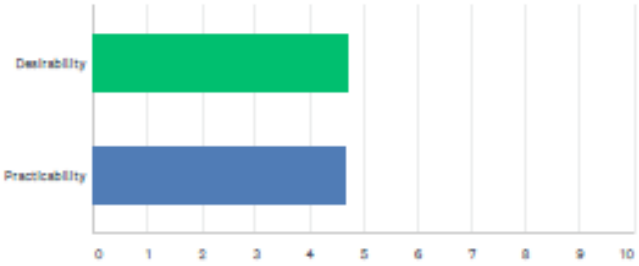
#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:45 PM
2	Important to be able to properly perform length and area calculations.	10/9/2019 5:00 PM

Q4 Please rate the Desirability and Practicability of subcategory: Basic Analytical Opertations and Methods

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	30.30% 10	69.70% 23
Practicability	0.00% 0	0.00% 0	0.00% 0	35.29% 12	64.71% 22

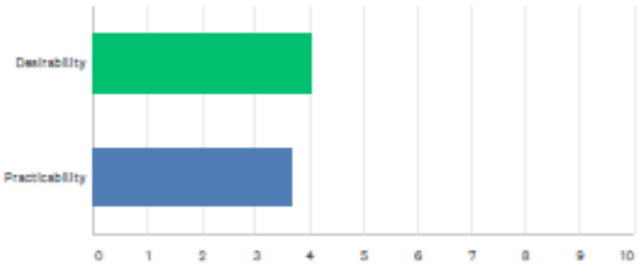
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.70	0.46
Practicability	4.00	5.00	5.00	4.65	0.48

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:45 PM
2	Requirement depends on what level we are hiring for. More important for an analyst. Less for a tech.	10/9/2019 5:00 PM

Q5 Please rate the Desirability and Practicability of subcategory: Raster Analysis

Answered: 34 Skipped: 0



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	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	15.15% 5	66.67% 22	18.18% 6
Practicability	0.00% 0	0.00% 0	41.18% 14	50.00% 17	8.82% 3

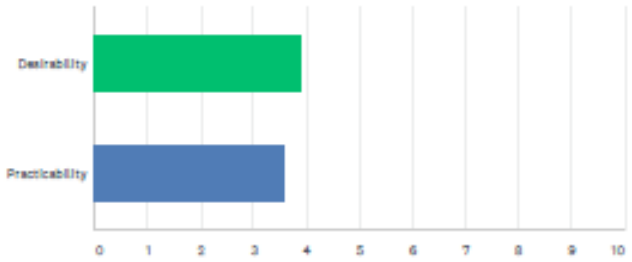
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.03	0.58
Practicability	3.00	5.00	4.00	3.68	0.63

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Requirement depends on what level we are hiring for. More important for an analyst. Less for a tech. Not a deal breaker no experience.	10/9/2019 5:00 PM

Q6 Please rate the Desirability and Practicability of subcategory: Surface Analysis and Derived Data Products

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.13% 1	3.13% 1	15.63% 5	56.25% 18	21.88% 7
Practicability	2.94% 1	2.94% 1	41.18% 14	41.18% 14	11.76% 4

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	3.91	0.88
Practicability	1.00	5.00	4.00	3.56	0.85

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not used in business analytics	10/10/2019 10:07 AM
2	Requirement depends on what level we are hiring for. More important for an analyst. Less for a tech. Not a deal breaker.	10/9/2019 5:00 PM

Q7 Please rate the Desirability and Practicability of subcategory: Subsurface and AGL Analyses

Answered: 34 Skipped: 0

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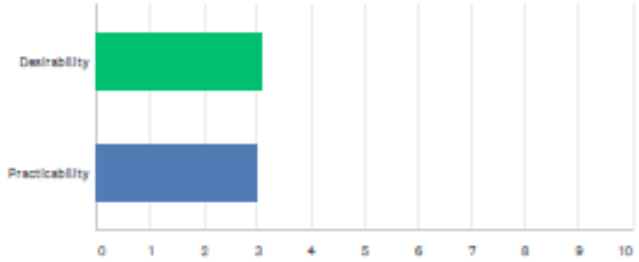


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.03% 1	12.12% 4	57.58% 19	27.27% 9	0.00% 0
Practicability	2.94% 1	20.59% 7	50.00% 17	26.47% 9	0.00% 0

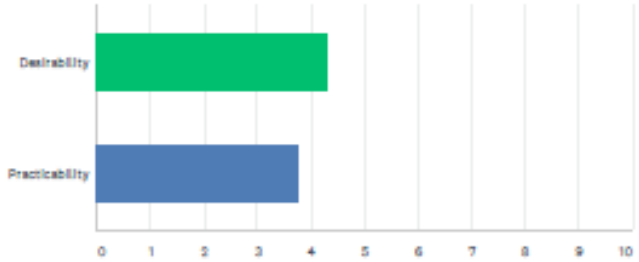
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	4.00	3.00	3.09	0.71
Practicability	1.00	4.00	3.00	3.00	0.77

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	did you mean subsurface? or surface?	10/15/2019 11:37 AM
2	This is so industry specific.	10/15/2019 11:02 AM
3	Not used in business analytics	10/10/2019 10:07 AM
4	Not a requirement, not typically used in our workflow/analysis tasks or projects. Nice if there is experience.	10/9/2019 5:00 PM

Q8 Please rate the Desirability and Practicability of subcategory: Spatial Statistics and Geostatistics

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.06% 2	57.58% 19	36.36% 12
Practicability	0.00% 0	8.82% 3	23.53% 8	52.94% 18	14.71% 5

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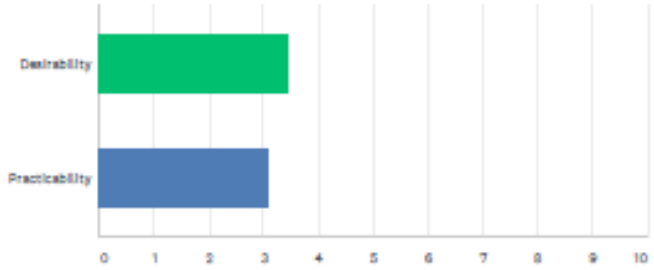
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.30	0.58
Practicability	2.00	5.00	4.00	3.74	0.82

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not a requirement, not typically used in our workflow/analysis tasks or projects. Nice if there is experience.	10/9/2019 5:00 PM

Q9 Please rate the Desirability and Practicability of subcategory: Spatial Regression and Econometrics

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	9.09% 3	42.42% 14	42.42% 14	6.06% 2
Practicability	0.00% 0	26.47% 9	44.12% 15	23.53% 8	5.88% 2

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.45	0.74
Practicability	2.00	5.00	3.00	3.09	0.85

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This is a tough one. It's not taught effectively and not every student of geography has a talent for this.	10/15/2019 11:02 AM
2	Not a requirement, not typically used in our workflow/analysis tasks or projects. Nice if there is experience.	10/9/2019 5:00 PM

Q10 Please rate the Desirability and Practicability of subcategory: Data Mining

Answered: 34 Skipped: 0

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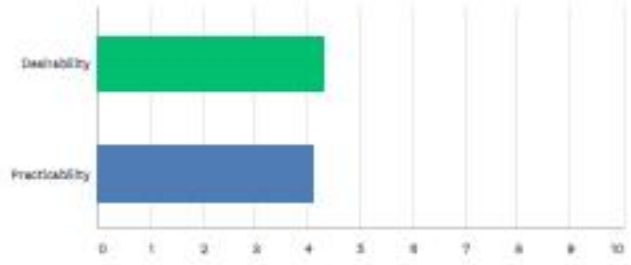


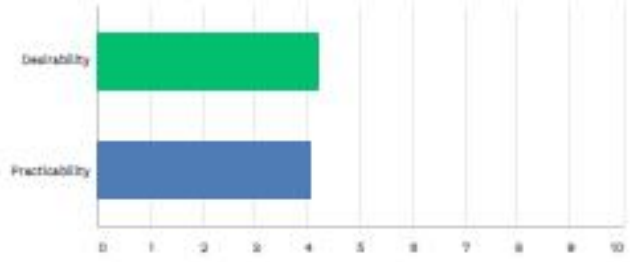
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	9.09% 3	51.52% 17	39.39% 13
Practicability	0.00% 0	3.03% 1	18.18% 6	45.45% 15	33.33% 11

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.30	0.63
Practicability	2.00	5.00	4.00	4.09	0.79

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This is a hard one too. Data mining is so dependent on programming chops.	10/15/2019 11:02 AM
2	This should be close to core knowledge especially with proliferation of data services and open data	10/10/2019 6:45 PM

Q11 Please rate the Desirability and Practicability of subcategory: Network Analysis

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.03% 1	9.09% 3	51.52% 17	36.36% 12
Practicability	0.00% 0	5.88% 2	11.76% 4	52.94% 18	29.41% 10

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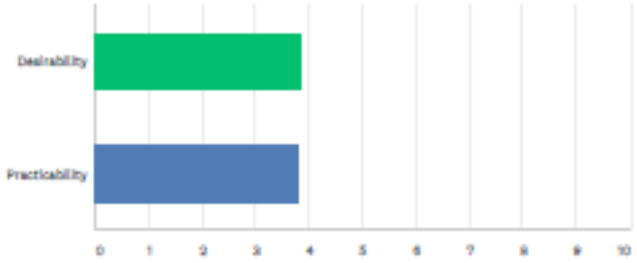
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	4.21	0.73
Practicability	2.00	5.00	4.00	4.06	0.80

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not a requirement, not typically used in our workflows/analytic tasks or projects. Nice if there is experience.	10/9/2019 5:00 PM

Q12 Please rate the Desirability and Practicability of subcategory: Optimization and Location-Allocation Modeling

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	2.94% 1	0.00% 0	26.47% 9	52.94% 18	17.65% 6
Practicability	0.00% 0	6.06% 2	30.30% 10	42.42% 14	21.21% 7

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	3.82	0.82
Practicability	2.00	5.00	4.00	3.79	0.84

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not ever used	10/9/2019 5:00 PM

Q13 Please rate the Desirability and Practicability of subcategory: Spatio-temporal Modeling and Analysis

Answered: 34 Skipped: 0

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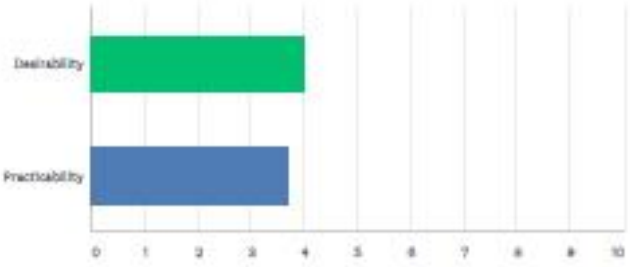


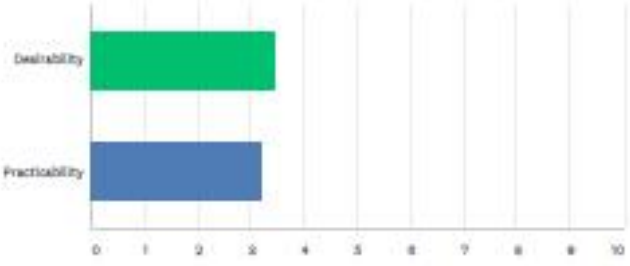
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	24.24% 8	51.52% 17	24.24% 8
Practicability	0.00% 0	5.88% 2	35.29% 12	41.18% 14	17.65% 6

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.00	0.70
Practicability	2.00	5.00	4.00	3.71	0.82

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	As our databases include more temporal information the importance of this will grow.	10/10/2019 6:45 PM
2	Not a requirement, not typically used in our workflows/analytic tasks or projects. Nice if there is experience.	10/9/2019 5:00 PM

Q14 Please rate the Desirability and Practicability of subcategory: Error Modeling

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	9.09% 3	39.39% 13	48.48% 16	3.03% 1
Practicability	0.00% 0	14.71% 5	50.00% 17	35.29% 12	0.00% 0

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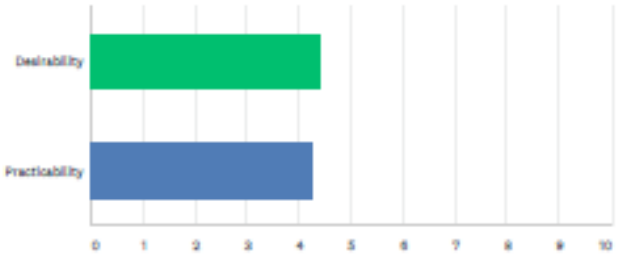
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.45	0.70
Practicability	2.00	4.00	3.00	3.21	0.68

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	The process of error modeling I don't think is the issues, its knowing when to model it, or knowing the value of modeling it that's problematic, IMOP.	10/15/2019 11:37 AM

Q15 Please rate the Desirability and Practicability of subcategory: Spatial Modeling and Analysis

Answered: 34 Skipped: 0



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.06% 2	48.48% 16	45.45% 15
Practicability	0.00% 0	2.94% 1	5.88% 2	52.94% 18	38.24% 13

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.39	0.60
Practicability	2.00	5.00	4.00	4.26	0.70

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Potentially you'll have a need for some serious programming. In my agency, the modelers use GIS as a tool, but their hands are mostly in code.	10/15/2019 11:02 AM
2	This should be core knowledge	10/10/2019 6:45 PM
3	Requirement depends on what level we are hiring for. More important for an analyst. Less for a tech.	10/9/2019 5:00 PM

Q16 Please rate the Desirability and Practicability of subcategory: Forecasting

Answered: 34 Skipped: 0

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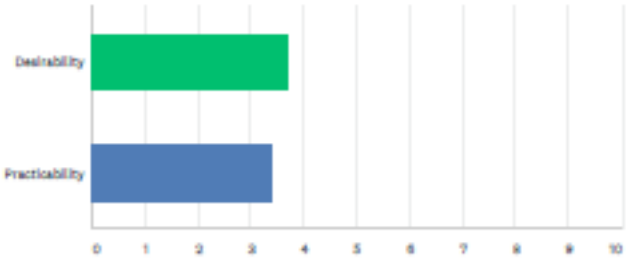


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	2.94% 1	0.00% 0	41.18% 14	38.24% 13	17.65% 6	
Practicability	0.00% 0	9.09% 3	48.48% 16	36.36% 12	6.06% 2	

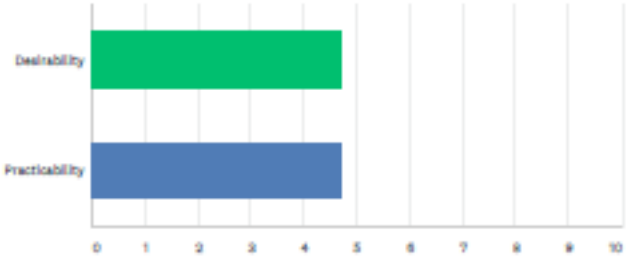
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	3.68	0.87
Practicability	2.00	5.00	3.00	3.39	0.74

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Same as for #15	10/15/2019 11:02 AM
2	Not used	10/9/2019 5:00 PM

Q17 Please rate the Desirability and Practicability of subcategory: Principles of Map Design

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	6.45% 2	19.35% 6	74.19% 23	
Practicability	0.00% 0	0.00% 0	6.25% 2	18.75% 6	75.00% 24	

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.68	0.59
Practicability	3.00	5.00	5.00	4.69	0.58

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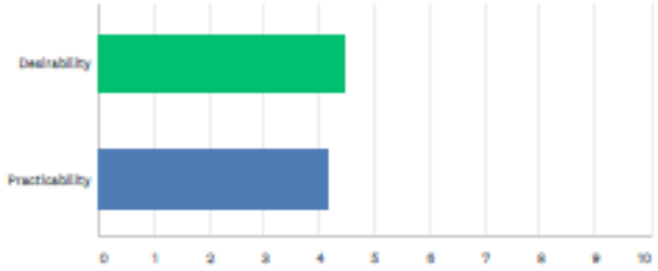
#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 0:47 PM
2	Required	10/9/2019 5:02 PM

Q18 Please rate the Desirability and Practicability of subcategory: Dynamic Mapping

Answered: 32 Skipped: 2



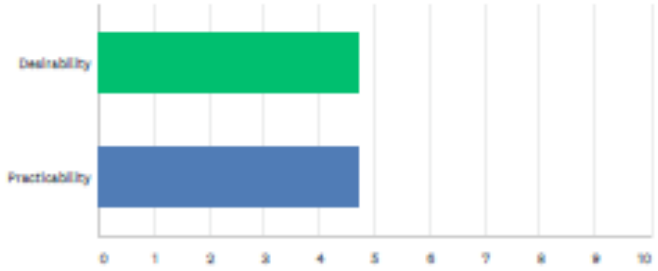
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.23% 1	3.23% 1	38.71% 12	54.84% 17
Practicability	0.00% 0	3.13% 1	12.50% 4	53.13% 17	31.25% 10

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	5.00	4.45	0.71
Practicability	2.00	5.00	4.00	4.13	0.74

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 0:47 PM

Q19 Please rate the Desirability and Practicability of subcategory: Core Cartographic Principles

Answered: 32 Skipped: 2



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	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	3.23% 1	25.81% 8	70.97% 22	
Practicability	0.00% 0	0.00% 0	9.38% 3	12.50% 4	78.13% 25	

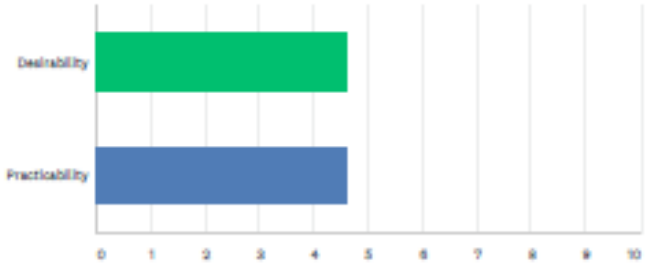
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.68	0.53
Practicability	3.00	5.00	5.00	4.69	0.63

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:47 PM

Q20 Please rate the Desirability and Practicability of subcategory: Data Considerations

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	6.45% 2	25.81% 8	67.74% 21	
Practicability	0.00% 0	0.00% 0	6.25% 2	28.13% 9	65.63% 21	

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.61	0.61
Practicability	3.00	5.00	5.00	4.59	0.61

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:47 PM

Q21 Please rate the Desirability and Practicability of subcategory: Graphic Representation Techniques

Answered: 32 Skipped: 2

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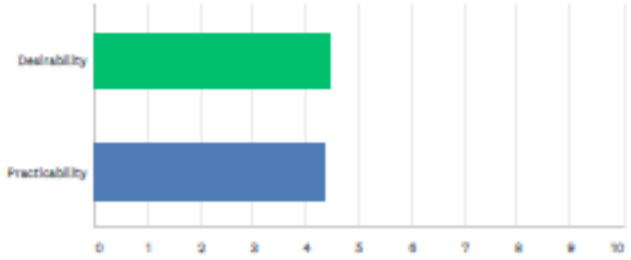


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	9.68% 3	35.48% 11	54.84% 17
Practicability	0.00% 0	0.00% 0	6.25% 2	53.13% 17	40.63% 13

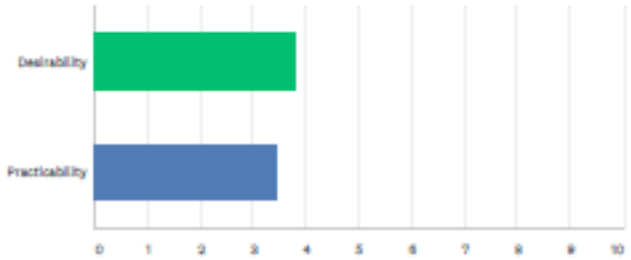
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.45	0.66
Practicability	3.00	5.00	4.00	4.34	0.59

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 0:47 PM

Q22 Please rate the Desirability and Practicability of subcategory: Digital Integrative Mediums and Accesibility/ADA Compliance

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	35.48% 11	51.61% 16	12.90% 4
Practicability	3.13% 1	6.25% 2	43.75% 14	37.50% 12	9.38% 3

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	3.77	0.66
Practicability	1.00	5.00	3.00	3.44	0.86

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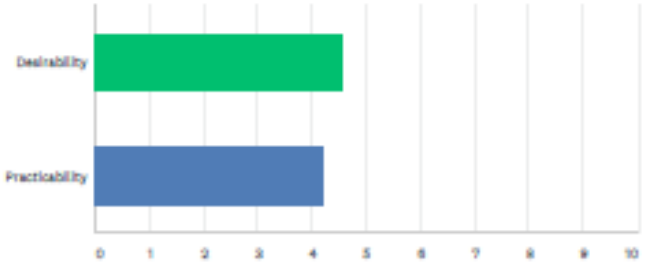
Q23 Please rate the Desirability and Practicability of subcategory: Web and Mobile Mapping and Responsive Design

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	45.16% 14	54.84% 17
Practicability	0.00% 0	6.25% 2	12.50% 4	37.50% 12	43.75% 14

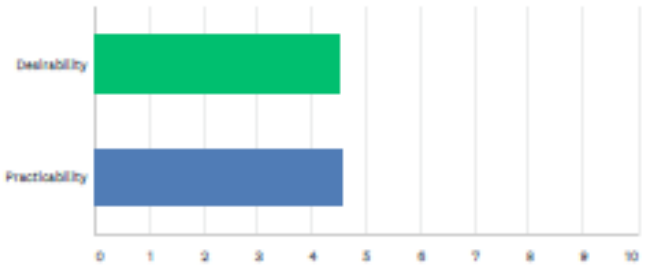
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.55	0.50
Practicability	2.00	5.00	4.00	4.19	0.88

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 0:47 PM

Q24 Please rate the Desirability and Practicability of subcategory: Digital and Physical Map Production

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.45% 2	35.48% 11	58.06% 18
Practicability	0.00% 0	0.00% 0	9.38% 3	28.13% 9	62.50% 20

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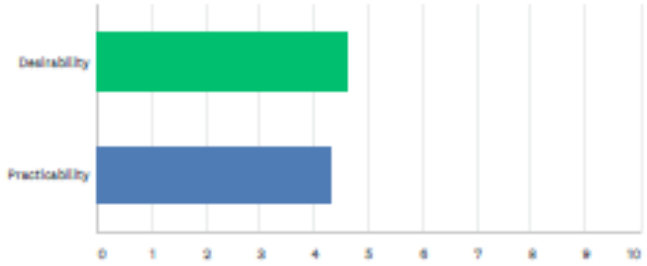
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.52	0.62
Practicability	3.00	5.00	5.00	4.53	0.66

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:47 PM

Q25 Please rate the Desirability and Practicability of subcategory: Web Cartography and Digital Mapping Principles

Answered: 32 Skipped: 2



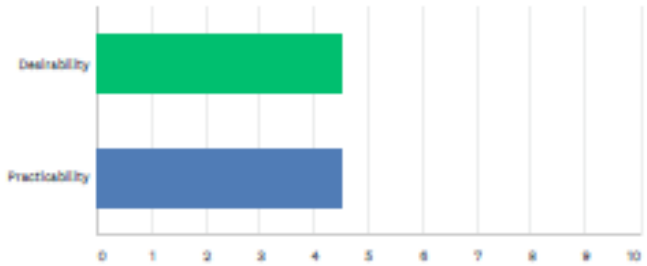
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.45% 2	25.81% 8	67.74% 21
Practicability	0.00% 0	3.13% 1	18.75% 6	21.88% 7	56.25% 18

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.61	0.61
Practicability	2.00	5.00	5.00	4.31	0.88

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:47 PM

Q26 Please rate the Desirability and Practicability of subcategory: Visual Map and Data Interpretation

Answered: 32 Skipped: 2



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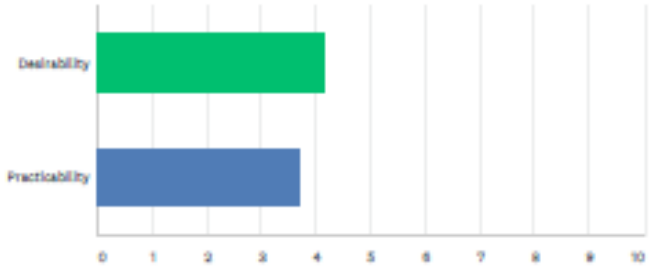
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	3.23% 1	41.94% 13	54.84% 17	
Practicability	0.00% 0	0.00% 0	3.13% 1	46.88% 15	50.00% 16	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.52	0.56
Practicability	3.00	5.00	4.50	4.47	0.56

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:47 PM

Q27 Please rate the Desirability and Practicability of subcategory: GIS&T System Design

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	3.23% 1	9.68% 3	54.84% 17	32.26% 10	
Practicability	0.00% 0	3.13% 1	37.50% 12	46.88% 15	12.50% 4	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	4.16	0.72
Practicability	2.00	5.00	4.00	3.69	0.73

Q28 Please rate the Desirability and Practicability of subcategory: GIS Project Workflows and Modeling

Answered: 32 Skipped: 2

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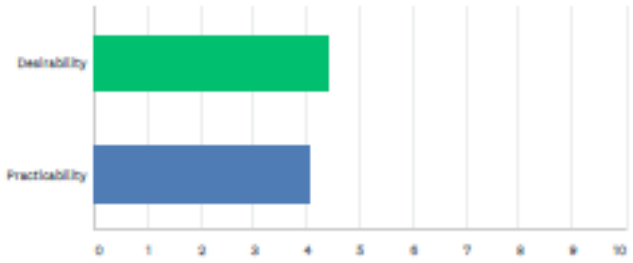


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	9.68% 3	41.94% 13	48.39% 15
Practicability	0.00% 0	3.13% 1	21.88% 7	43.75% 14	31.25% 10

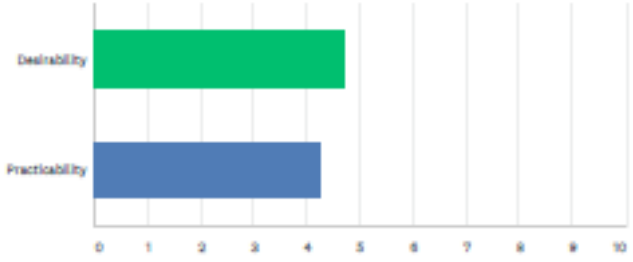
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.39	0.66
Practicability	2.00	5.00	4.00	4.03	0.81

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 0:49 PM

Q29 Please rate the Desirability and Practicability of subcategory: Database Design, Modeling, and Standardization

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	32.26% 10	67.74% 21
Practicability	0.00% 0	3.13% 1	12.50% 4	40.63% 13	43.75% 14

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.68	0.47
Practicability	2.00	5.00	4.00	4.25	0.79

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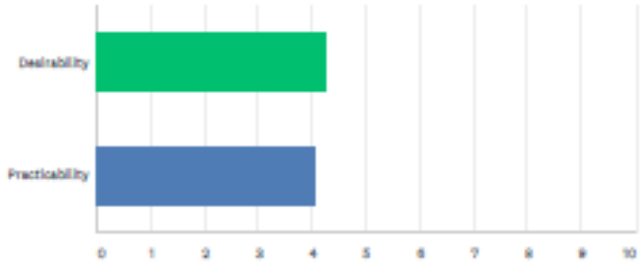
#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:49 PM

Q30 Please rate the Desirability and Practicability of subcategory: Analysis Design

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	12.90% 4	48.39% 15	38.71% 12
Practicability	0.00% 0	6.25% 2	15.63% 5	43.75% 14	34.38% 11

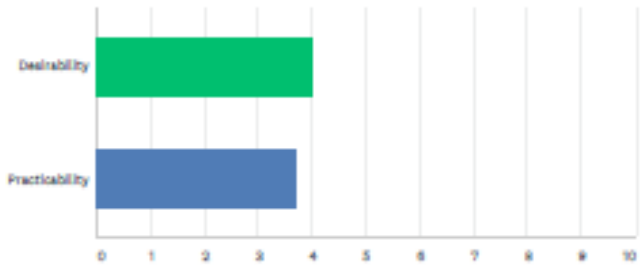
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.26	0.67
Practicability	2.00	5.00	4.00	4.06	0.86

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:49 PM

Q31 Please rate the Desirability and Practicability of subcategory: Application Design and Evaluation

Answered: 32 Skipped: 2



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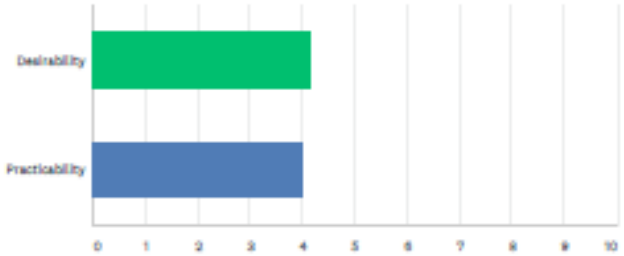
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	22.58% 7	54.84% 17	22.58% 7
Practicability	0.00% 0	3.13% 1	37.50% 12	46.88% 15	12.50% 4

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.00	0.67
Practicability	2.00	5.00	4.00	3.69	0.73

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	We rarely design applications.	10/9/2019 5:10 PM

Q32 Please rate the Desirability and Practicability of subcategory: System Implementation and Data Workflows

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	16.13% 5	51.61% 16	32.26% 10
Practicability	0.00% 0	6.25% 2	25.00% 8	31.25% 10	37.50% 12

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.16	0.68
Practicability	2.00	5.00	4.00	4.00	0.94

Q33 Please rate the Desirability and Practicability of subcategory: Cloud Computing, Storage, and Retrieval

Answered: 32 Skipped: 2

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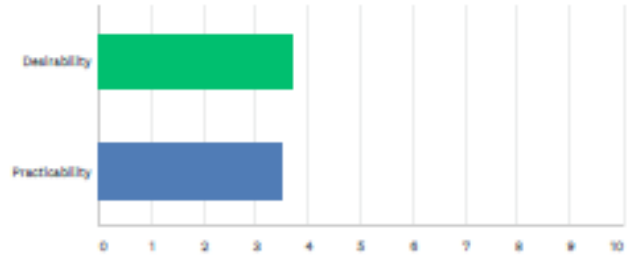


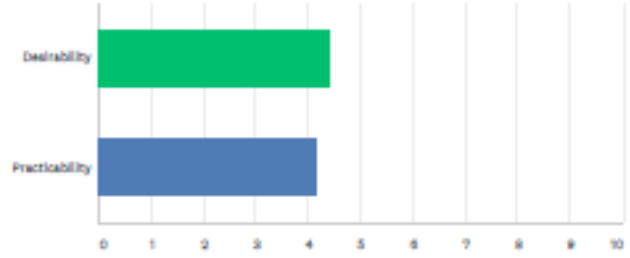
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	6.45% 2	35.48% 11	38.71% 12	19.35% 6
Practicability	6.25% 2	6.25% 2	34.38% 11	40.63% 13	12.50% 4

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.71	0.85
Practicability	1.00	5.00	4.00	3.47	1.00

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	A lot of places have this done by someone in a specialized System Administrator role. KNowledge of cloud concepts is still important.	10/15/2019 8:31 AM
2	Not used.	10/9/2019 5:10 PM

Q34 Please rate the Desirability and Practicability of subcategory: Database Administration

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	3.23% 1	54.84% 17	41.94% 13
Practicability	0.00% 0	6.25% 2	15.63% 5	37.50% 12	40.63% 13

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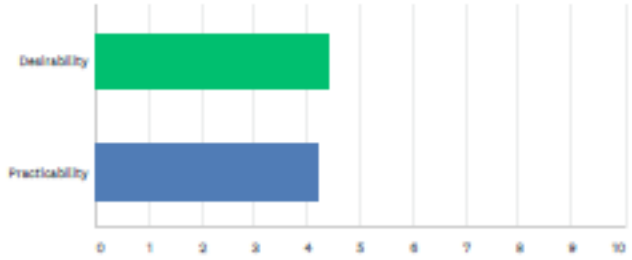
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.39	0.55
Practicability	2.00	5.00	4.00	4.13	0.89

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	A good working knowledge is desirable but this falls into a different work area, at least in my agency	10/15/2019 11:09 AM

Q35 Please rate the Desirability and Practicability of subcategory: Database Management

Answered: 32 Skipped: 2



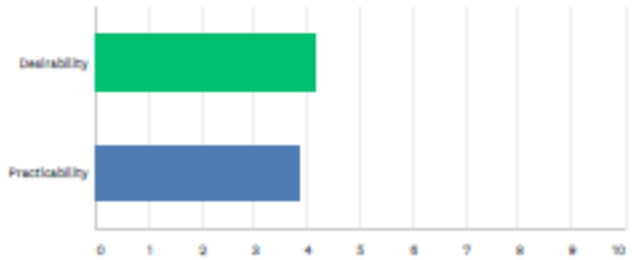
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	3.23% 1	54.84% 17	41.94% 13
Practicability	0.00% 0	3.13% 1	15.63% 5	40.63% 13	40.63% 13

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.39	0.55
Practicability	2.00	5.00	4.00	4.19	0.81

Q36 Please rate the Desirability and Practicability of subcategory: Enterprise System Design

Answered: 32 Skipped: 2



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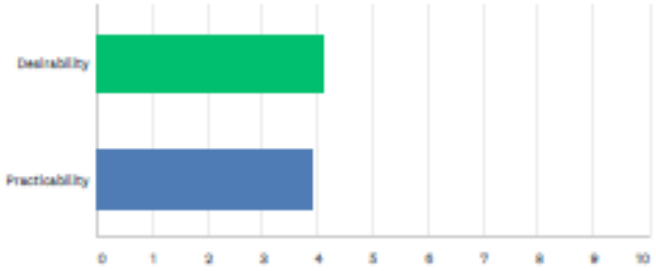
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	12.90% 4	58.06% 18	29.03% 9	
Practicability	0.00% 0	12.50% 4	21.88% 7	34.38% 11	31.25% 10	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.16	0.63
Practicability	2.00	5.00	4.00	3.84	1.00

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	I struggle with how core this is to the GIS profession (or any information system) versus more Information Technology. Definately a desirable skillset within an IT/GIS team but not neccessarily within a GIS professional.	10/15/2019 11:46 AM
2	This seems like a small subset of GIS professionals	10/15/2019 11:09 AM

Q37 Please rate the Desirability and Practicability of subcategory: Basic Storage/Retrieval Structures and Infrastructure Scalability

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	3.23% 1	22.58% 7	35.48% 11	38.71% 12	
Practicability	0.00% 0	3.13% 1	37.50% 12	28.13% 9	31.25% 10	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	4.10	0.86
Practicability	2.00	5.00	4.00	3.88	0.89

Q38 Please rate the Desirability and Practicability of subcategory: Data Organization, File Structures, and Workflows

Answered: 32 Skipped: 2

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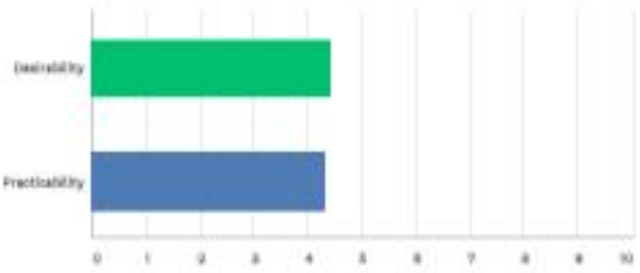


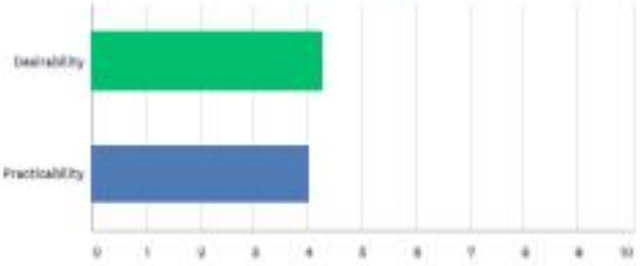
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	12.90% 4	35.48% 11	51.61% 16
Practicability	0.00% 0	0.00% 0	21.88% 7	28.13% 9	50.00% 16

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.39	0.70
Practicability	3.00	5.00	4.50	4.28	0.80

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:49 PM

Q39 Please rate the Desirability and Practicability of subcategory: Relational Database Management Systems

Answered: 32 Skipped: 2



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	9.68% 3	54.84% 17	35.48% 11
Practicability	0.00% 0	3.13% 1	21.88% 7	50.00% 16	25.00% 8

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.26	0.62
Practicability	2.00	5.00	4.00	3.97	0.77

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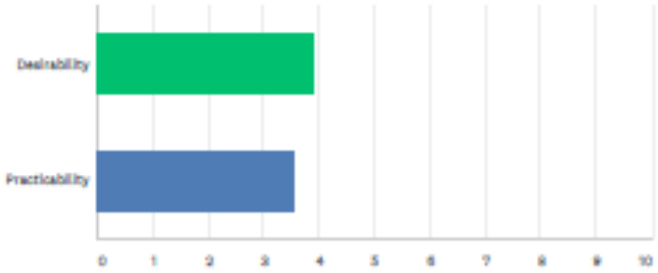
#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:49 PM

Q40 Please rate the Desirability and Practicability of subcategory: Big Data - Storage and Database Management

Answered: 32 Skipped: 2



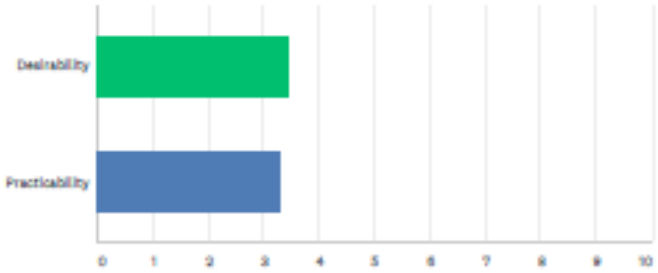
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.23% 1	29.03% 9	45.16% 14	22.58% 7
Practicability	0.00% 0	15.63% 5	31.25% 10	34.38% 11	18.75% 6

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.87	0.79
Practicability	2.00	5.00	4.00	3.56	0.97

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not currently used	10/9/2019 5:10 PM

Q41 Please rate the Desirability and Practicability of subcategory: Tessellation Data Models

Answered: 31 Skipped: 3



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	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	6.67% 2	50.00% 15	36.67% 11	6.67% 2
Practicability	0.00% 0	16.13% 5	48.39% 15	25.81% 8	9.68% 3

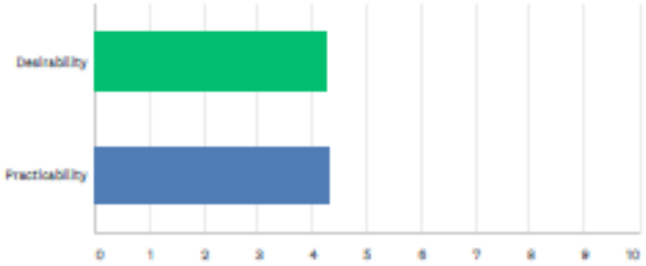
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.43	0.72
Practicability	2.00	5.00	3.00	3.29	0.85

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:50 PM

Q42 Please rate the Desirability and Practicability of subcategory: Vector and Object Data Models

Answered: 31 Skipped: 3



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	10.00% 3	53.33% 16	36.67% 11
Practicability	0.00% 0	0.00% 0	12.90% 4	45.16% 14	41.94% 13

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.27	0.63
Practicability	3.00	5.00	4.00	4.29	0.68

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:50 PM

Q43 Please rate the Desirability and Practicability of subcategory: Multi-dimensional, Uncertain, and Temporal Data Modeling

Answered: 31 Skipped: 3

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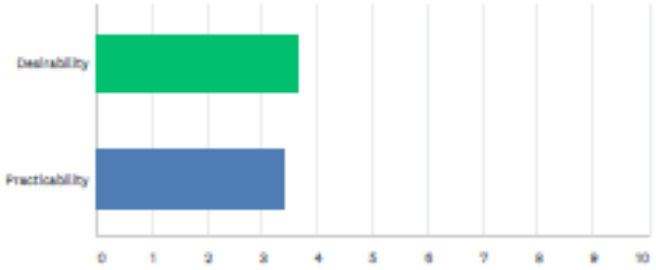


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.33% 1	46.67% 14	30.00% 9	20.00% 6
Practicability	3.23% 1	9.68% 3	45.16% 14	29.03% 9	12.90% 4

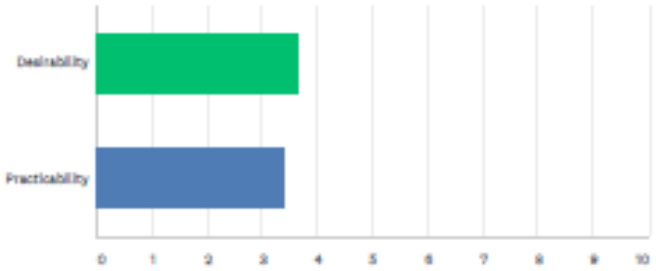
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.50	3.67	0.83
Practicability	1.00	5.00	3.00	3.39	0.94

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	I'm somewhere between a 3-4 on desirability. Certainly nice, but rarely of use beyond visualizations in my world	10/15/2019 11:49 AM
2	This should be core knowledge	10/10/2019 6:50 PM

Q44 Please rate the Desirability and Practicability of subcategory: Big Data Modeling and Analysis

Answered: 31 Skipped: 3



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.33% 1	43.33% 13	36.67% 11	16.67% 5
Practicability	0.00% 0	12.90% 4	45.16% 14	32.26% 10	9.68% 3

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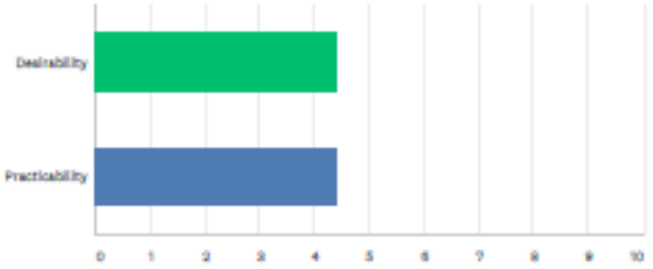
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.67	0.79
Practicability	2.00	5.00	3.00	3.39	0.83

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not used or needed	10/9/2019 5:13 PM

Q45 Please rate the Desirability and Practicability of subcategory: Geospatial File Types and Data Models

Answered: 21 Skipped: 3



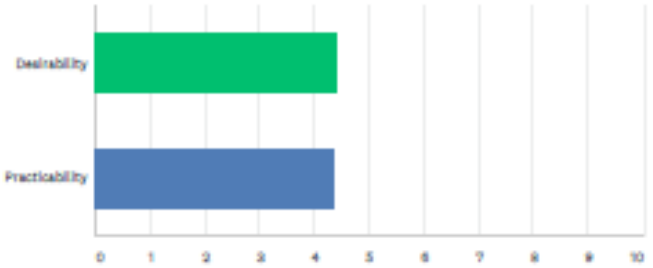
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.67% 2	46.67% 14	46.67% 14
Practicability	0.00% 0	0.00% 0	12.90% 4	32.26% 10	54.84% 17

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.40	0.61
Practicability	3.00	5.00	5.00	4.42	0.71

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:50 PM

Q46 Please rate the Desirability and Practicability of subcategory: Data Representation

Answered: 21 Skipped: 3



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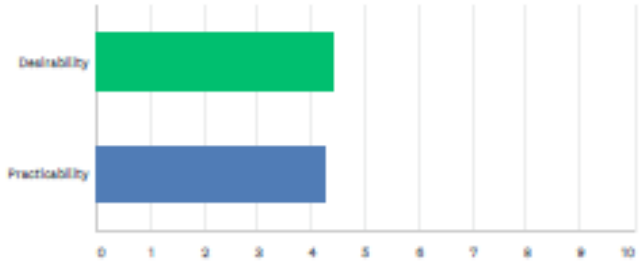
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	10.00% 3	40.00% 12	50.00% 15	
Practicability	0.00% 0	0.00% 0	6.45% 2	51.61% 16	41.94% 13	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.50	4.40	0.66
Practicability	3.00	5.00	4.00	4.35	0.60

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:51 PM

Q47 Please rate the Desirability and Practicability of subcategory: Generalization and Aggregation

Answered: 31 Skipped: 3



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	6.67% 2	50.00% 15	43.33% 13	
Practicability	0.00% 0	0.00% 0	16.13% 5	41.94% 13	41.94% 13	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.37	0.60
Practicability	3.00	5.00	4.00	4.26	0.72

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:51 PM

Q48 Please rate the Desirability and Practicability of subcategory: Transactional Management of Geospatial Data

Answered: 31 Skipped: 3

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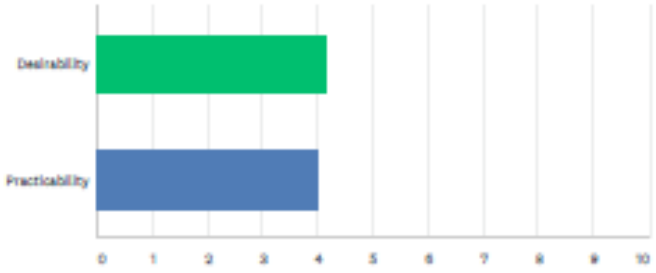


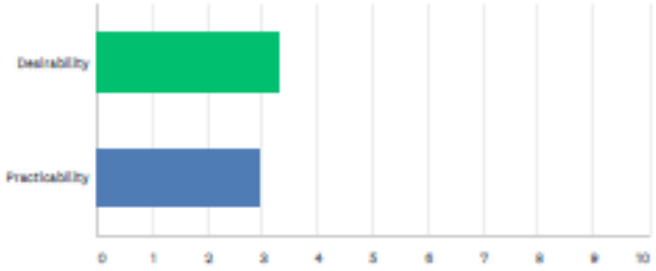
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	20.00% 6	43.33% 13	36.67% 11
Practicability	0.00% 0	3.23% 1	19.35% 6	51.61% 16	25.81% 8

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.17	0.73
Practicability	2.00	5.00	4.00	4.00	0.76

Q49 Please rate the Desirability and Practicability of subcategory: Emergence Computation

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.45% 1	65.52% 19	31.03% 9	0.00% 0
Practicability	6.67% 2	16.67% 5	53.33% 16	23.33% 7	0.00% 0

BASIC STATISTICS

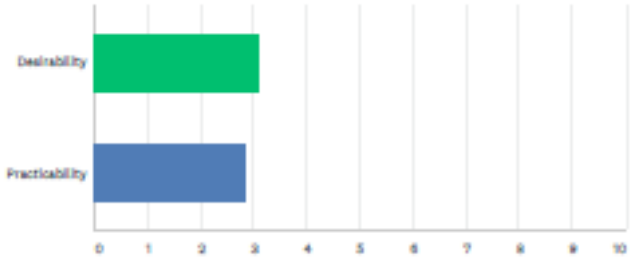
	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	4.00	3.00	3.28	0.52
Practicability	1.00	4.00	3.00	2.93	0.81

Round 2 Survey - Delphi Study - Shannon Doyle

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not sure what this is	10/15/2019 12:55 PM
2	Dont know what this is	10/14/2019 8:00 PM
3	Need to have greater knowledge of mathematics and the theory of emergence computation. What is the cost/benifit?	10/10/2019 2:39 PM
4	Out of scope with regards to maturity of organization.	10/10/2019 10:22 AM
5	Not used	10/9/2019 5:17 PM

Q50 Please rate the Desirability and Practicability of subcategory: Computational Aspects of Geocomputing Cellular Automata (CA) Models

Answered: 30 Skipped: 4



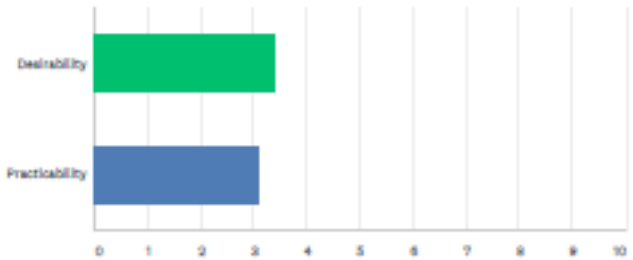
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	13.79% 4	65.52% 19	17.24% 5	3.45% 1
Practicability	3.33% 1	26.67% 8	53.33% 16	16.67% 5	0.00% 0

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.10	0.66
Practicability	1.00	4.00	3.00	2.83	0.73

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Out of scope with regards to maturity of organization.	10/10/2019 10:22 AM
2	Not used	10/9/2019 5:17 PM

Q51 Please rate the Desirability and Practicability of subcategory: Heuristics

Answered: 30 Skipped: 4



Round 2 Survey - Delphi Study - Shannon Doyle

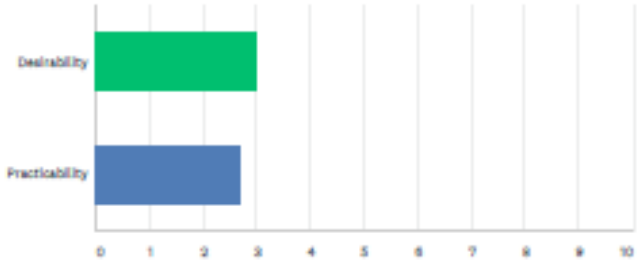
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.45% 1	58.62% 17	31.03% 9	6.90% 2
Practicability	3.33% 1	10.00% 3	66.67% 20	16.67% 5	3.33% 1

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.41	0.67
Practicability	1.00	5.00	3.00	3.07	0.73

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	No strong use case for business analytics	10/10/2019 10:22 AM
2	Not used	10/9/2019 5:17 PM

Q52 Please rate the Desirability and Practicability of subcategory: Genetic Algoritms (GA)

Answered: 20 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.45% 1	17.24% 5	58.62% 17	20.69% 6	0.00% 0
Practicability	6.67% 2	33.33% 10	46.67% 14	13.33% 4	0.00% 0

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	4.00	3.00	2.97	0.72
Practicability	1.00	4.00	3.00	2.67	0.79

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not sure what this is	10/15/2019 12:55 PM
2	I dont know what these are, can have a gis career without them.	10/14/2019 0:00 PM
3	No strong use case for business analytics	10/10/2019 10:22 AM
4	Not used	10/9/2019 5:17 PM

Q53 Please rate the Desirability and Practicability of subcategory: Agent-based Models

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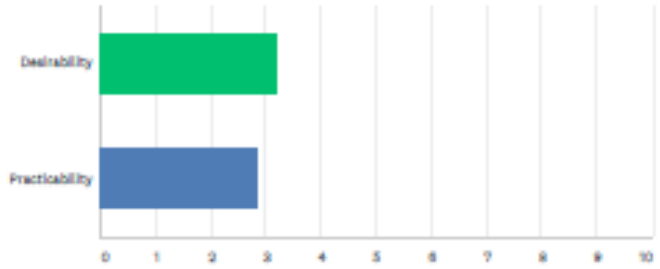
Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	17.24% 5	51.72% 15	27.59% 8	3.45% 1
Practicability	6.67% 2	26.67% 8	43.33% 13	23.33% 7	0.00% 0

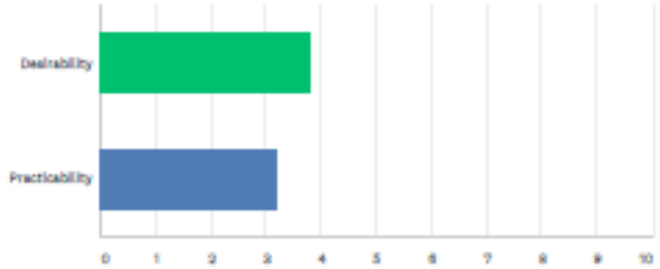
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.17	0.75
Practicability	1.00	4.00	3.00	2.83	0.86

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	No strong use case for business analytics	10/10/2019 10:22 AM
2	Not used	10/9/2019 5:17 PM

Q54 Please rate the Desirability and Practicability of subcategory: Simulation Models

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.45% 1	31.03% 9	51.72% 15	13.79% 4
Practicability	3.33% 1	16.67% 5	46.67% 14	26.67% 8	6.67% 2

Round 2 Survey - Delphi Study - Shannon Doyle

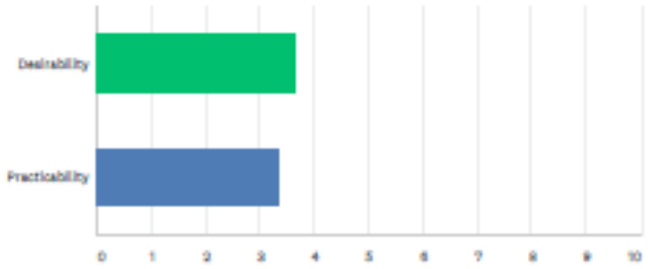
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.76	0.73
Practicability	1.00	5.00	3.00	3.17	0.90

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not used	10/9/2019 5:17 PM

Q55 Please rate the Desirability and Practicability of subcategory: Data Uncertainty

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	6.90% 2	31.03% 9	55.17% 16	6.90% 2
Practicability	3.33% 1	13.33% 4	36.67% 11	40.00% 12	6.67% 2

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.62	0.72
Practicability	1.00	5.00	3.00	3.33	0.91

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Regarded as overly complex and difficult to describe in business analytics.	10/10/2019 10:22 AM
2	Not used	10/9/2019 5:17 PM

Q56 Please rate the Desirability and Practicability of subcategory: Fuzzy Sets

Answered: 30 Skipped: 4

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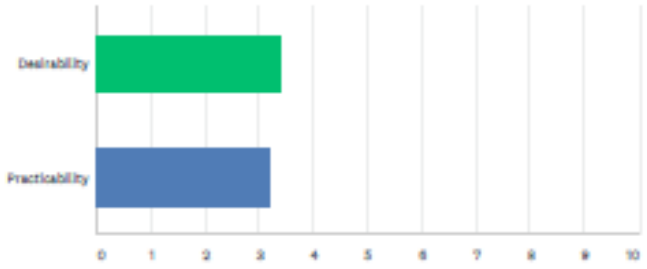


	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	10.34% 3	41.38% 12	44.83% 13	3.45% 1
Practicability	6.67% 2	13.33% 4	36.67% 11	40.00% 12	3.33% 1

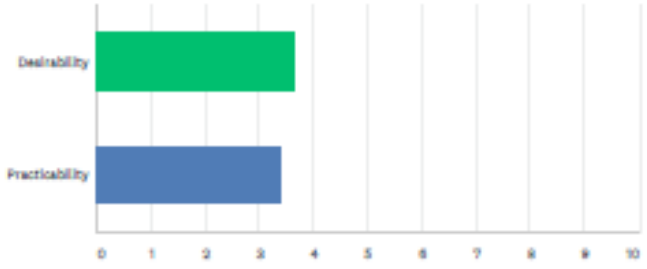
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	3.00	3.41	0.72
Practicability	1.00	5.00	3.00	3.20	0.96

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Not used	10/9/2019 5:17 PM

Q57 Please rate the Desirability and Practicability of subcategory: Multi-scalar Data Sets

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.45% 1	34.48% 10	55.17% 16	6.90% 2
Practicability	3.33% 1	6.67% 2	43.33% 13	43.33% 13	3.33% 1

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.66	0.66
Practicability	1.00	5.00	3.00	3.37	0.80

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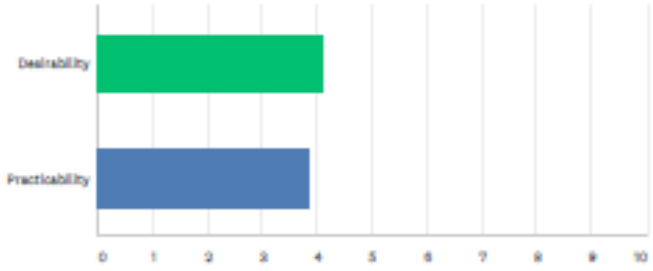
#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	#49-57... they're so specific to certain analytical needs.	10/15/2019 11:45 AM
2	not used	10/9/2019 5:17 PM

Q58 Please rate the Desirability and Practicability of subcategory: Geodesy and Earth Geometry

Answered: 30 Skipped: 4



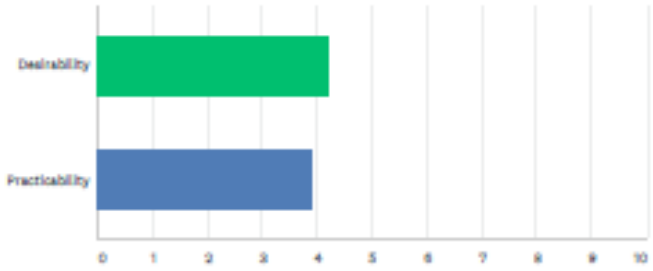
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.45% 1	17.24% 5	44.83% 13	34.48% 10
Practicability	0.00% 0	6.67% 2	33.33% 10	30.00% 9	30.00% 9

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	4.10	0.80
Practicability	2.00	5.00	4.00	3.83	0.93

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Granularity detail of Earth's shape is trivial in business analytics. Seems more of a academic pursuit.	10/10/2019 10:59 AM

Q59 Please rate the Desirability and Practicability of subcategory: Land Partitioning Systems

Answered: 30 Skipped: 4



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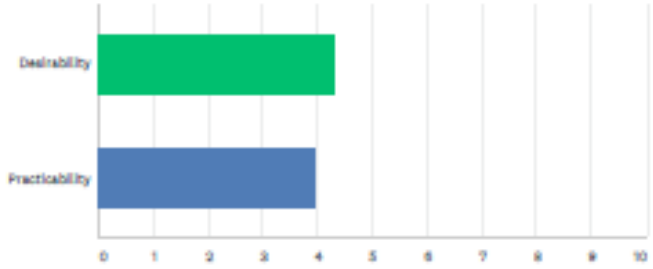
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.45% 1	0.00% 0	13.79% 4	37.93% 11	44.83% 13
Practicability	3.33% 1	0.00% 0	30.00% 9	36.67% 11	30.00% 9

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	4.21	0.92
Practicability	1.00	5.00	4.00	3.90	0.94

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Business users use existing data. Rare (unless geocoding) to create/build new data from instruments.	10/10/2019 10:59 AM

Q60 Please rate the Desirability and Practicability of subcategory: Linear Referencing

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.90% 2	55.17% 16	37.93% 11
Practicability	0.00% 0	3.33% 1	26.67% 8	43.33% 13	26.67% 8

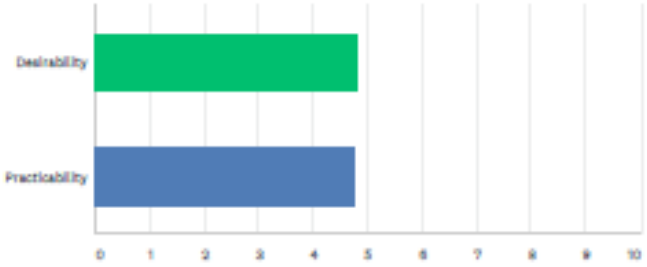
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.31	0.59
Practicability	2.00	5.00	4.00	3.93	0.81

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Rare to require linear referencing in business analytics.	10/10/2019 10:59 AM

Q61 Please rate the Desirability and Practicability of subcategory: Data Quality and Data Integrity

Answered: 30 Skipped: 4

Round 2 Survey - Delphi Study - Shannon Doyle



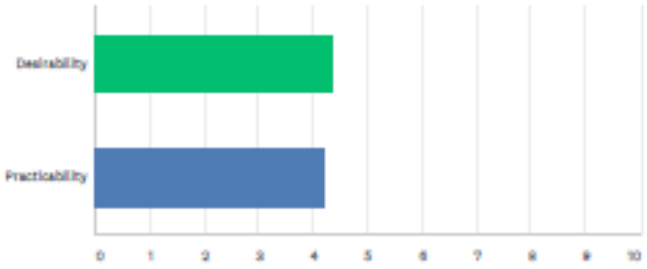
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	20.69% 6	79.31% 23
Practicability	0.00% 0	0.00% 0	6.67% 2	13.33% 4	80.00% 24

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.79	0.41
Practicability	3.00	5.00	5.00	4.73	0.57

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM

Q62 Please rate the Desirability and Practicability of subcategory: Datums

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.90% 2	51.72% 15	41.38% 12
Practicability	0.00% 0	3.33% 1	16.67% 5	36.67% 11	43.33% 13

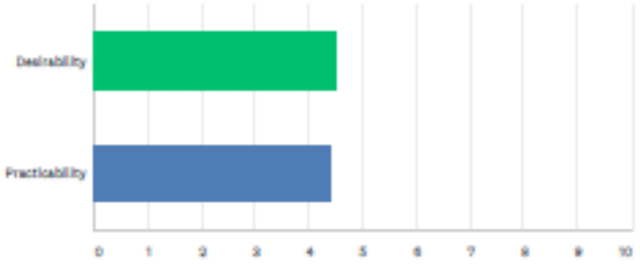
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.34	0.60
Practicability	2.00	5.00	4.00	4.20	0.83

Round 2 Survey - Delphi Study - Shannon Doyle

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Meh, sometime these can be useful in study areas near water boundaries, but usually because geocodes locate in water.	10/10/2019 10:59 AM

Q63 Please rate the Desirability and Practicability of subcategory: Map Projections

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	48.28% 14	51.72% 15
Practicability	0.00% 0	0.00% 0	10.00% 3	43.33% 13	46.67% 14

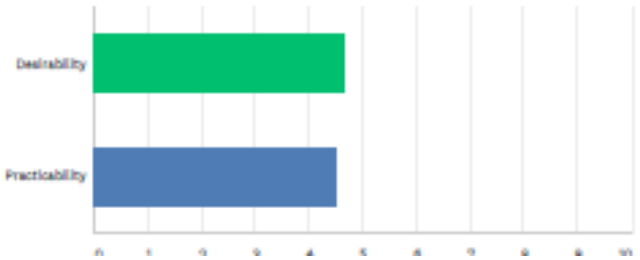
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.52	0.50
Practicability	3.00	5.00	4.00	4.37	0.66

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Standardizing on most common web map projection (Google) mitigates perceived errors in Shape, Size, Direction & Distance that another projection can introduce.	10/10/2019 10:59 AM

Q64 Please rate the Desirability and Practicability of subcategory: Georeferencing Systems

Answered: 30 Skipped: 4



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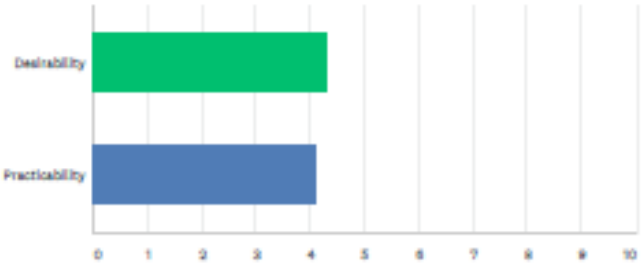
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	37.93% 11	62.07% 18
Practicability	0.00% 0	0.00% 0	6.67% 2	36.67% 11	56.67% 17

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.62	0.49
Practicability	3.00	5.00	5.00	4.50	0.62

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Ability to rubber-sheet CAD and other map formats in non-GIS data types (PDF,JPEG,etc...) is great for providing context with your own data.	10/10/2019 10:59 AM

Q65 Please rate the Desirability and Practicability of subcategory: Land Surveying and GPS

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.45% 1	0.00% 0	0.00% 0	55.17% 16	41.38% 12
Practicability	0.00% 0	0.00% 0	13.33% 4	66.67% 20	20.00% 6

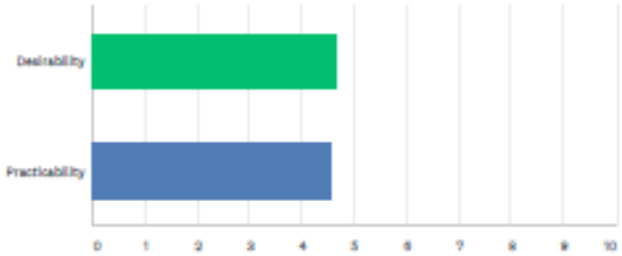
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	4.31	0.79
Practicability	3.00	5.00	4.00	4.07	0.57

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	The use of survey data is vaulable, but only as a consumable end product. Business Analytics rarely requires field collection of data.	10/10/2019 10:59 AM

Q66 Please rate the Desirability and Practicability of subcategory: Digitization and Vectorization

Answered: 30 Skipped: 4

Round 2 Survey - Delphi Study - Shannon Doyle



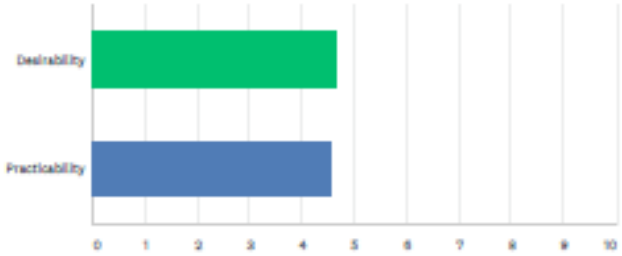
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	6.90% 2	20.69% 6	72.41% 21
Practicability	0.00% 0	0.00% 0	6.67% 2	33.33% 10	60.00% 18

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.66	0.60
Practicability	3.00	5.00	5.00	4.53	0.62

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Rare to create new data in business analytics.	10/10/2019 10:59 AM

Q67 Please rate the Desirability and Practicability of subcategory: Field Data Collection and Quality

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	3.45% 1	27.59% 8	68.97% 20
Practicability	0.00% 0	0.00% 0	6.67% 2	33.33% 10	60.00% 18

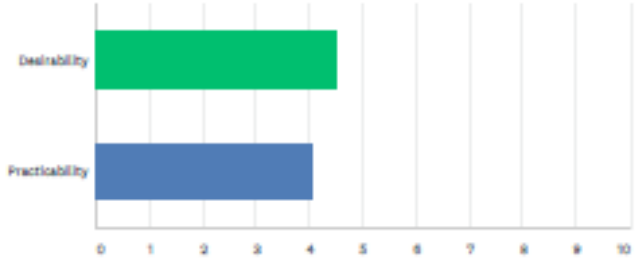
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.66	0.54
Practicability	3.00	5.00	5.00	4.53	0.62

Round 2 Survey - Delphi Study - Shannon Doyle

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Used to correct bad geocodes and provide more precise and accurate data. Important for positive public perception of company locations on a public facing website or app.	10/10/2019 10:59 AM

Q68 Please rate the Desirability and Practicability of subcategory: Aerial Imagery and Photogrammetry

Answered: 20 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	0.00% 0	48.28% 14	51.72% 15
Practicability	0.00% 0	3.33% 1	20.00% 6	46.67% 14	30.00% 9

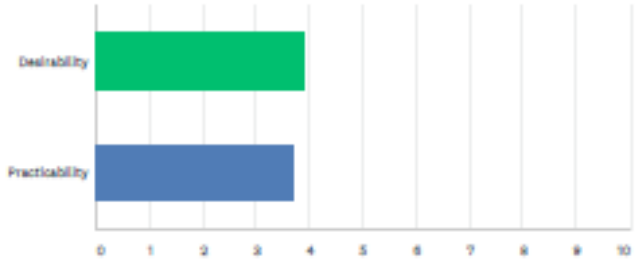
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.52	0.50
Practicability	2.00	5.00	4.00	4.03	0.80

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Mostly used as eye-candy and educating end users on the scale of other geography. Low ROI for anything beyond contextual maps.	10/10/2019 10:59 AM

Q69 Please rate the Desirability and Practicability of subcategory: Satellite and Shipboard Remote Sensing

Answered: 20 Skipped: 4



Round 2 Survey - Delphi Study - Shannon Doyle

	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.45% 1	0.00% 0	27.59% 8	41.38% 12	27.59% 8
Practicability	0.00% 0	0.00% 0	46.67% 14	36.67% 11	16.67% 5

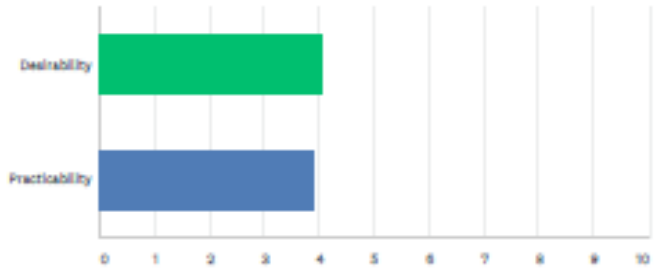
BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	3.90	0.92
Practicability	3.00	5.00	4.00	3.70	0.74

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This is consistently outsourced so knowledge is kind of desirable to communicate with vendors.	10/15/2019 12:08 PM
2	Real-time analytics unnecessary in most use cases for business geographics.	10/10/2019 10:59 AM

Q70 Please rate the Desirability and Practicability of subcategory: UAS Data Collection

Answered: 30 Skipped: 4



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	3.45% 1	0.00% 0	17.24% 5	48.28% 14	31.03% 9
Practicability	0.00% 0	0.00% 0	33.33% 10	43.33% 13	23.33% 7

BASIC STATISTICS

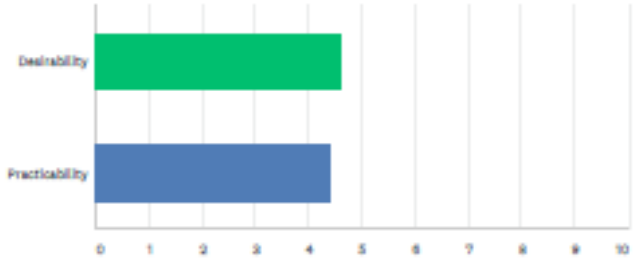
	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	1.00	5.00	4.00	4.03	0.89
Practicability	3.00	5.00	4.00	3.90	0.75

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Limited use case for business analytics. could be used for niche projects, but overall too detailed for most needs.	10/10/2019 10:59 AM

Q71 Please rate the Desirability and Practicability of subcategory: Mobile Data Collection

Answered: 30 Skipped: 4

Round 2 Survey - Delphi Study - Shannon Doyle



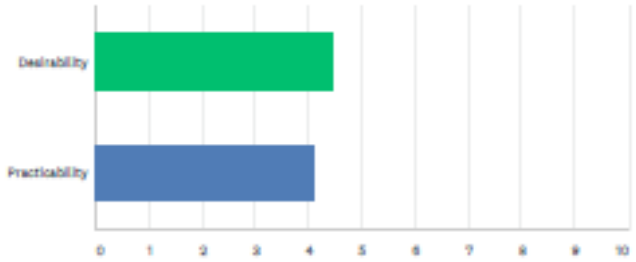
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	3.45% 1	34.48% 10	62.07% 18
Practicability	0.00% 0	3.33% 1	6.67% 2	36.67% 11	53.33% 16

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.59	0.56
Practicability	2.00	5.00	5.00	4.40	0.76

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:54 PM
2	Important for keeping field data accurate and up to date.	10/10/2019 10:59 AM

Q72 Please rate the Desirability and Practicability of subcategory: Metadata

Answered: 29 Skipped: 5



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	14.29% 4	28.57% 8	57.14% 16
Practicability	0.00% 0	6.90% 2	17.24% 5	34.48% 10	41.38% 12

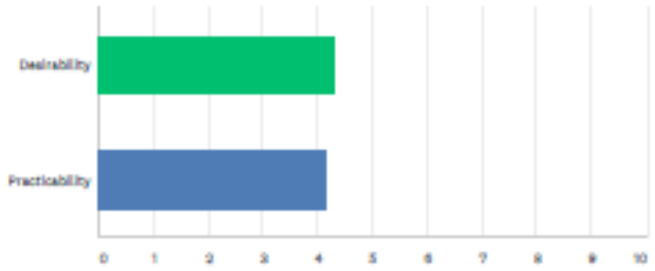
BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.43	0.73
Practicability	2.00	5.00	4.00	4.10	0.92

Round 2 Survey - Delphi Study - Shannon Doyle

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Tough to dedicate energy to; not enough business value	10/15/2019 12:09 PM
2	This should be core knowledge	10/10/2019 6:55 PM

Q73 Please rate the Desirability and Practicability of subcategory: Ethical Considerations

Answered: 29 Skipped: 5



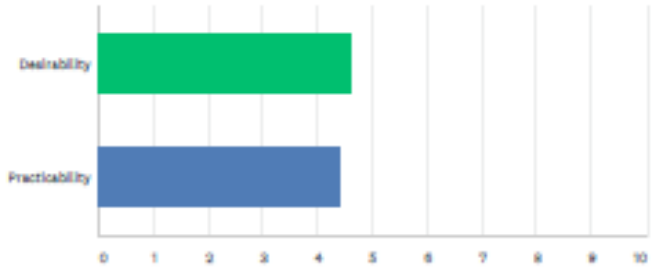
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	10.71% 3	46.43% 13	42.86% 12
Practicability	0.00% 0	0.00% 0	20.69% 6	41.38% 12	37.93% 11

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.32	0.66
Practicability	3.00	5.00	4.00	4.17	0.75

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:55 PM

Q74 Please rate the Desirability and Practicability of subcategory: Data Integration

Answered: 29 Skipped: 5



Round 2 Survey - Delphi Study - Shannon Doyle

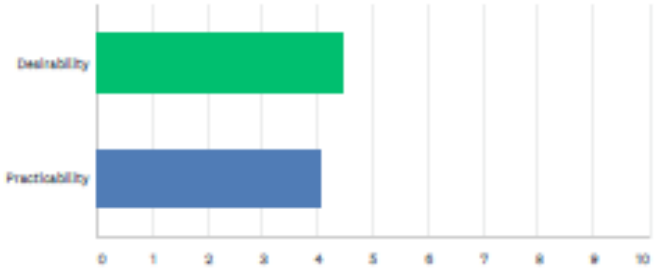
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	0.00% 0	39.29% 11	60.71% 17	
Practicability	0.00% 0	3.45% 1	13.79% 4	24.14% 7	58.62% 17	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	4.00	5.00	5.00	4.61	0.49
Practicability	2.00	5.00	5.00	4.38	0.85

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	This should be core knowledge	10/10/2019 6:55 PM

Q75 Please rate the Desirability and Practicability of subcategory: Scripting and Automation

Answered: 29 Skipped: 5



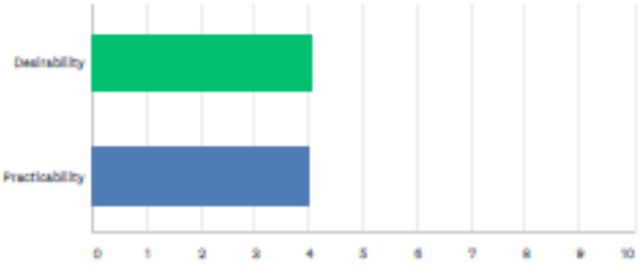
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)	
Desirability	0.00% 0	0.00% 0	10.71% 3	35.71% 10	53.57% 15	
Practicability	3.45% 1	3.45% 1	17.24% 5	37.93% 11	37.93% 11	

BASIC STATISTICS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	5.00	4.43	0.68
Practicability	1.00	5.00	4.00	4.03	1.00

Q76 Please rate the Desirability and Practicability of subcategory: Asset Management

Answered: 29 Skipped: 5

Round 2 Survey - Delphi Study - Shannon Doyle



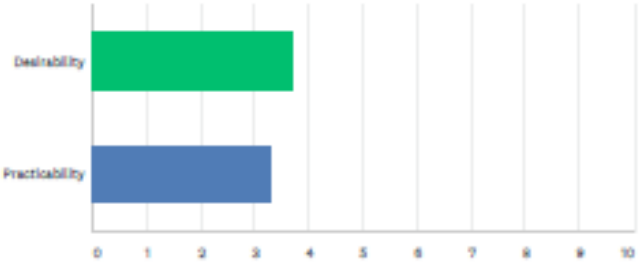
	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	0.00% 0	21.43% 6	53.57% 15	25.00% 7
Practicability	0.00% 0	0.00% 0	24.14% 7	51.72% 15	24.14% 7

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	3.00	5.00	4.00	4.04	0.68
Practicability	3.00	5.00	4.00	4.00	0.69

Q77 Please rate the Desirability and Practicability of subcategory: Machine Learning

Answered: 29 Skipped: 5



	1 - VERY UNDESIRABLE/VERY IMPRACTICAL (1)	2 - UNDESIRABLE/IMPRACTICAL (2)	3 - NEITHER DESIRABLE NOR UNDESIRABLE/NEITHER PRACTICABLE NOR IMPRACTICAL (3)	4 - DESIRABLE/PRACTICABLE (4)	5 - VERY DESIRABLE/VERY PRACTICABLE (5)
Desirability	0.00% 0	3.57% 1	39.29% 11	39.29% 11	17.86% 5
Practicability	6.90% 2	6.90% 2	51.72% 15	17.24% 5	17.24% 5

BASIC STATISTICS

	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION
Desirability	2.00	5.00	4.00	3.71	0.80
Practicability	1.00	5.00	3.00	3.31	1.05

#	USE THIS SPACE IF YOU WISH TO PROVIDE RATIONALE FOR CHOOSING A RATING OF 1 OR 2, OR TO PROVIDE GENERAL COMMENTS.	DATE
1	Hard to describe to non-analytics people.	10/10/2019 11:03 AM

Appendix J: Analysis Matrix

	Column 1	Column 2	Column 3	Column 4
Category/Competency	**Desirable and Practicable**	**Desirable and Impractical**	**Undesirable and Impractical**	**Undesirable and Practicable**
Analytical Methods Category				
Query Operations and Languages	X			
Geometric Measures	X			
Basic Analytical Operations and Methods	X			
Raster Analysis		X		
Surface Analysis and Derived Data		X		
Subsurface and AGL Analyses			X	
Spatial Statistics and Geostatistics		X		
Spatial Regression and Econometrics			X	
Data Mining	X			
Network Analysis	X			
Optimization and Location-Allocation		X		
Spatio-Temporal Modeling and Analysis		X		
Error Modeling			X	
Spatial Modeling and Analysis	X			
Forecasting			X	
Cartography and Visualization Category				
Principles of Map Design	X			
Dynamic Mapping	X			
Core Cartographic Principles	X			
Data Considerations	X			
Graphic Representation Techniques	X			
Digital Integrative Mediums and Accessibility/ADA Compliance			X	
Web and Mobile Mapping and Responsive Design	X			
Digital and Physical Map Production	X			
Web Cartography and Digital Mapping Principles	X			

Visual Map and Data Interpretation	X			
Design Aspects Category				
GIS&T System Design		X		
GIS Project Workflows and Modeling	X			
Database Design, Modeling, and Standardization	X			
Analysis Design	X			
Application Design and Evaluation		X		
System Implementation and Data Workflows		X		
Cloud Computing, Storage, and Retrieval			X	
Database Administration	X			
Database Management	X			
Enterprise System Design		X		
Basic Storage/Retrieval Structures and Infrastructure Scalability			X	
Data Organization, File Structures, and Workflows	X			
Relational Database Management Systems	X			
Big Data - Storage and Database Management			X	
Data Modeling Category				
Tessellation Data Models			X	
Vector and Object Data Models	X			
Multi-dimensional, Uncertain, and Temporal Data Modeling			X	
Big Data Modeling and Analysis			X	
Geospatial File Types and Data Models	X			
Data Manipulation Category				
Data Representation	X			
Generalization and Aggregation	X			
Transactional Management of Geospatial Data	X			
Geocomputation				
Emergence Computation			X	

Computational Aspects of Geocomputing Cellular Automata (CA) Models			X	
Heuristics			X	
Genetic Algorithms (GA)			X	
Agent-based Models			X	
Simulation Models			X	
Data Uncertainty			X	
Fuzzy Sets			X	
Multi-scalar Data Sets			X	
Geospatial Data				
Geodesy and Earth Geometry		X		
Land Partitioning Systems		X		
Linear Referencing		X		
Data Quality and Data Integrity	X			
Datums	X			
Map Projections	X			
Georeferncing Systems	X			
Land Surveying and GPS	X			
Digitization and Vectorization	X			
Field Data Collection and Quality	X			
Aerial Imagery and Photogrammetry	X			
Satellite and Shipboard Remote Sensing			X	
UAS Data Collection		X		
Mobile Data Collection	X			
Additional Competencies Category				
Metadata	X			
Ethical Considerations	X			
Data Integration	X			
Scripting and Automation	X			
Asset Management	X			
Machine Learning			X	
	41	**13**	**22**	**0**

Appendix K: Round 3 Survey

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Welcome to Rounds 3 and 4!

- Competencies included in Round 3 reflect current and future geospatial industry needs that were rated Desirable and Practicable by a majority of the panel in Round 2.
- Please refer to the Analysis Matrix attached, which summarizes the results of Round 2. Use the spaces provided under each survey question to provide comments.
- Rounds 3 and 4 have been combined in this survey. The estimated time to complete the five questions below is approximately 10-15 minutes.
- You can pause your responses as needed and finish later. Upon completion, please click Done.

* 1. Please confirm your email address. This will ensure I am able to share the final study results with you.

NOTE: All email addresses will be kept confidential and will only be seen by me. No personal identifiable information will be shared with anyone, and SurveyMonkey's privacy policy also ensures information will be kept confidential and private.

Analysis Matrix

Category/Competency	Column 1 Desirable and Practicable	Column 2 Desirable and Impractical	Column 3 Undesirable and Impractical	Column 4 Undesirable and Practicable
Analytical Methods Category				
Query Operations and Languages	X			
Geometric Measures	X			
Basic Analytical Operations and Methods	X			
Raster Analysis		X		
Surface Analysis and Derived Data		X		
Subsurface and AGL Analyses			X	
Spatial Statistics and Geostatistics		X		
Spatial Regression and Econometrics			X	
Data Mining	X			
Network Analysis	X			
Optimization and Location-Allocation		X		
Spatio-Temporal Modeling and Analysis		X		
Error Modeling			X	
Spatial Modeling and Analysis	X			
Forecasting			X	
Cartography and Visualization Category				
Principles of Map Design	X			
Dynamic Mapping	X			
Core Cartographic Principles	X			
Data Considerations	X			
Graphic Representation Techniques	X			
Digital Integrative Mediums and Accesibility/ADA Compliance			X	
Web and Mobile Mapping and Responsive Design	X			
Digital and Physical Map Production	X			
Web Cartography and Digital Mapping Principles	X			
Visual Map and Data Interpretation	X			
Design Aspects Category				
GIS&T System Design		X		
GIS Project Workflows and Modeling	X			
Database Design, Modeling, and Standardization	X			
Analysis Design	X			
Application Design and Evaluation		X		
System Implementation and Data Workflows		X		
Cloud Computing, Storage, and Retrieval			X	
Database Administration	X			
Database Management	X			
Enterprise System Design		X		
Basic Storage/Retrieval Structures and Infrastructure Scalability		X		
Data Organization, File Structures, and Workflows	X			
Relational Database Management Systems	X			
Big Data - Storage and Database Management			X	
Data Modeling Category				
Tessellation Data Models			X	
Vector and Object Data Models	X			
Multi-dimensional, Uncertain, and Temporal Data Modeling			X	
Big Data Modeling and Analysis			X	
Geospatial File Types and Data Models	X			
Data Manipulation Category				
Data Representation	X			
Generalization and Aggregation	X			
Transactional Management of Geospatial Data	X			
Geocomputation				
Emergence Computation			X	
Computational Aspects of Geocomputing Cellular Automata (CA) Models			X	
Heuristics			X	
Genetic Algorithms (GA)			X	
Agent-based Models			X	
Simulation Models			X	
Data Uncertainty			X	
Fuzzy Sets			X	
Multi-scalar Data Sets			X	
Geospatial Data				
Geodesy and Earth Geometry		X		
Land Partitioning Systems		X		
Linear Referencing		X		
Data Quality and Data Integrity	X			
Datums	X			
Map Projections	X			
Georeferncing Systems	X			
Land Surveying and GPS	X			
Digitization and Vectorization	X			
Field Data Collection and Quality	X			
Aerial Imagery and Photogrammetry	X			
Satellite and Shipboard Remote Sensing		X		
UAS Data Collection		X		
Mobile Data Collection	X			
Additional Competecies Category				
Metadata	X			
Ethical Considerations	X			
Data Integration	X			
Scripting and Automation	X			
Asset Management	X			
Machine Learning			X	

2. Please review the attached Analysis Matrix. If you would like to change the Column number for any items/competencies in the matrix, list the competency and the new Column number. Thank you.

3. If you have any comments regarding what could be done to change or improve item ratings for items that were rated Desirable and Impractical (Column 2), so that they become Desirable and Practicable (Column 1), please use this space. Thank you.

4. If you have any comments regarding items that were rated Undesirable and Impractical (Column 3), please use this space. Thank you.

* 5. Please rate your **Overall Confidence** with the full list of items and ratings in the Analysis Matrix attached to this survey.

1 - Unreliable (great risk of being wrong)	2 - Risky (substantial risk of being wrong)	3 - Neither Reliable nor Unreliable	4 - Reliable (some risk of being wrong)	5 - Certain (low risk of being wrong)
○	○	○	○	○

Use this space if you wish to provide additional comments.

NEW QUESTION

or Copy and paste questions

Next

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Thank you!

Thank you for your time, participation, and support throughout this process. You have completed all the required rounds of survey. I appreciate your feedback and willingness to take part in my research study. I will send you the final results at the completion and approval of the study. Thanks again!

Appendix L: Round 3 Data

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Q2 Please review the attached Analysis Matrix. If you would like to change the Column number for any items/competencies in the matrix, list the competency and the new Column number. Thank you.

Answered: 12 Skipped: 12

#	RESPONSES	DATE
1	If meant to reflect a current state I think the results are reflective. If meant to reflect a future state I think the Geocomputation results should be given more importance, and maybe more focus on multi-scalar & fuzzy sets. I also expect more need in the future for Machine Learning, UAS, & Data Modeling in general	10/25/2019 10:25 AM
2	Forecasting 2	10/25/2019 9:49 AM
3	In hindsight I might move the Big Data related items to Column 1	10/24/2019 1:13 PM
4	Query Operations and Languages should be changed to column 2; Data Mining should be column 2	10/24/2019 11:04 AM
5	UAS Data Collection Move to 1 GIS&T System Design Move to 1 System Implementation & Data Workflows Move to 1	10/24/2019 10:08 AM
6	No change.	10/23/2019 6:20 PM
7	I don't consider raster analysis impractical. I think it belongs in column 1. Cloud computing and big data storage may not be practical for small business, but they are essential to larger businesses and should be moved up.	10/23/2019 11:26 AM
8	Raster Analysis - 1 Spatial Statistics and Geostatistics - 1 Digital Integrative Mediums and Accessibility/ADA Compliance - 2 System Implementation and Data Workflows - 1 GIS&T System Design - 1 Cloud Computing, Storage and Retrieval - 2 Geodesy and Earth Geometry - 1 Land Partitioning Systems - 1 UAS Data Collection -1	10/23/2019 10:20 AM
9	Cloud computing, storage and retrieval should be Desirable and Impractical	10/22/2019 2:54 PM
10	"needs that were rated Desirable and Practicable by a majority of the panel in Round 2." I would change a number of items to reflect my original survey results. I don't understand the purpose of this exercise, since my individual results will be lost in the law of averages. If I make a change to a category, it will require a majority of respondents to agree to change the results, in order to make a difference. If the purpose is to track if my opinion has changed since the last questionnaire, then, no, I have no edits to make and please refer to my last questionnaire to see how I weighted these categories. Furthermore, these results are the synthesis/aggregation of the previous survey, so again, I don't understand the value of this logic. If these reflect my original (individual) responses, then I think there is a mistake in the data?! Since, I am fairly certain, some of these categories don't reflect the choices I made in the last round.	10/22/2019 7:41 AM
11	As a whole I think the matrix is a fair representation. I am saying this as a 20 year GIS professional in a the water and wastewater industry. I graduated in the mid 1990's.	10/21/2019 4:13 PM
12	NA	10/21/2019 3:58 PM

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Q3 If you have any comments regarding what could be done to change or improve item ratings for items that were rated Desirable and Impractical (Column 2), so that they become Desirable and Practicable (Column 1), please use this space. Thank you.

Answered: 8 Skipped: 16

#	RESPONSES	DATE
1	not specific, but greater collaboration with computer sciences to develop more accessible tools for the geosciences.	10/25/2019 10:25 AM
2	No comment.	10/23/2019 6:20 PM
3	Raster analysis was the original basis of GIS. Send those kids back to school and have them take some classes on raster analysis. If the issue is software, use software, simply use software that handles rasters. The first 3 items under "Geospatial Data" should have been taught in school. Why are these classed as impractical? These are basic concepts that all GIS analysis should have a grasp of. Again, send your technicians to a class. There are many available.	10/23/2019 11:26 AM
4	I think providing better examples of tasks in these areas might be helpful. Also reminding folks completing the survey that this is based on what a qualified should know rather than necessarily be doing.	10/23/2019 10:20 AM
5	Items in this category may indicate specialties that are just not applicable to the general GIS practitioner. They may be important...just not relevant across the skills sets from basic to advanced GIS users.	10/22/2019 11:59 AM
6	I feel the ratings are not necessarily a reflection of the GIS industry, but a reflection of the industry or group that GIS professionals belong. For my day to day needs, certain functionality is impractical or unusable, however, if I had a different role, then my needs would change. For example, as a business GIS professional, I have little to no use of subsurface and AGL analysis. Yes, I could probably find a way to apply this modeling technique to street networks in one-way city centers, but it would be impractical and would be difficult for me to explain to non-GIS people. If my job changed to working with natural resources, a utility or a water district, then this functionality might be critical and the use of Big Data modeling may be useless. In other words, depending on where you work, your needs will change. It doesn't mean the category isn't valuable for the GIS community, it means a category will get scored lower because people are not familiar with its use related to their job. It seems that you need a category related to industry or job title/area/department of work in order to group or identify the trends or patterns that may exist in this research.	10/22/2019 7:41 AM
7	I see the Desirable and Impractical items two ways. There are some that are new to the industry (UAV's and some of the IT centric items such as system design) and others that have been around a while such as the Geodesy and Spatial Statistics. The items that are new to the industry will become more practical as they are adopted in the workplace, thereby creating a need for education and training in college . Items such as Geodesy and Spatial statistics could also be addressed in college. The challenge is trying to get everything in a degree program. Maybe the answer is specialization in a graduate program, or professional certificates. Ultimately the job market will drive skillsets.	10/21/2019 4:13 PM
8	NA	10/21/2019 3:58 PM

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Q4 If you have any comments regarding items that were rated Undesirable and Impractical (Column 3), please use this space. Thank you.

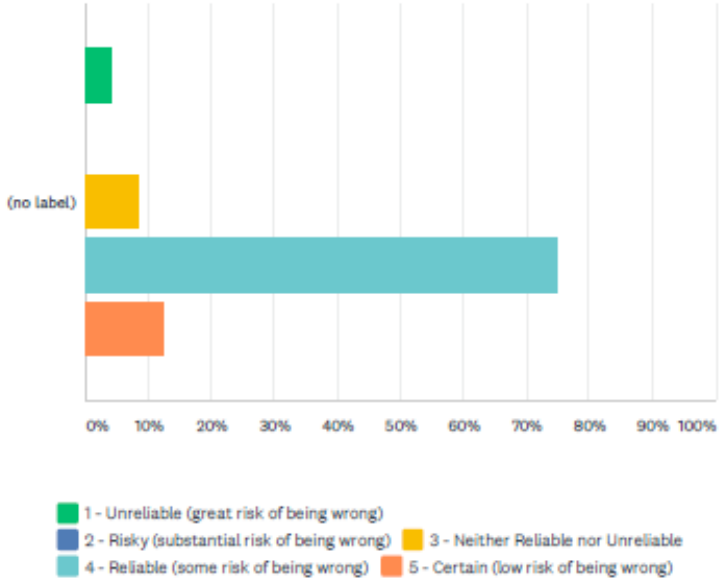
Answered: 11 Skipped: 13

#	RESPONSES	DATE
1	Accessibility/ADA compliance may impractical at the moment, but should be desirable just because it is important to consider as many people as possible when it come to geotechnology.	10/24/2019 10:08 AM
2	Agree with survey.	10/23/2019 6:20 PM
3	I was a little surprised that Forecasting got such a low rating. This is important for some applications, but I guess not all.	10/23/2019 11:26 AM
4	Generally, I believe these are not well understood or applied outside of research institutions. Until they emerge into the realm of practical applications they will be viewed as undesirable and impractical. It's also probably why none of these areas are listed as core knowledge in the GIS&T BOK (except Tessellation)	10/23/2019 10:20 AM
5	All geocomputation were aggregated to Undesirable and impractical - I think this should be improved using education and technical innovation	10/22/2019 2:54 PM
6	Items in this column tended to be categories that are highly advanced topics that are not specific to GIS data.	10/22/2019 11:59 AM
7	See response to question 3.	10/22/2019 7:41 AM
8	Cloud computing is already widely used, thats ArcGIS online, shouldn't be in this category.	10/21/2019 5:23 PM
9	Curious about why ADA/508 design criteria is undesirable, as it is often now the requirement for Federal projects with graphic deliverables (USACE, FEMA, etc).	10/21/2019 4:25 PM
10	In my opinion the items in column 3 have fallen victim to two things, advances in technology and an overall lack of demand for GIS professionals to perform these tasks. They may have some niche value for a particular industry.	10/21/2019 4:13 PM
11	NA	10/21/2019 3:58 PM

Rounds 3 and 4 Survey - Delphi Study - Shannon Doyle

Q5 Please rate your Overall Confidence with the full list of items and ratings in the Analysis Matrix attached to this survey.

Answered: 24 Skipped: 0



	1 - UNRELIABLE (GREAT RISK OF BEING WRONG)	2 - RISKY (SUBSTANTIAL RISK OF BEING WRONG)	3 - NEITHER RELIABLE NOR UNRELIABLE	4 - RELIABLE (SOME RISK OF BEING WRONG)	5 - CERTAIN (LOW RISK OF BEING WRONG)	TOTAL	WEIGHTED AVERAGE
(no label)	4.17% 1	0.00% 0	8.33% 2	75.00% 18	12.50% 3	24	3.92

#	USE THIS SPACE IF YOU WISH TO PROVIDE ADDITIONAL COMMENTS.	DATE
1	If some of my upgrades were addressed, I could move my rating up to Certain	10/23/2019 10:20 AM
2	The rating seems fair. Without knowing the range of GIS expertise across participants it may be hard to gauge how reliable the data is. That said the information is very telling about what perceived importance of these topics are.	10/22/2019 11:59 AM
3	I feel this survey needs to be grouped by industry or user roles in order to see which categories are relevant to the sector in which the might or might not be used.	10/22/2019 7:41 AM
4	Thank you for reaching out. I enjoyed the survey. It would be interesting to see the results based on age and industry.	10/21/2019 4:13 PM
5	Amazing analysis, be sure that your methodology for how you arrived at these is sound. Otherwise, nice work.	10/21/2019 3:58 PM

Appendix M: Round 2 Frequencies and Medians

Competency Item	Desirability Frequency % (Likert-type scale)					Median	Practicability Frequency % (Likert-type scale)					Median
	1	2	3	4	5	M	1	2	3	4	5	M
Query Operations and Languages	0	0	6.8	34.4	58.6	5	0	6.8	3.4	44.8	44.8	4
Geometric Measures	0	0	13.8	51.7	34.5	4	0	3.4	6.8	51.7	37.9	4
Basic Analytical Operations and Methods	0	0	0	27.6	72.4	5	0	0	0	34.5	65.5	5
Raster Analysis	0	0	17.2	65.5	17.2	4	0	0	41.4	51.7	6.8	4
Surface Analysis and Derived Data	3.4	6.8	17.2	51.7	20.7	4	3.4	3.4	41.4	41.4	10.3	4
Subsurface and AGL Analyses	3.4	13.8	55.2	27.6	0	3	3.4	20.7	48.3	27.6	0	3
Spatial Statistics and Geostatistics	0	3.4	6.8	58.6	31	4	0	10.3	24.1	51.7	13.8	4
Spatial Regression and Econometrics	0	10.3	44.8	41.4	3.4	3	0	27.6	44.8	24.1	3.4	3
Data Mining	0	0	13.8	48.2	37.9	4	0	3.4	20.7	44.8	31	4
Network Analysis	0	3.4	10.3	51.7	34.5	4	0	3.4	13.8	55.2	27.6	4
Optimization and Location-Allocation	3.4	0	24.1	58.6	13.8	4	3.4	3.4	31	41.4	20.7	4
Spatio-Temporal Modeling and Analysis	0	3.4	24.1	48.3	24.1	4	0	6.9	34.5	41.4	17.2	4
Error Modeling	0	10.3	41.4	44.8	3.4	3	0	17.2	51.7	31	0	3
Spatial Modeling and Analysis	0	0	6.9	44.8	48.3	4	0	3.4	6.9	48.3	51.4	4
Forecasting	3.4	0	37.9	41.4	17.2	4	3.4	10.3	41.4	37.9	6.9	3
Principles of Map Design	0	0	6.9	20.7	72.4	5	0	0	6.9	20.7	72.4	5
Dynamic Mapping	0	3.4	6.9	34.5	55.2	5	0	3.4	13.8	51.7	31	4
Core Cartographic Principles	0	0	3.4	27.6	69	5	0	0	10.3	13.8	75.9	5
Data Considerations	0	0	6.9	27	65.5	5	0	0	6.9	31	62.1	5
Graphic Representation Techniques	0	0	13.8	34.5	51.7	5	0	0	6.9	55.2	37.9	4

Digital Integrative Mediums and Accessibility/ADA Compliance	0	0	37.9	51.7	10.3	4	3.4	6.9	44.8	37.9	6.9	3
Web and Mobile Mapping and Responsive Design	0	0	3.4	41.4	55.2	5	0	6.9	13.8	31	48.3	4
Digital and Physical Map Production	0	0	6.9	34.5	58.6	5	0	0	10.3	27.6	62.1	5
Web Cartography and Digital Mapping Principles	0	0	10.3	24.1	65.5	5	0	3.4	20.7	20.7	55.2	5
Visual Map and Data Interpretation	0	0	3.4	44.8	51.7	5	0	0	3.4	51.7	44.8	5
GIS&T System Design	0	3.4	13.8	51.7	31	4	0	3.4	37.9	48.3	10.3	4
GIS Project Workflows and Modeling	0	0	10.3	44.8	44.8	4	0	3.4	20.7	48.3	27.6	4
Database Design, Modeling, and Standardization	0	0	0	34.5	65.5	5	0	3.4	12.8	44.8	37.9	4
Analysis Design	0	0	17.2	48.3	34.5	4	0	6.9	17.2	44.8	31	4
Application Design and Evaluation	0	3.4	24.1	51.7	20.7	4	0	3.4	41.4	41.4	13.8	4
System Implementation and Data Workflows	0	0	20.7	55.2	24.1	4	0	6.9	27.6	31	34.5	4
Cloud Computing, Storage, and Retrieval	0	10.3	37.9	34.5	17.2	4	6.9	6.9	37.9	37.9	10.3	3
Database Administration	0	0	3.4	58.6	37.9	4	0	6.9	17.2	41.4	34.5	4
Database Management	0	0	3.4	58.6	37.9	4	0	3.4	17.2	44.8	34.5	4
Enterprise System Design	0	0	17.2	58.6	24.1	4	0	124	24.1	34.5	27.6	4
Basic Storage/Retrieval Structures and Infrastructure Scalability	0	3.4	27.6	34.5	34.5	4	0	3.4	41.4	27.6	27.6	4
Data Organization, File Structures, and Workflows	0	0	13.8	37.9	48.3	4	0	0	24.1	31	44.8	4

Relational Database Management Systems	0	0	13.8	55.2	31	4	0	3.4	24.1	51.7	20.7	4
Big Data - Storage and Database Management	0	3.4	31	48.3	17.2	4	0	17.2	34.5	31	17.2	3
Tessellation Data Models	0	6.9	48.3	37.9	6.9	3	0	17.2	48.3	24.1	10.3	3
Vector and Object Data Models	0	0	10.3	55.2	34.5	4	0	0	13.8	44.8	41.4	4
Multi-dimensional, Uncertain, and Temporal Data Modeling	0	3.4	48.3	27.6	20.7	3	3.4	10.3	44.8	27.6	13.8	3
Big Data Modeling and Analysis	0	6.9	41.4	34.5	17.2	4	0	13.8	44.8	31	10.3	3
Geospatial File Types and Data Models	0	0	6.9	44.8	48.3	4	0	0	12.8	31	55.2	5
Emergence Computation	3.4	3.4	62.1	31	0	3	6.9	17.2	51.7	24.1	0	3
Computational Aspects of Geocomputing Cellular Automata (CA) Models	3.4	13.8	62.1	17.2	3.4	3	3.4	27.6	51.7	17.2	0	3
Heuristics	3.4	3.4	58.6	27.6	6.9	3	3.4	10.3	69	13.8	3.4	3
Genetic Algorithms (GA)	6.9	17.2	55.2	20.7	0	3	6.9	34.5	44.8	13.8	0	3
Agent-based Models	3.4	17.2	51.7	24.1	3.4	3	6.9	27.6	44.8	10.7	0	3
Simulation Models	3.4	3.4	31	51.7	10.3	4	3.4	17.2	48.3	27.6	3.4	3
Data Uncertainty	3.4	6.9	31	51.7	6.9	4	3.4	13.8	37.9	37.9	6.9	3
Fuzzy Sets	3.4	10.3	37.9	44.8	3.4	3	6.9	13.8	34.5	41.4	3.4	3
Multi-scalar Data Sets	3.4	3.4	34.5	51.7	6.9	4	3.4	6.9	44.8	41.4	3.4	3
Geodesy and Earth Geometry	0	3.4	17.2	41.4	37.9	4	0	6.9	34.5	27.6	31	4
Land Partitioning Systems	3.4	0	17.2	37.9	41.4	4	3.4	0	31	37.9	27.6	4
Linear Referencing	0	0	10.3	51.7	37.9	4	0	3.4	27.6	41.4	27.6	4
Data Quality and Data Integrity	0	0	0	20.7	79.3	5	0	0	6.9	13.8	79.3	5
Datums	0	0	6.9	51.7	41.4	4	0	3.4	17.2	37.9	41.4	4
Map Projections	0	0	0	48.3	51.7	5	0	0	10.3	44.8	44.8	4

Georeferncing Systems	0	0	0	37.9	62.1	5	0	0	6.9	37.9	55.2	5
Land Surveying and GPS	3.4	0	0	55.2	41.4	4	0	0	13.8	65.5	20.7	4
Digitization and Vectorization	0	0	6.9	20.7	72.4	5	0	0	6.9	31	62.1	5
Field Data Collection and Quality	0	0	3.4	31	65.5	5	0	0	6.9	34.5	58.6	5
Aerial Imagery and Photogrammetry	0	0	0	48.3	51.7	5	0	3.4	20.7	48.3	27.6	4
Satellite and Shipboard Remote Sensing	3.4	0	27.6	44.8	24.1	4	0	0	48.3	37.9	13.8	4
UAS Data Collection	3.4	0	17.2	44.8	34.5	4	0	0	34.5	44.8	20.7	4
Mobile Data Collection	0	0	3.4	37.9	58.6	5	0	3.4	6.9	37.9	51.7	5
Metadata	0	0	13.8	27.6	58.6	5	0	6.9	17.2	34.5	41.4	4
Ethical Considerations	0	0	10.3	44.8	44.8	4	0	0	20.7	41.4	37.9	4
Data Integration	0	0	0	37.9	62.1	5	0	3.4	13.8	24.1	58.6	5
Scripting and Automation	0	0	10.3	37.9	51.7	5	3.4	3.4	17.2	37.9	37.9	4
Asset Management	0	0	20.7	55.2	24.1	4	0	0	20.7	51.7	24.1	4
Machine Learning	3.4	3.4	37.9	37.9	17.2	4	6.9	6.9	51.7	17.2	17.2	3