A Science Policy Research Report

A Research Agenda for the Science of Broadening Participation: STEM Employment of Individuals with Disabilities[1]

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Executive Summary

This science policy research report addresses key issues, barriers and opportunities for increasing participation in STEM fields and the workforce among under-served populations, focusing on individuals with disabilities and, in particular, veterans with disabilities. This is especially important as these populations might not be aware of, or not actively involved in, social networks of STEM innovators, and conversely technology innovators might not fully consider these individuals as important contributors to innovation systems. The report also explores the potential of new frameworks, dissemination design parameters, and knowledge-generating communities to provide lessons learned and guidance for effective practices and inclusion in STEM disciplines. Addressing the underrepresentation of individuals with disabilities in STEM fields, it offers an analysis of relevant research and policy approaches and looks to inform related government agenda-setting and decision-making.

1.0 Introduction

The economic competitiveness and global leadership of the United States (U.S.) in cutting-edge technology and science-based fields rely on a well-prepared and agile science, technology, engineering, and mathematics (STEM) workforce. Access to the full capacity of the workforce requires inclusion of diverse populations, where advances in STEM benefit from a variety of characteristics, perspectives, skills, and capabilities among workers (James and Singer, 2016). "To remain competitive in the global economy, foster greater innovation, and provide a foundation for shared prosperity, the United States needs a workforce with the right mix of skills to meet the diverse needs of the economy. Conversely, an insufficiently skilled workforce can impose significant burdens on the economy, including higher costs to workers and employers and lower economic productivity" (NASEM, 2017, p. 2). Accordingly, calls have been issued for strategies that can expand and develop a strong STEM workforce that encompasses and takes advantage of the country's human capital potential and diverse population (e.g., NAS, 2007, 2010; NSF, 2017; NASEM, 2017). From a complementary perspective, calls have been issued for the creation of flexible, integrated, and inclusive educational and training programs and environments to meet the needs of that diverse population and workforce. This goal requires a highly adaptive and networked system of educational and disciplinary collaboration, informed by emerging discoveries and trends, applying strategies and programs to enable a fully prepared STEM workforce. Relevant preparation for building and supporting a diverse and competitive STEM workforce involves outreach and

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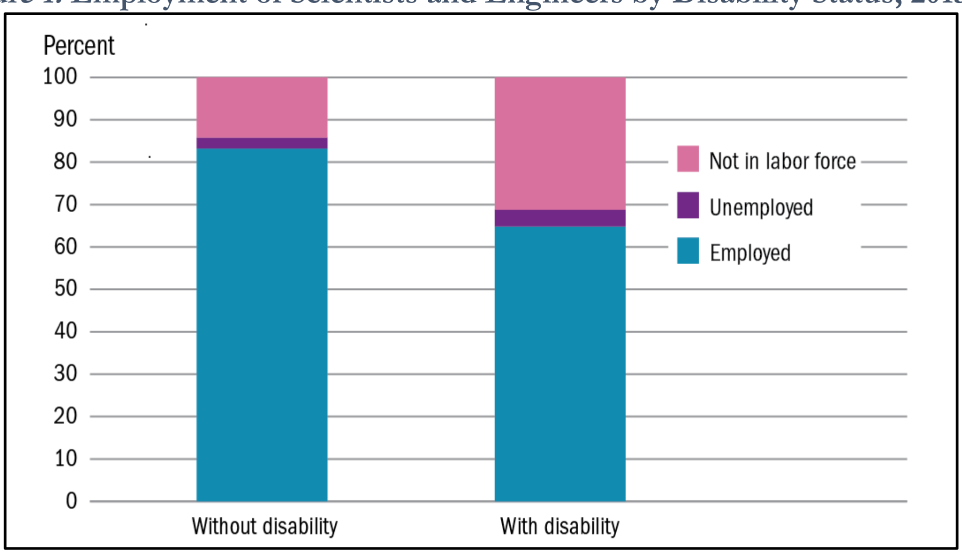
recruitment informed by subsystems encompassing scientists and engineers, educational and training institutions, innovation networks, and employing organizations across academia, industry, and government sectors.

Of particular note in this regard, and the focus of this science policy research report, are individuals with disabilities, who represent an under-studied group in STEM workforce research. While identification and designation of the concept "disabled" can vary (Santuzzi and Waltz, 2016), the practice of the U.S. Census Bureau (2013), followed here, is to use a set of questions to capture aspects of disability, referring to individuals with "serious difficulty" in one or more of six basic areas of functioning: sensory, physical, mental, self-care, "go-outside-home," and employment. Note that disabilities do not necessarily limit a person's capacity for educational attainment or occupational productivity, and individuals with disabilities may or may not require special accommodations to succeed in educational or occupational arenas (NSF, 2017). However, issues of "ableism" can become directly applicable as outcome determinants linked to definitions of disability (Campbell, 2009). Ableism refers to practices, attitudes, and beliefs that that assign inferior value or worth to people who have developmental, emotional, physical, or psychiatric disabilities, and invokes notions of discrimination and bias against individuals with disabilities in the form of ideas, assumptions, stereotypes, attitudes, practices, physical barriers, or oppression (Campbell, 2009). As is the case with many other underrepresented individuals and groups, individuals with disabilities have faced various barriers to participation (Kulkarni and Lengnick-Hall, 2014) and constitute a special category of persons marked for attention in terms of representation and protections, as delineated in the Americans for Disabilities Act (1990). As shown in Figure 1, about one in nine scientists and engineers aged 75 and younger has a disability and is more likely to be unemployed than those without disabilities (NSF, 2017). As a group, individuals with disabilities are underrepresented in the STEM workforce compared with the college-educated population as a whole. This is also the case for the participation of veterans in the STEM workforce (Jensen, et al., 2011; Routon, 2014; Potter, 2015).

Figure 1: **Employment of Scientists and Engineers by Disability Status, 2015**



(Source: NSF 2017)

Engaging a Science of Broadening Participation (SoBP) approach (McNeely and Fealing, 2018; Kuiler 2018), the principal purpose here is to detail barriers and opportunities for increasing participation in STEM fields in terms of two dimensions of underrepresentation: (1) the specific population — individuals with disabilities, and (2) the policy outcome — employment trends and occupational engagement. With particular attention to the wider array of high-technology employment and consequential policy directives and analyses in consideration of the representation and participation of individuals with disabilities in STEM fields, this report draws upon and extends findings generated during a Symposium on the Science of Broadening Participation, held in 2016 and sponsored by the National Science Foundation (Fealing and McNeely, 2016; McNeely, Hopewell, and Fealing, 2018).[2] The Symposium convened a broadly inclusive group of researchers, analysts, policy analysts, and practitioners to address the need for a scientific approach to developing and nurturing a qualified, diverse, and agile STEM workforce. Organized around four primary interrelated themes — frameworks, measures, education, and workforce — symposium presentations and discussions emphasized delineating critical aspects of participation and inclusion. With specific reference and application to the underrepresentation of individuals with disabilities in STEM fields and related employment, this report engages and builds upon lessons from the Symposium to further identify, explore, and analyze fundamental issues aimed at addressing this underrepresentation. It ultimately offers policy implications and provides directions for relevant agenda setting and organizational decision making in academia, government, and industry. In doing so, this report takes steps to advance knowledge and understanding of broadening participation dynamics and structures and, ultimately, to the enhancement of a science and practice of broadening participation in STEM.

2.0 Institutional Contexts and Dynamics

2.1 STEM and Innovation for Economic Competitiveness

A great deal of research and, subsequently, policy discussion, turns on the premise that U.S. competitiveness depends on continued development and deployment of cutting-edge technology and science to drive economic growth, requiring a well-prepared and skilled workforce (Gabe, 2017; Sachs, 2017). The education and training of individuals with STEM related capabilities relies on a highly adaptive and networked system of interdisciplinary collaboration, informed by emerging discoveries and trends, that can support the creation, development, and critical assessment of new strategies, programs, and approaches to enable a fully prepared STEM workforce. This preparation consists of many subsystems, each of which contributes to the end result. Aside from the target scientists and engineers, there are the educators, trainers, and institutions, enabling networks and nodes of knowledge and technology development and productivity, and the "end users" – especially laboratories, research institutions, and high-tech sector employers (Baker et al., 2016).

Universities are key contributors to the objective of developing nodes of inclusive STEM activity. The significance of institutions of higher education and related organizations has long been recognized especially in three fundamentally encompassing roles:

1) in the preparation and training of STEM workers (e.g., NASEM, 2017);
2) in the production, transfer, and sharing of relevant knowledge (e.g., Guena and Muscio, 2009; Agrawal, 2001); and
3) as nodes or centers of innovation (e.g., Clough, 2007; NASEM, 2016b; NRC, 2012).

[2] NSF Awards 1551904 and 1551880

Research institutions in particular are the setting in which disciplinary cultures are enacted and epistemic networks are rooted. However, viewing the development of the STEM workforce as a project, institutions of higher education do not represent the *sole* active component in achieving related participatory objectives. Indeed, "it is necessary to recognize that in the United States, the responsibility for developing and sustaining a skilled STEM workforce is fragmented across many groups, including educators; students; workers; employers; the federal, state, and local governments; labor organizations; and civic associations" (NASEM, 2017, p. 1).

2.2 STEM Inclusion and Diversity as Drivers of Innovation

Not only does research consistently indicate that higher levels of performance, productivity, and innovation are associated with a diverse workforce (Hunt, Layton, and Prince, 2015; Herring, 2009; RRA, 2009; Hewlett, Marshall, and Sherbin, 2013), it also speaks to questions of expanding STEM communities of practice and of network density and collaboration (Leung and McNeely, 2015). Moreover, policies that recognize the value added of diversity and that encourage broader participation arguably can yield increased innovation in key industrial sectors and in improved social wellbeing (Hilpert, 2018). In addition, techno-scientific range and creativity often lead to innovative thinking and development across disciplines such that, increasingly, the diversity and variety of STEM professionals are recognized as playing an important role (Lee, Walsh, and Wang, 2015). Heterogeneous teams, drawing on different backgrounds, experiences, and perspectives, can offer resourceful problem-solving attributes, expanding capabilities beyond those in more monolithic homogeneous groups and reflecting how diversity can create "better groups, firms, schools, and societies" (Page, 2007). However, organizations often are reticent to implement interventions for various reasons, including a lack of knowledge of what will work, and by institutionalized practices and approaches buttressed by both internal and external values and dynamics (Baker et al., 2018b). Resulting exclusionary workplace environments have been shown to be particularly obstructive in reference to individuals with disabilities, facing obstacles to participation and success as a matter of course (Kulkarni and Lengnick-Hall, 2014). Thus, continued discrepancies and imbalances in diversity continue to exist in many fields, and full potential goes unnurtured and unrecognized at many levels of engagement and innovation.

Thus, the need for a scientific approach resting on an assembled body of knowledge ready for use to support effective policy development and implementation for broadening participation in STEM education and the STEM workforce. To that end, as determined in the aforementioned SoBP symposium (Fealing and McNeely, 2016; McNeely and Fealing, 2018), further work is needed in four principal areas:

1) curated knowledge from various areas of study related to understanding and assessing underrepresentation in STEM fields;
2) curated data, metrics, and statistics from various areas of study related to assessing underrepresentation in STEM fields;
3) curated knowledge from various areas of study assessing educational attainment, contextualizing educational access, opportunities, and outcomes, and identifying critical causes of underrepresentation in STEM fields; and
4) curated knowledge for identifying workforce dimensions and dynamics, contextualizing occupational access, opportunities, and outcomes, and investigating recruitment, retention, and network inadequacies leading to underrepresentation in the STEM workforce.

While focusing on individuals with disabilities as an underrepresented and under-studied group in this regard, addressing such issues relative to policy engagement for increasing diversity in the STEM workforce will contribute to further SoBP development for application and engagement. The goal is to contribute to solutions to related problems with the overall aim of broadening participation and inclusion to enhance STEM capabilities and innovation.

2.3 Scaling Organizational (Under) Inclusivity

Much of the research on increasing representation, diversity, and inclusion in the STEM workforce has concentrated on improving participation via supply side approaches. This work has followed typical studies of STEM underrepresentation that center on the educational "pipeline" and, with particular emphasis on individuals with disabilities in general and, especially, on disabled veterans, and accommodations to enhance an individual's ability to participate in the workplace (Moon and Baker, 2012). Understanding, however, might be further advanced by considering and exploring other less conventional approaches and routes to participation and inclusion (Hawley et al., 2014). Also, research shows that, in practice, many large organizations often have some sort of diversity initiatives or policies for broader recruitment and retention (Julian, Oforio-Dankwa, 2017; Knouse, 2009; Phillips et al., 2016), at least ostensibly. While they may be well intentioned, they ultimately can be de facto undervalued or made irrelevant in actual engagement in terms of innovation. In addition, research on individuals with disabilities in the workforce has focused on employment in government agencies (NSF, 2017). What is less known is the applicability of these observations to small to medium enterprises (SMEs) and to entrepreneurial startup companies (Renko, Parker Harris, and Caldwell, 2016; Stam et al., 2014; Ali, Metz, and Kulik, 2015; Starr-Glass, 2017).

Large organizations with diversity supportive policies and workforce profiles tend to be successful, reflecting high levels of innovation, performance, and productivity (Hunt et al., 2015; Herring, 2009; RRA, 2009). However, it is not clear that there is a successful translation of that knowledge to SME's and startups. Given different structural conditions and contextual demands, incorporating broader participation and diversity principles can take on different characteristics and implications when not a "normal" part of operations and organizational cultures. While lessons certainly can be learned from larger organizations (and vice versa), challenges of appropriate scaling can affect, in fundamental ways, SME diversity adoption potential and inclusion outcomes. This situation leads to various questions for further research emphasizing level and unit of analysis in addition to sector focus. For example, given their small size in comparison with larger organizations, what role does diversity play in their propensity for innovation and related processes, or conversely might diversity be a *consequence* of an innovative orientation? How meaningful is diversity in light of their functional and productive capacities? In addition, how many STEM trained innovators with disabilities participate in SMEs and startups? It is clear that there are barriers that must be defined in addressing such questions, some of which might include perceptions, knowledge, sourcing, physical and technological environments, and regional contexts, amongst others, to be discovered in terms of diversity and participation in general and of disabilities more specifically (cf. Linkow, Barrington, Bruyère, Figueroa, and Wright, 2013; Kulkarni and Lengnick-Hall, 2014; Santuzzi and Waltz, 2016; Moon and Baker, 2012).

The guiding idea here is to consider what organizations, as social actors, are doing, what practices they employ, and with what effect relative to broadening participation. In this case, especially pertinent is research on capabilities and perceived and actual barriers to participation as questions of accommodations and the breadth and recognition of disabilities as determinant factors in organizational cultures and performance (Ward et al., 2012; Santuzzi and Waltz, 2016, Baker, et al., 2018b). Moreover, underrepresentation and lack of inclusion in any organization can have unintended outcomes for employers and employees. Although agencies and firms are increasingly aware of evidence indicating that diversity at all levels of an organization can give way to better problem solving and productivity, shortcomings still can loiter, whether intentional or unintentional (Baker, et al., 2018b). Stereotypes associated with particular groups such as individuals with disabilities can influence the behaviors of organizations and individuals within them in recruiting and hiring processes, retention, idea generation, and other areas (Linkow, Barrington, Bruyère, Figueroa, and Wright, 2013; Kulkarni and Lengnick-Hall, 2014).

Societal and implicit biases are not traits that can be easily obviated with training and policy directives (Hawley et al., 2014). They are grounded in intrinsic attitudes and values that may not yield immediately to instrumental approaches. Rather, they are something that groups must work on over time if change is to be seriously pursued (Lai et al., 2014). While there are some policies and interventions that have shown some success (Chubin, Didion, and Beoku-Betts, 2015; Leggon, McNeely, and Yoon, 2015; Leggon and Pearson, 2008), research has shown that many conventional approaches or assumptions about related problems do not lead automatically or directly, or at all, to the encompassing or sustainable changes necessary to effect inclusion and positive transformation (e.g., Babcock, Laschever, Gelfand, and Small, 2003, Babcock and Laschever, 2008; Richeson and Nussbaum, 2004). Thus, for example, "diversity training" does not lead necessarily to greater diversity in upper management in corporations (Dobbin, Kim, and Kalev, 2011); "diversity professionals" training can be generally ineffective (Kalev, Dobbin, and Kelly, 2006); and successful diversity initiatives in one field can have unintended negative effects in others (Myers and Fealing, 2012; Fealing, Lai, and Myers, 2015).

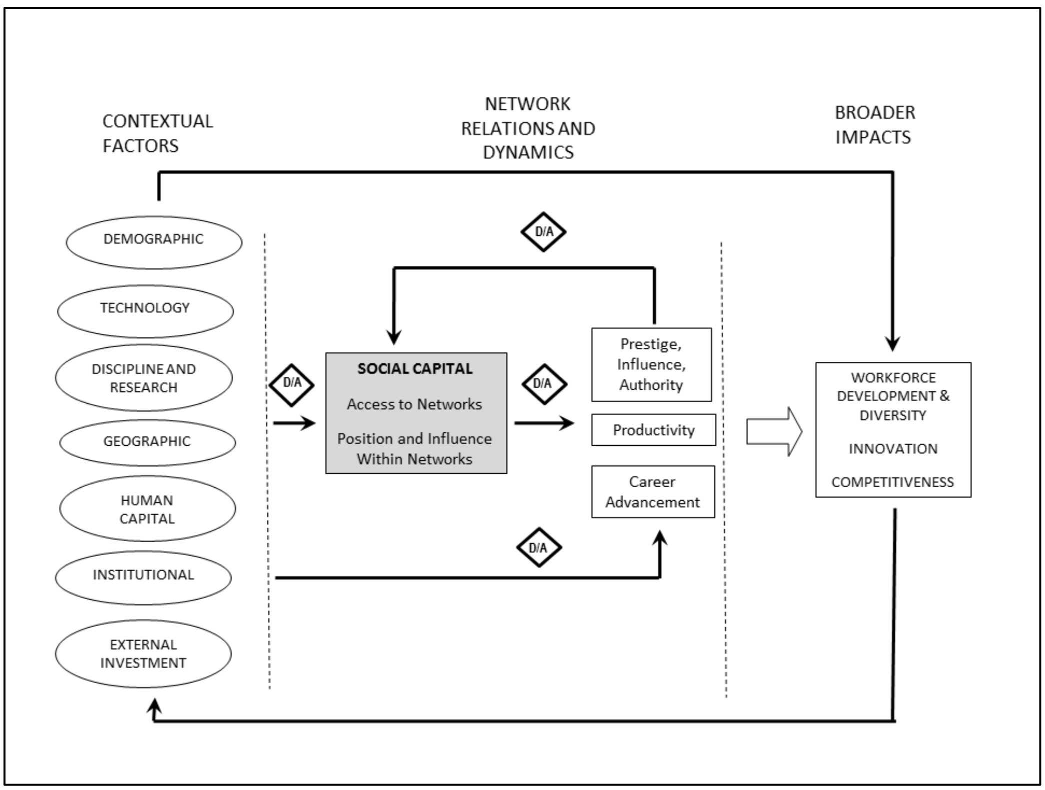
Organizations that institute explicit policies for increasing participation and avoiding implicit biases already may have other diversity-type programs implemented, making their environments more open to addressing related issues. However, SMEs might not have the capacities to develop such structures and may lack in diversity strategies. Understanding these types of impediments, along with social-psychological barriers, highlight areas that need to be addressed when considering institutionalized patterns of (non)participation and (non)inclusion in general and at different levels and units of analysis. Such issues underscore the need for an expanded SoBP as a comprehensive and systematically organized approach for analyzing, understanding, and effecting broadening participation in STEM fields and the related workforce (Smith-Doerr, 2009; Craig-Henderson, 2013; Fealing and McNeely, 2016; McNeely and Fealing, 2018).

2.4 Communities, Networks, and Participation

Considering occupational structure, mobility, and access, differentially available opportunities based on related societal constraints and needs become increasingly apparent as determinant labor market factors. STEM workforce development largely depends on social networks, and the formation of communities of learning and practice that have been identified and operationalized in research through analyses of collaboration patterns and participation (McNeely and Schintler, 2010, 2016). Moreover, increased scientific capacity translates into increased participation in scientific communities, and participation in expanded scientific networks can boost scientific intellectual, social, and cultural capital. The factors influencing participation have been delineated along dimensions that are internal and/or external to STEM fields. Each has different policy implications with respect to the diffusion of STEM capacity and/or to the interconnectedness of involved individuals (cf. Wagner and Leydesdorff, 2006). In addition to internal institutional features, these arrangements encompass educational systems, professional associations and meetings, funding organizations and policies, and the like. Such conditions also affect participation and the size, specialization, centrality, reach, and autarky of broader scientific communities, which are constituted by networks that enable or constrain participation and productivity (cf. Centola, 2010).

As shown in Figure 2, disability is a key determinant within a complex web of relational dynamics and processes. Epistemic community building in general is a highly complex process and, when disability and ableism are explicitly recognized and engaged as critical influences on observed outcomes, another layer of complexity is added to that process to the extent that further study is demanded in order to gain insight and understanding of the institutional, cultural, political, and economic dynamics that shape the STEM workforce (cf. McNeely and Schintler, 2016). Only by capturing those interactive dynamics can the kind of understanding and evidence be developed on which to formulate effective policies and interventions for building an inclusive, diversified, and strengthened STEM workforce.

***Figure 2:* Disability and Ableism (D/A) in Productivity and Workforce Development Processes**



(Source: McNeely and Schintler, 2016, modified)

Contextual relations encompass spatial, cultural, and political links and, viewing STEM knowledge capacity as a public good, both internal and external social, political, and economic factors concern influences of particular interest to decision makers regarding mobilizing and supporting STEM networks and communities (Katz and Martin, 1997; Callon, Law, and Rip, 1986; Latour and Woolgar, 1986). Network connections arguably contribute to participatory influence (Brass, 1984) and career opportunities (Burt, 1992); network structures and relative positions within them influence access to resources of all types (Lin, 2002). Research in STEM fields typically involves working with others to pool intellectual resources, such that participation and inclusion means providing expertise in associated disciplines, collegial vetting and support networks, a sense of community, and opportunities to relate to others (cf. Pfirman and Balsam, 2004). Accordingly, important considerations in determining such issues are sensitivity to network boundaries and awareness of bias introduced by perceptions and network positions. Disability acts as a differentiating factor in such perceptions and social dynamics play a central role in determining related developments in the STEM workforce which. Growing attention to research on networks and community inclusion as a key aspect of STEM productivity—not only as an outcome, but as a process—has led to a broader recognition that it must be understood within the context of larger social, cultural, political, and economic factors (McNeely and Schintler, 2016). The importance of identifying network structures and positions has been identified as a critical determinant of participation and inclusion possibilities (Hill, 2008; Lin, 2002), few if any studies contrast network structure and position by disability at different levels of analysis (Campbell, 2009; Hawley et al., 2014; Ward et al., 2012), leaving this a fertile area for SoBP exploration.

2.5 Markets and Incentives

In addition to the influence of organizations and networks on participation of STEM trained individuals with disabilities, another understudied area is the impact of economic instruments and outcomes related to diversity and inclusion measures for individuals with disabilities. Some studies (e.g., DeLeire 2000) indicate that there seems to be a steady employment of persons with disabilities in blue collar jobs. More broadly, the ADA is a demand-side intervention, noting that "education may serve as a wage buffer for workers with disabilities" (Hollenbeck and Kimmel, 2008, p. 710). Large wage returns were evident for people with disability onset after age 25, but less evident in those with earlier onset of disability. "An interpretation of these results is that the quality and quantity of education received by individuals who are disabled at the time of their educational decisions (i.e., those with early onset) are not serving them well in terms of finding productive job matches" (Hollenbeck and Kimmel, 2008, p. 721). Regarding low employment and low wages for individuals with disabilities, "simply having a job does not eliminate some of the economic and skills gaps they face" (Schur 2002). Employment can lead to higher incomes *and* higher civic skills.

However, very little work was found that investigated the specific economic impacts of diversity and inclusion policy changes for individuals with disabilities by industry sector. Further, there was a lack of information in the economics literature on what types of economic incentives worked and what was ineffective in getting employers to hire, develop, and promote individuals with disabilities in STEM-oriented places of employment (Baker et al., 2018b).

Much of the pertinent research that exists can be found in vocational/rehabilitation and disability studies arenas, with relatively little even tangentially addressing these questions in the economic and business literature. As for wages, the literature focused on impacts of the ADA, showing that there have been negative impacts on earnings (Beegle and Stock, 2003; DeLeire, 2000). However, this outcome can vary depending on how disabilities are categorized (Schur, 2002). An additional complexity may lie in the way in which data is collected and reported. For example, individual self-reported data has been used to examine reported declines in employment among individuals with disabilities since the enactment of the ADA (Hotchkiss, 2004). The data reflect the propensity to report disability if looking for a job. Reporting disability has been (positively) correlated with the decision to enter the labor market, and partially explains why individuals with disabilities have lower reservation wage and lower supply—productivity and accommodations factors (Hotchkiss, 2004). Strong evidence exists that the decline in the labor force participation rate for individuals with disabilities was not the result of individuals with disabilities exiting the labor force, but more likely the result of "re-identification" of some non-labor force participants from the category of "nondisabled" to "disabled." Also, based on analysis of U.S. Census Bureau's Survey of Income and Program Participation and Current Population Survey data, individuals with disabilities are no more or less likely to be employed than individuals without disabilities, post-ADA (Hotchkiss, 2004).

Paucity of research in this area—the economics of broadening participation in STEM for individuals with disabilities—is another indication of the need for closer investigation of incentives and market outcomes for programs meant to assist persons with disabilities gain employment in STEM fields.

3.0 Analytical Gaps: Disabilities as (Non)Barriers to STEM Inclusivity

As mentioned, a significant effort driving STEM workforce development has focused on the supply and on enhancing the preparation of STEM skilled workers (Hawley et al., 2014; Duerstock and Shingledecker, 2014; Mervis, 2016). Less is understood about the demand side of the equation (organizations and institutions that employ STEM workers), as questions of participation and inclusion typically are framed in terms of the comparatively low employment rate of qualified individuals with disabilities. According to the U.S. Bureau of Labor Statistics, the 17.2 percent employment rate of individuals with disabilities in general stands in contrast to the 65 percent rate of employment for those without disabilities.[3] Further, employment of scientists and engineers with disabilities is significantly less than those without disabilities: 63.8 percent with disabilities versus 83.5 percent without disabilities (NSF, 2017). Of course, it would be more informative if more detailed data and depictions were available by, for example, disability and the extent to which there are differences across type, especially as regards "visible" as opposed to "invisible" disabilities. In any case, a combined workforce supply and demand focus means leveraging resources and determining training capacities, skill gaps, and lessons learned within different sectors to support and promote responsive, rigorous, and relevant workforce education and training for a viable workforce (NASEM, 2017).

Recognizing that broadening participation is a conceptually complicated issue, engaging various measures for workforce development components can add to analytical clarity. Several key concepts raised at the SoBP Symposium suggest critical areas for policy intervention and for developing an integrated and encompassing approach. For example, one such concept is "Hubs of Innovation," involving public-private partnerships for joint activities that "seal gaps in career progression."[4] This idea encompasses leveraging connections and amplifying characteristics of epistemic networks and communities to achieve policy objectives. As discussed above, it was recognized that institutional and organizational behaviors and cultures, reflecting factors such as employer perceptions, can represent obstacles to participation and include concerns about perceived versus actual cost as a barrier to hiring employees with disabilities and perceived versus actual mismatch of education and/or skills and capabilities to job qualifications among applicants with disabilities (Baker, et. al. 2018b). Further research is needed in this area, considering social psychological dynamics and

[3] https://www.bls.gov/news.release/disabl.nr0.htm
[4] An NIH proposed programmatic strategy, presented by Dr. Hannah Valantine.

effects on perceptual and other barriers to specified participation and inclusion in the STEM workforce.

Given gaps in the literature with respect to the importance of network and contextual considerations in broadening participation, research on stakeholder relational structures is needed to provide a solid evidence base for enhancing STEM participation and inclusion. In addition, beyond focus on outcomes (e.g., representation ratios; see Myers and Fealing, 2012; Fealing, Lai, and Myers, 2015), differences and changes in network densities (indicators of sustainability and resilience) and in culture, climate, and community (indicators of sustainability and scalability), and on the extension of programmatic approaches to advance policy aims. For instance, NSF's Innovation Corps (I-Corps) program is designed to "broaden the impact of selected NSF-funded basic research projects by preparing scientists and engineers to focus beyond the laboratory. Leveraging experience and guidance from established entrepreneurs and a targeted curriculum, I-Corps grantees learn to identify valuable product opportunities that can emerge from NSF-supported academic research."[5] Directed policies could target outreach to STEM trained individuals with disabilities as a way to facilitate network engagement and participation. For another example, federal agencies have been granted the authority to host prize incentive competitions (through the America COMPETES Reauthorization Act of 2015), emphasizing national importance and the capacity to spur economic growth. Opportunities to challenge bias and broaden participation and inclusion in STEM require clear and meaningful measures of success for assessing reliable and replicable programs and practices.

4.0 Foundations for Inclusive Participation in STEM Employment for Individuals with Disabilities

A number of critical conditions have important policy implications, including, for example, employment of social networks (Kulkarni and Lengnick-Hall, 2014), use of social media (Moore et al., 2015), career and professional development (Byars-Winston 2014), mentoring and industry and institutional efforts to address various issues such as organizational climate (Linkow, Barrington, Bruyère, Figueroa, and Wright, 2013), and identity and related influence (Ward et al, 2012; Santuzzi and Waltz, 2016). Note too that employers often lack the tools they need to improve progress toward increased employment of STEM workers with disabilities (Linkow, Barrington, Bruyère, Figueroa, and Wright, 2013). Thus, in addition to the need for more robust data collection, professional development issues, such as post-doctoral training strategies, research infrastructure approaches (Moore et al., 2015), and nontraditional efforts such as "makerspaces" (Godfrey, 2015), represent programmatic and policy foci for application to individuals with disabilities and other underrepresented groups.

Despite some efforts to remove related biases, disabled persons remain underrepresented in STEM in careers and research. Thus, it might be more profitable to introduce a more comprehensive "mainstreaming" approach across levels of analysis to address related problems and issues. Based on ideas taken from notions of gender mainstreaming,[6] this approach refers to the treatment of disability as normalized and integral to the design, implementation, monitoring, and evaluation of relevant policies and programs in all political, economic, and social spheres (cf. Burgstahler and Cory, 2008). Mainstreaming is a strategy for integrating equity considerations in standard

[5] NSF Factsheet: I-Corps Teams, https://www.nsf.gov/news/special_reports/i-corps/pdf/factsheet_teams.pdf
[6] http://www.un.org/womenwatch/osagi/gendermainstreaming.htm

organizational operating procedures and activities. The greater the extent to which a policy is integrated into the standard operational procedures of an organization, the greater the likelihood that the policy will be sustainable. In this regard, promising policies for mainstreaming clearly delineate individuals with disabilities and others as specific policy categories, and include directives for action asserting their consideration for enhancing national growth and competitiveness (Leggon, McNeely, and Yoon, 2015). Accordingly, mainstreaming policies would be integral components of national and organizational policies (rather than peripheral add-ons). In this same context, sustainability can be operationally defined as the extent to which policies, programs, and practices are likely to persist over time, as might be necessary to fulfill their objectives and promise. Indeed, sustainability is context-specific; across contexts, sustainability is an important criterion in decisions to accept or reject a given policy, practice, or program. More to the point, mainstreaming, with a focus on enhancing STEM participation, is a policy strategy for more sustainable workforce development and economic growth including individuals with disabilities.

5.0 Assessments and Recommendations for Policy and Practice

As noted in discussions and presentations at the SoBP Symposium presentations (McNeely et al., 2018), while it appears that steady progress is being made in fundamental post-secondary education and training, advancement and research are still critically needed in areas dealing with awareness, outreach, and professional networks of practice for increasing participation of individuals with disabilities in STEM occupations. Against this backdrop and looking to the extant literature, a variety of strategies have been suggested for further exploration and engagement, including (1) building a sustainable, targeted "network" of innovation nodes and researchers, (2) an "observatory" or ongoing review of inclusion in STEM fields and cultures, and (3) a "toolkit" for assessing innovative practices and institutions in the context of knowledge transfer and closing the knowledge-practice gap.

5.1 A Network of Innovation Nodes and Researchers

Harkening back to the topic of networked STEM development, research is needed on designing a Professional Inclusive Innovation Network (PIIN). As a practical application, the PIIN could offer the SoBP community an opportunity to capture relevant research and policy data, to cultivate meaningful programs at the appropriate scale, and to develop a network of analysts, advocates, mentors, and other stakeholders to inform broader efforts and initiatives for expanding participation and inclusion. In fact, a "network of networks" approach could provide insights and involvement at scale. Thus, deploying a PIIN with regional nodes of innovation could offer access and bring together successful industry innovators, academic, and technical specialists, and young STEM professionals (and aspiring students) with disabilities. By attending to smaller, specialized regional networks that feed into the nexus of SoBP, relevant data and the ability to explore remedies and applicable policy approaches can then be recognized. This is especially the case as a common theme amongst STEM communities — and in broader academic and professional realms — for investigating lessons that can be translated across disciplines or sectors (Dobbin and Kalev, 2016). However, some lessons and practices may not be translatable across levels and units of analysis and their scope conditions must be identified accordingly. STEM engagement tools may not be equally effective across different populations, and this is especially the case for individuals with disabilities, who encompass a wide range of characteristics, abilities, and interests.

As an example, taking on the task of defining the parameters of a PIIN, addressing community participation and inclusion in a specific field could provide insight on related processes and problems that must be taken under consideration in PIIN development. A pilot project might rest on selecting a field that (1) will narrow the scope so that results are not diluted by an affluence of factors or inputs, and, in practical terms, (2) will allow for PIIN establishment and management. The biomedical field is particularly apt in this regard (Valantine, Lund, and Gammie, 2016), and has also been identified as a discipline that has an imbalance in diversity demographics (Valantine and Collins, 2015). Over the past few decades, technological advancements have allowed for profound changes in the ways that healthcare and medical services are provided and have given way to new industries. From bio-ceramics to robotic prosthetics, or microbe and gene therapy to 3D printed heart valves, researchers and companies have been working towards the next cutting-edge life-saving treatments. In turn, this work has spurred competition among large medical device and pharmaceutical driven companies, as many innovators apply their skills in entrepreneurial efforts. Just within the last three months, reports indicate that there have been nearly 90 biomedical technology start-ups.[7] Such a focus can provide insight into the types of start-ups in the biomedical technology field, the barriers that they face in regards to disabilities and diversity, and whether a PIIN is a suitable platform for engagement within this group. Moreover, it can enable other interested parties, including researchers and policy analysts, to better understand the nuances and concerns that attend participation on such a platform (Myers and Fealing, 2012).

5.2 An Observatory for STEM Participation

Along with the PIIN, the idea of an observatory in this context is to more precisely capture target data, topics, solutions, and proposals while simultaneously identifying a network of mentors, leaders, and other resources for those in the respective regions looking to get involved, adopt practices, or contribute to relevant fields and discussions. By considering and, further, determining the data that will be collected, there will be opportunities to design applicable and evidenced-based research and policy interventions. Evidence is crucial to developing effective policies. Accordingly, data that are accurate, credible, reliable, and valid both drive and inform effective policies. This point is especially important since the types of data and measures that are used in policy planning can themselves be problematic if they do not actually capture or reflect the intended policy issue or related factors (Leggon, McNeely, and Yoon, 2015).

Regarding data limitations, one primary source of data on individuals with disabilities in STEM fields is the National Center for Science and Engineering Statistics (NCSES) at the National Science Foundation. NCSES, which produces reports by statute for the National Science Board, is a valuable source of statistical data particularly related to educational preparation in STEM fields, especially baccalaureates and doctorates. However, those reports mainly show supply side statistics. Providing information on barriers to STEM jobs for individuals with disabilities, and on salaries and wages, could improve the reports and their usefulness for understanding workforce participation. More data about attainment of master's degrees in engineering fields, for example, would offer information that might be more relevant to the workforce in industry, as opposed to academia. In addition, the data provided on demand-side actors could be improved by conducting a

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[7] From AngelList, an online platform that allows global investors and job seekers to be part of a venture start-up. https://angel.co/biotechnology

set of industry-sector investigations or by engaging with groups that focus on employers in industry (e.g., the U.S. Business Leadership Network and the Society of Human Resource Management).[8]

However, generating statistics on individuals with disabilities can be complicated at best, owing to the necessity for individuals to self-disclose; there are varying degrees of reluctance to do this depending on type of disability, age, and context in which the disclosure occurs (Santuzzi and Waltz, 2016; Kranke et al., 2016; Scorgie and Scorgie, 2017). "For several reasons, data on people with disabilities have limitations. First, the operational definitions of disability may vary across a wide range of physical and mental impairments, and they may not be comparable" (NSF, 2017). Empirical data on workers with disabilities from the employer side are limited generally, and especially absent from management journals (Dwertmann, 2016; Baker et al., 2018b). While data on many aspects of disability are available at the population level,[9] the specifics of employment, particularly regarding STEM trained employees in industry, are more difficult to obtain with consistency for extended periods of time.

Another data issue is the taxonomy used for gathering data on individuals with disabilities. For example, as a rule, the definitions used in the NCSES report *Women, Minorities, and Persons with Disabilities in Science and Engineering* follow standard approaches (e.g., ADA guidance).[10] The report notes, however, that data are self-reported, rather than objective clinical data (NSF 2017). This approach can be potentially problematic depending on type of disability—functional limitations rather than observable characteristics. This perspective tends to rely on a medical model that was prevalent in the past, but currently is less favored than social welfare and human rights models (Barnes and Mercer, 2010; Kelemen and Vanhala, 2010).

With the support of accurate and appropriate data, and expanded taxonomy and measurement capabilities, many of these issues may be addressed within the SoBP PIIN. Note too that the PIIN observatory is bi-directional, exposing industry and businesses to STEM professionals with disabilities, thereby increasing awareness of an under-recognized population and increasing the awareness of young professionals in STEM fields of the array of possibilities for participation in related areas. The PIIN would network interested parties, who could collaborate on data collection (e.g., U.S. Business Leadership Network, surveys of professional group memberships, and some potential work in progress at the Office of Disability Employment Policy in the Department of Labor).

5.3 A Toolkit for Assessing Innovation and Inclusion

In addition, the development of a supporting toolkit is suggested to catalog and leverage typical industry inclusive practices and approaches that have been developed for business and that have some deployment in related sectors.[11] Although not typically used in STEM professional development, a two-pronged effort aimed at (1) tailoring them for employers and other end-users,

[8] See the U.S. Business Leadership Network (http://www.usbln.org/), or more broadly Disability in the Workplace: Employers' Organizations and Business Networks (Bureau for Employers' Activities, ILO 2011) (http://www.businessanddisability.org/images/pdf/working_paper_n6.pdf).

[9] E.g., Cornell University maintains a robust website on disability statistics (http://www.disabilitystatistics.org/); and the Interagency Committee on Disability Research has a detailed set of resources (https://icdr.acl.gov/resources/disability-data).

[10] https://nsf.gov/statistics/2017/nsf17310/technical-notes.cfm#information-about-people-with-disabilities

[11] E.g., http://www.peatworks.org/ and http://www.askearn.org/about/

and then (2) further identifying nodes and building PIINs that seek to bring together industry, successful practitioners, and target STEM populations (in this case individuals with disabilities and veterans) is an action-oriented, tool-based approach. The toolkit would consist of resources for professional development and contacts, and would operate in conjunction with observatory data collection and evaluation and monitoring activities.

Relevant data are critical to understanding the impact of given or proposed policies on various stakeholders from different populations, fields, and sectors. These data can provide a basis for benchmarking and evaluation as they can facilitate the identification and assessment of indicators of policy efficacy at various points in time and for various populations. Such data are invaluable in their contribution to the policy process itself, refining the implementation, enriching the assessment, and expanding understanding of the impact of policies on various stakeholders. In sum, these data enable identification of "what is working well, what is not working well, and why" (Leggon, McNeely, and Yoon, 2015, pp. 318-319). Therefore, the toolkit, coupled with an iterative observatory approach, would allow for both top-down and bottom-up insights that fit to different contexts, organizational demands and cultures, and population needs and characteristics, with the hope of promoting favorable outcomes of broadening participation and inclusion.

6.0 Conclusions

Drawing on a range of relevant research and taking direction from the SoBP Symposium, this report has identified several areas on which policy development and analysis might focus in relation to broadening the participation of individuals with disabilities, including veterans, in the STEM workforce. Broadly, these include:

1) multidisciplinary integration of knowledge related to understanding and assessing underrepresentation in STEM fields;
2) enhanced focus on empirical observations (data, metrics, and statistics) related to assessing underrepresentation in STEM fields;
3) curated knowledge focused on educational preparation, including assessment of educational attainment, contextualizing educational access, opportunities, and outcomes, and identification of critical causes of underrepresentation in STEM fields;
4) expanded research focused on identifying workforce dimensions and dynamics, contextualizing occupational access, opportunities, and outcomes, and investigating recruitment, retention, and network inadequacies leading to underrepresentation in the STEM workforce; and
5) the need to conduct additional research targeting the economic impacts of inclusion and non-inclusion in the workforce of STEM-trained individuals with disabilities.

As observed above, much of the research on STEM employment of individuals with disabilities, to date has, rightly, focused on educational preparation, leaving the more complex object of workforce integration, participation, and advancement as fertile fields for observation and policy innovation. For instance, recognition and inclusion of social dynamics and relations in analyses of STEM productivity offer a more detailed depiction and insight into the processes affecting STEM workforce issues, especially in regard to disability status and perception. Furthermore, research also looks to extant "lessons learned," primarily from large institutional contexts (e.g., public-sector entities, large corporations, and industry research), that can be applied in other areas and to other groups, further informing and providing direction for future inquiry and policy development. From a proactive policy perspective, this would be a strong first step: identifying strengths and gaps in the current literature, indicating fruitful areas for research and important questions that remain to be asked and addressed. Accordingly, straightforward "action items" for considering complex processes involving disability are integral to developing an expanded capable and effective STEM workforce.

While not addressed here as such, it must be noted too that disability, as a construct, is saturated with other modes of difference and bias. The intersectionality of the construct can turn on other axes of inequality—e.g., race, sexuality, nationality, wealth—all of which can cut across notions of disability at different angles and can affect observed outcomes in participation and inclusion. Also considered here is a somewhat overlapping group of underrepresented individuals: military veterans with STEM training (especially more applied forms). U.S. military veterans have been widely excluded from the conversation, especially those veterans with service connected disabilities. The education, training, and skills that military veterans possess cut across a wide range of STEM disciplines, from microbiology to hydrology and from computer science to robotics. Any viable path for an expanded pilot of the proposed PIIN platform should consider including this group.

Veterans have shown a propensity for self-employment opportunities (Hope, Oh, and Mackin, 2011), with recent figures indicating that 7.3 percent of veteran business owners report service connected disabilities (Sobota, 2017). Understanding the motivation and makeup of relevant veteran owned small businesses, relative to small business owners in general, may provide insight as to why they do not seek employment at traditional firms and to the ways in which their STEM education and skills have been useful. Participants in the Veterans STEM Innovation Network: Participatory Design Workshop, held at Georgia Institute of Technology in connection with the production of this report, indicated the need for a better system for translating veterans' service records into a form that is meaningful for employers in STEM and STEM-related sectors. One example is PurePost (https://www.purepost.co), a resume builder for members of the military and veterans. Other tools that could help address the implementation of policies and practices aimed at improving the participation of veterans (particularly those with disabilities) in the STEM workforce include:

- customized personal skills assessment and pathway for employment;
- an informational network/app;
- communications to the public and employers about the advantages of hiring a veteran;
- online resources for veterans and potential employers;
- trainings with career advisors;
- combined professional development and scholarship programs for veterans;
- Veterans Affairs benefits that support "stackable credentials"[12]; and
- online educational opportunities (e.g., MOOCs) for veterans only.

Various approaches can be employed to both explore and address issues noted above as well as offer potential scalable initiatives that could generate data to better develop policy that more closely fits the specific characteristics of the target groups. As discussed, these include (1) building a sustainable, targeted "network" of innovation nodes and researchers, (2) an "observatory" or

[12] Stackable credentials is a term that refers to movement from more technical vocational training to professional education, e.g., from a certificate to a bachelor's degree. "Stacking" is the process that allows the earlier training to count toward the latter.

ongoing review of inclusion in STEM fields and cultures, and (3) a "toolkit" for assessing innovative practices and institutions in the context of knowledge transfer and closing the knowledge-practice gap.

Next Steps

Looking further into the future, there is a growing need to undertake research that explores the range of possibilities made possible by continued technological innovation, such as artificial intelligence and robotic applications and their impact on the need for, and hence, careers of individuals with disabilities. Such technologies are widely noted as critical to building pathways to future industries. However, automation and computerization capabilities demonstrate an imminent impact on low-wage and low-skill workers and pose potential threats to mid-level science and engineering careers (Baker et al., 2018a; Frey and Osborne, 2017). These technologies then represent a double-edged sword, adding value to current industries and increasing some types of job opportunities (Purdy and Daughety, 2016; Gorle and Clive, 2013), while eliminating the need for more traditional manufacturing related work. Although research exists investigating resulting entrepreneurial activities and the potential of the contingent workforce and "gig" economy (see Barrington et al., 2014; Dokko et al., 2015; Hauge and Parton, 2016; Lee et al., 2016; Shaheen, 2016; Groah et al., 2017), what is missing in these generalized scenarios is a specific analytic lens that takes into account the impact on individuals with disabilities, working in STEM disciplines or careers. Thus, for example, will employers look to supplant "different" employees (such as individuals with disabilities) with novel technologies? Will the integration of future technology create additional barriers or opportunities for veterans? Questions such as these need to be answered as technology advances towards an unavoidable integration.

In addition to data gaps discussed earlier, one other issue that was discovered during preparation of this report was the lack of specific linkages of the evidence to policies that can lead to an increase in both the participation of individuals with disabilities in the STEM workforce and to greater opportunity for these individuals to contribute to the STEM discoveries and innovation. The current policy focus is primarily on supply side approaches. This is evident from an extensive review of the literature that concentrates on preparation, on academic and educational literature, and on the disability (e.g., rehabilitation) literature from the viewpoint of people with disabilities. Much of the work that exists on the demand-side focuses on federal contractors, who are encouraged (or required) to adhere to federal rules. Of particular interest is Section 503 of the Rehabilitation Act of 1973, as amended (41 CFR Part 60–741), which includes a "nationwide 7% utilization goal for qualified individuals with disabilities" in their workforces. Policy approaches that focus on addressing demand-side approaches start with data collection and engagement of a wide array of industry and business actors. Interesting approaches include advanced skills/apprenticeship programs (e.g., Cantor, 2015), paired professional development, and an industry drive analogue of the undergraduate work study program in which STEM trained individuals explore industry opportunities. As mentioned, one of the key problems from the demand side is lack of awareness or familiarity with the characteristics, limitations, and skills of people with disabilities (Henry et al., 2014). Greater exposure could reduce perceptual barriers and (hopefully) unconscious biases. Somewhat related to this point is the possibility of exploring the other side of the problem—not hiring, but firing of people with disabilities and, to an extent, veterans. Exploration of the reasons in which people do not stay in a workforce could yield valuable insights (Rumrill and Fitzgerald, 2010). International work exploring policy interventions in this area also yields valuable insights (see Parker et al., 2012). Moreover, given the hidden aspect of some of the disabilities considered here, the policy solutions and approaches suggested in this report could shed light on other aspects of discrimination endured by other groups, with and without disabilities.

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APPENDIX

Veterans STEM Innovation Network: Participatory Design Workshop
Piedmont Room, Georgia Tech Student Center, Georgia Institute of Technology
Workshop Agenda

April 27, 2018

9:00 am	**Registration & Refreshments**
9:15 am	**Welcome** Andrew Hanus, School of Public Policy, GT
9:20 am to 9:45 am	**Background and Overview – Dimensions of Broadening Participation** Paul M.A. Baker, Ph.D., Center for Advanced Communications Policy, Georgia Tech Professor Kaye Husband Fealing, Chair, School of Public Policy, Georgia Tech Andrew Hanus, School of Public Policy, Georgia Tech
9:45 am to 10:15 am	**Veterans, Engagement and Opportunity** David Maron, Innovator & Health Consultant
10:20 am to 11:30 am	**Perspectives on Veteran Engagement and Participation Panel** ▪ Jeff Cullen, Office of Government and Community Relations, Georgia Tech ▪ Ronald L. Johnson, Professor, Industrial and Systems Engineering, Georgia Tech ▪ Brad Fain, Ph.D., GTRI ▪ Michelle McBee, VA Innovators Network
11:40 pm to 1:20 pm	**Lunch & Facilitated Design Exercise (20 Min each – Design/Ideation)** **Session 1** – What are the characteristics/perspectives of STEM trained Veterans and what barriers exist to participation in STEM Innovation activities **Session 2** – What opportunities exist, what unmet needs are present, and what tools could address these (policy/technology/practice) **Session 3** – Ideation on "how might we …?" session. Output would be potential solutions addressing Veterans needs and ways of bringing together industry, innovation support Intermediaries and veterans
1:30 pm to 2:00 pm	**Discussion/Next Steps – STEM, Innovation and Engagement** Idea translation and moving forward. Who could (should) be at the table?
2:00 pm	**Final Thoughts/Closing Remarks**