catastrophic risk models which are among the most significant developments in risk management and insurance over the last 30 years. Aided by increased computational power and high-quality, high-resolution, and timely GEOINT datasets, probabilistic simulations from these models are allowing stakeholders to quantify exposures, measure risk potential, and manage financial consequences. These models are becoming critical tools in combating the threat of natural and human-made catastrophes and are powering a revolution in the risk management and insurance industries.

Munich Re estimates global insurance premiums will nearly double by 2030 from about $3.5 trillion to $6.4 trillion.[2] Over this same time horizon, there is similar growth expected in disaster mitigation as FEMA plans to start issuing about $500 million per year in pre- and post-disaster mitigation and risk reduction grants.[3] This economic growth and technological revolution in the insurance and risk management sectors will undoubtedly create opportunities across the GEOINT Community for academia to educate and train the next-generation workforce, for the public sector to advance science and technology through further investment in basic and applied research, and spur industry to continuously deliver innovative technology and solutions.

Empowering Innovations and New Solutions by Expanding the GEOINT Workforce Through University, Industry, and Government Partnerships

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Challenges Faced by the GEOINT Community to Meet the Supply and Demand of GEOINT Requirements

The current state of geospatial intelligence (GEOINT) revolves around massive amounts of data, and a scarcity of trained professionals and effective tools to efficiently access and synthesize intelligence to support decision-making, especially in the cleared environment. TS/SCI-cleared geospatial professionals can be difficult to find, especially given the expanding demand for these skill sets across military, government, and private organizations. This has led to large staffing gaps across the cleared GEOINT Community. Moreover, even though many GEOINT workflows consist of laborious QA/QC procedures that soak up time and resources, analysts find it difficult to integrate new and innovative tools that could reduce overall labor into their workflows, if they can do it at all. In addition, there is still no viable pathway to integrate education and industry-based skills in cleared environments other than agency-sponsored internships. This forces the majority of GEOINT tradecraft to come directly from the military, which limits exposure, ideas, and innovation that could be gained from a more diverse workforce and puts a further strain on the supply of analysts who fit government requirements, not to mention the fact that it presents a real barrier to entry for non-cleared geospatial professionals.

GEOINT is a horizontal market that can fill vertical demands in almost any field, yet the average person or many businesses that could benefit from the integration of GEOINT into their workflows do not know what GEOINT is. This fact was made more apparent recently when Esri, one of the largest industry leaders in geospatial technology, used the term "location technology" in its robust national advertising campaign, because they determined the public simply would not understand the term "geospatial intelligence." GEOINT has a marketing problem; and in order to fulfill evolving GEOINT market needs and requirements currently and in the future, the size and diversity of the workforce will necessarily need to increase, which means more people ought to know what GEOINT is and the multiple benefits it can provide. Educational institutions can play a significant role in improving the visibility of GEOINT and employability of broadly trained GEOINT professionals, especially if aided by government and private industry—but therein often lies a disconnect in communication and collaboration we hope to explore with this contribution.

Aside from the communication and collaboration disconnect among academia, government, and industry, one of the major challenges in bridging the education and training (professional development), tradecraft, and workforce needs triad composed of academic, government, and industry players stems from an artificial supply-and-demand constraint on the skills and abilities of GEOINT analysts. The slow pace or lack of ability to integrate new tools, lack of public insight into the GEOINT Community, and recruitment into the field hamstringed by restrictive contracting requirements further exacerbate the supply-and-demand issue for GEOINT. While we are not necessarily highlighting a novel issue, we believe that closer connections and creative partnerships among academia, government, and industry could contribute greatly to addressing current challenges in GEOINT.

In August 2018, University of North Carolina Wilmington (UNCW) earned USGIF Collegiate Accreditation in GEOINT and has since been working closely with government partners to establish effective and mutually beneficial internships and collaborations to allow students to receive the hands-on training needed to succeed in the job market. Specifically, we established a three-credit, 120-hour internship with the U.S. Army Corps of Engineers (USACE) Wilmington District that provides students

2. MunichRe. Insurance Market Outlook. MunichRe Group. April 30, 2019.
3. Elizabeth Zimmerman. "BRIC Expanding the Concepts of Federal Pre-Disaster Mitigation." *Government Technology* Magazine. September 25, 2019.

with training in both GIS and imagery analysis in support of various USACE projects. More recently, we created similar internships with private industry as well as research and development (R&D) collaborations with state government entities that we are leveraging to improve student success, diversification, and alignment with evolving workforce needs. The former, an internship program that started in May 2019 with Wilmington-based GEOINT company Geo Owl LLC, has led to the employment of several UNCW students, while the latter R&D activities with the North Carolina Department of Transportation resulted in a $300,000 contract that is training and employing both undergraduate and graduate students. Throughout this process of more closely aligning university curricular offerings and research agendas with government and industry demands—both in terms of student training and R&D outputs—a few crosscutting issues emerged that further underscore the need to establish creative and collaborative multi-stakeholder partnerships.

Solutions for Expanding the GEOINT Workforce and More Effective Integration Among Training, Tradecraft, and Workforce Development

The triad of education (university), training (government and private industry), and tradecraft development (collaborative R&D among all three) should be managed to ensure that educational programs are aligned with developments in government and industry standards while maintaining a high level of academic rigor. As big data becomes bigger, faster, and more varied, and automation continues to replace manual tasks, GEOINT analysts will need to build new skill sets to empower their abilities for intelligence synthesis. They will need to understand a wide range of solutions to include open-source options and be able to integrate them into customer spaces. They will need to be able to program automated analyses and understand where the gaps in automation occur, correct data gaps, and ensure decisions are made solely on accurate information. Connecting the dots among education, training, and tradecraft development through flexible and adaptive curricular and training offerings can contribute to ensuring these transitions can take place successfully.

Furthermore, to bridge the gap between GEOINT supply and demand, there ought to be concerted efforts among universities, industry, and government to better market the capabilities of GEOINT professionals and provide legitimate pathways from K–12 to GEOINT subject matter experts (SMEs). One avenue to increase understanding of educational requirements relative to workforce needs is for government to encourage these types of partnerships in contract negotiations with industry. In turn, this incentivizes industry to build and maintain long-term relationships with universities and ensures a stable talent pool that is familiar with GEOINT. Universities can make a larger impact on industry and government missions by being more involved with GEOINT operations. Typically, universities play relatively small roles as reachback or training support on some of the most robust GEOINT operations in the world. However, to have a more nuanced understanding of GEOINT demands and contribute more effectively toward marketing and increasing GEOINT awareness, universities should partner with industry and provide liaisons in the form of GEOINT research analysts who serve the dual functions of enhancing mission operations and driving educational requirements. The government should consider incentives for the inclusion of university subcontractors as part of contracting requirements, similar to requirements for small businesses.

Another similar and parallel avenue to increase understanding of educational requirements relative to workforce needs is to encourage these types of partnerships in contract negotiations directly with industry. In turn, this incentivizes industry to build and maintain long-term relationships with universities and ensures a stable talent pool that is familiar with GEOINT. As such, from an industry perspective, government acquisitions officers should consider the real market value for these skills and award contracts that are priced proportionally to executable levels by working more closely with industry to empower innovative methods for solving problems. More vendor-defined solutions that integrate services with toolsets enable and incentivize industry to build better tools.

Government should consider a broader range of contract types, to include performance/metric-based incentives and institute rules for goal setting that act as elevators of innovation. GEOINT analysts now have a plethora of options as businesses are starting to realize the benefits of having those skill sets on board, and new GEOINT sensors and assets are continually deployed, putting massive constraints on the talent pool. By exploring new, nonrestrictive pathways to GEOINT careers, the community would allow and empower professionals to provide the right solution and develop tradecraft via university partnerships, internships, and other professional development avenues. For example, many government requirements list a Military Occupational Specialty (MOS) as necessary to fill GEOINT analysis positions. This requirement disables industry's ability to build, train, and mature a workforce to specifically suit the needs of the government. If a professional has years of GEOINT experience, the educational background, and the proven behavioral characteristics, then he or she shouldn't be hindered from enhancing the GEOINT mission and gaining access to this professional field. Likewise, many contracts contain degree requirements that have little to nothing to do with actual GEOINT skill sets. For example, on one contract with many GEOINT labor categories, the government listed a bachelor's degree as equivalent to six years of experience, regardless of major. This is misaligned with most GEOINT missions and places even more nuanced constraints on talent acquisition.

Conclusions and Pathways Forward for More Effective Integration Among Training, Tradecraft, and Workforce Development

To conclude, we reflect on current, future, and evolving GEOINT workforce trends and how educational institutions that offer GEOINT degrees and accreditations

can and should shift business as usual to support these evolving demands. Major GEOINT challenges include tackling ever-increasing data volumes, supply-and-demand imbalances of skill sets and trained professionals, a lack of proper GEOINT marketing, and hamstringed tradecraft development due to restrictive contracting requirements.

To address challenges with the exponential growth in data volume, velocity, and variety, we propose incentivizing innovation by requiring robust, vendor-defined solutions as well as industry/university partnerships in GEOINT-related acquisitions. This would subsequently drive further competition and lead to even more innovative solutions to address pressing GEOINT challenges. For example, a simple shift in contract requirements from full-time equivalents to outcome- or performance-based requirements leads to heightened competition and increased funding for R&D.

To address workforce talent pool and GEOINT visibility challenges, we propose new solutions for more effective GEOINT marketing and branding through concerted efforts by government, industry, and academic institutions. For example, to expand the potential interests in GEOINT for youth, we can explore working with celebrities, social media influencers, and other broadly recognized figures to proselytize GEOINT. In addition, we can improve GEOINT storytelling for current and historical events by providing the GEOINT perspective with engaging videography, visualizations, and professional success stories.

To address hamstringed workforce development, one possible solution is for universities to acquire facility clearances; universities should gain access to SCIF spaces for unique GEOINT training and initiate clearance investigations for highly qualified students. They can work closely with the U.S. National Geospatial-Intelligence Agency, the military, and industry to closely mimic real-world operations and even solve real-world, classified GEOINT problems. Another solution is to work toward the removal of misaligned and restrictive MOS or non-GEOINT degree requirements for personnel on GEOINT contracts.

Lastly, to address all three challenges, we propose the development of regional GEOINT centers of excellence where academic institutions, governmental, and private organizations can work together in creative idea incubators to develop sustainable, flexible, and mutually beneficial collaborations. There are many locations outside of Washington, D.C., that have large GEOINT workforces, including California, Texas, North Carolina, Florida, and Missouri. Regional centers of excellence act as incubators of GEOINT innovation through solution-focused competitions, GEOINT Community gatherings, professional development opportunities, and joint R&D initiatives among academic, private, and government institutions. They can encourage the recruitment of students in early career stages and allow for knowledge exchanges among faculty, government officials, and industry that can launch unique and successful enterprises that go beyond standard internship programs. For example, North Carolina has a large GEOINT Community consisting of three USGIF-accredited academic institutions, military bases performing GEOINT missions (Fort Bragg and Camp Lejeune), and state government agencies that are heavily reliant on GEOINT. A North Carolina-based center of excellence in GEOINT integration, as a starting point for a regional center of excellence in GEOINT, would bridge these communities into a common GEOINT purpose, provide creative opportunities for cross-sector solutions and interactions, and power innovative solution development for GEOINT as a whole. Given the mutually beneficial outcomes of such a regional initiative, the leadership team would necessarily be composed of representatives from each community that would work under the guidance of USGIF and NGA on actionable items that can begin to address the challenges in integrating education, training, and tradecraft development in GEOINT.

Creating an Integrated, Multi-Source, Accurate, Trusted, and Immersive Cognitive Analytic Environment

By Dr. Ann Carbonell, Riverside Research; Bob Gajda, Frontier Enterprise LLC; Johnnie DeLay, L3Harris Technologies; and Alex Fox, Hawkeye 360

The following vignette illustrates a future analysis environment:

The Joint Analysis Center in England alerts the AFRICOM watch desk that Lloyd's of London is reporting three super tankers off the Horn of Africa suddenly going dark as they cease sending Automatic Identification System (AIS) signals. More than six million barrels of oil and at least 75 crewmen are missing. AFRICOM's support analyst, Josephine, calls up the last three hours of AIS signals from the region, isolates the three ships, and plots their courses. Simultaneously, she queries for radio frequency (RF) intercepts and observes increases in activity before the AIS signals stopped. Geolocation plots show routes intercepting with the tankers, suggesting abnormal and suspicious activity from ocean-based transmitters.

Suspecting pirate activity, Josephine alerts the operations desks and begins exploring data in her immersive environment. She brings in historical sensor data covering all nearby coastal regions, and she interacts with other analysts from around the world. Much like players in the online video game "Fortnite," these analysts collaborate on analytic approaches and allocate workload to the most appropriate person. Social media analysis algorithms reveal two unusual trends: diminished activity from among identified