Improving Technology Transfer for National Security

Prepared for the National Security Innovation Network
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NATIONAL SECURITY
INNOVATION NETWORK

Contents

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Disclaimer

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

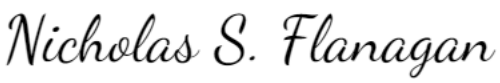
Honor Pledge

On my honor as a student, I have neither given nor received aid on this assignment.

Note on the Analysis

Much of this analysis was completed prior to moves by NSIN to incorporate some of the suggestions contained. For the purposes of this report, the content remains unchanged but can be adapted based on where NSIN is today rather than at the start of this analysis.

All dollar amounts are in current year dollars unless otherwise specified.



Acronyms

NSIN: National Security Innovation Network

NSIC: National Security Innovation Capital

DoD: Department of Defense

DII: Defense Innovation Intermediary

DIU: Defense Innovation Unit

IP: Intellectual Property

TTO: Technology Transfer Office

KPI: Key Performance Indicator(s)

MVP: Minimum Viable Product

MBA: Master of Business Administration

POR: Program of Record

Executive Summary

Technology transfer has long been a key topic of discourse for researchers and entrepreneurs, but only in recent years has there been a resurgent interest from the US government - namely within the Defense sector. In 2015, the Defense Innovation Unit (DIU) was founded with the express purpose of aiding the US military in making as-fast-as-possible use of emergent technologies. One of the principal bodies charged with carrying out that task is the National Security Innovation Network (NSIN), a program office created under the DIU in 2016.

Despite the growing importance of technology transfer in the time since NSIN's founding, they continue to **utilize outdated models and methods in understanding and undertaking their technology transfer efforts**.

In addition to allowing present trends to continue, this report proposes four methods to improve NSIN's technology transfer effort:

1. Improving the hiring process to target candidates with skills in the areas that NSIN lacks expertise in, such as market analysis (Personal Communication, 2020)
2. Implementing training to accomplish the same goal but among both new hires and current employees
3. Creating a formal, evidence-based identification process for identifying viable technologies for transfer into the Department of Defense (DoD) sphere
4. Reorienting internal policies and practices to align with NSIN's mission (i.e., rewrite KPIs)

These alternatives will be evaluated based on the following criteria:

1. Cost
2. Administrative Feasibility
3. Effectiveness
4. Long-Term Sustainability

Every alternative will receive a score of Low, Medium, or High which will then be converted to Low = 1, Medium = 3, and High = 5. Each criterion will be weighted equally and the highest cumulative score will determine the recommended alternative.

Based on my findings, I recommend that NSIN create a formal, evidence-based identification process for identifying viable technologies for transfer into the DoD sphere. This alternative would greatly improve the effectiveness of NSIN's technology transfer efforts at a reasonable cost while still maximizing administrative feasibility and long-term sustainability. This alternative will see a key implementation challenge in the form of engaging relevant stakeholders (i.e., DoD clients) to ensure information sharing on outcomes is facilitated so as to enable NSIN to accurately understand the success, or lack thereof, of its technology transfer efforts.

Background

Technology transfer, as we understand it today, is rooted in the passage of the Bayh-Dole Act in 1980 which revolutionized the nation's system of technology transfer. The Bayh-Dole act gave universities the rights to inventions and take on the subsequent patenting and licensing process. More importantly, it created a uniform patent policy among federal agencies that funded research, which allowed other bodies (e.g., small businesses and non-profits) to also retain the rights to inventions created under federal research programs (AUTM, 2021).

> Together with amendments in 1984 and augmentation in 1986, this unlocked all the inventions and discoveries that had been made in laboratories throughout the United States with the help of taxpayers' money. More than anything, this single policy measure helped to reverse America's precipitous slide into industrial irrelevance (Economist, 2002)

The above quote underscores the profound importance of "perhaps the most inspired piece of legislation to be enacted in America over the past half-century", and alludes to the basis for the newfound interest within US National Security (Economist, 2002). Where the emphasis on technology transfer was once rooted in concerns about a slide into "industrial irrelevance", many within the DoD are deeply concerned that the defense sector is too stagnant and an inability to innovate could result in an analogous slide into irrelevance. The driving concern is found in the belief that the US has "maintained decisive military advantage over its adversaries due, in large part, to superior technology capability" (DIU, 2019 qtd. in Schmid and Wong, 2020).

As a result, the DoD has, in just the last 6 years, established several new bodies, such as NSIN or the National Security Innovation Capital (NSIC), referred to as DIIs. These organizations were founded with the goal of greatly increasing the rate at which the DoD adopts external (i.e., commercial or University-based) technology to tackle emerging challenges to our national security and, more specifically, to maintain that decisive military advantage (Schmid and Wong, 2020). The fundamental issue at this stage is that there is simply no meaningful literature on DIIs and that almost all are too new to conduct meaningful evaluation of – the DIU is a likely candidate for such an analysis going forward, but, to date, nothing of the kind has been done (Schmid and Wong, 2020).

Meanwhile, the question of how best to approach technology transfer within universities and research bodies (e.g., federal laboratories) has a longstanding and extensive literature (Adomavicius et al., 2008; Agrawal, 2001; Bradley et al. 2013; Tran and Kocaoglu, 2009). And within that literature it is the case that most, if not all, studies that examine technology transfer success and effectiveness (or lack thereof) have, until recently, employed what is known as the "Out-the-Door" criterion; practitioners have likewise almost exclusively utilize it (Anderson et al., 2007; Park et al., 2010; Heisey and Adelman, 2011). This criterion can be effectively summarized as "was technology transferred?" because the basis is essentially "if the agent (e.g. NSIN) transfers the technology to an organization (e.g. a DoD client) then it was a success" and no attention is afforded to "motives nor the uses of the IP" (Bozeman et al., 2015). And NSIN, like so many of those institutions throughout the last 40 years, does indeed utilize this model as well.

The fundamental problem with the Out-the-Door model is that it massively diminishes the breadth of information an organization could possibly use to understand, let alone inform, its technology transfer efforts. Simply put, using only the Out-the-Door all but ensures that an organization will never have any evidence, or even knowledge, that the transfer of a given technology provided tangible benefit of any kind. Moreover, they would preclude themselves from knowing if the transfer's outcome was in fact harmful. A notable case (Kingsley and Farmer, 1997) demonstrates this effect: a state government transferred a technology and, upon its successful transfer, lauded it as immense success. That was the beginning and end of their assessment – even viewing it as a success in the first place was based wholly on an assumption.

Later it was realized that, in fact, the acquiring company immediately sold the technology to a foreign firm who in turn capitalized on it to gain a "strong competitive edge" against U.S. firms, resulting in them "arguably driving some out of business". Throughout the several years that elapsed before the transfer was examined, it was viewed as a massive success despite the reality of significant negative economic effects over the entire period (Bozeman et al., 2015). Similarly, a firm could be seeking out a transfer of intellectual property (IP) with the sole intent of ensuring no one else gets it, never themselves planning to utilize it in any form. In either case, an organization operating under the Out-the-Door model would never be positioned to understand if its efforts are meaningfully successful.

The importance of this problem is several-fold, with the above demonstrating that technology transfer efforts can easily result in outright negative outcomes and an organization utilizing Out-the-Door would likely never know. While it is not immediately obvious that a similar outcome would result from NSIN's efforts, given their charge is transferring exclusively to DoD clients, it remains possible. Imagine, for instance, that a technology is transferred to a DoD client that would greatly improve battlefield survival rates in some fashion. Ultimately, the DoD determines that it is too costly for them to utilize for their use-case and tables the technology indefinitely. In turn, the transfer has had, at best, a neutral impact and cannot be utilized by anyone else (e.g., domestic trauma centers), resulting in a net-negative impact.

Likewise, even before the actual transfer stage, acting on such limited information makes it far more difficult to properly assess what technology to facilitate the transfer of. And even prior to that stage, not understanding general best practices undertaken by other organizations precludes efficient internal organization (e.g., suboptimal hiring or training practices) that would increase NSINs capacity to maximize positive benefits and, ideally, avoid neutral or negative outcomes (qtd. in Bradley et al., 2013; Debackere and Veugelers, 2005; Siegel et al., 2004; Powers and McDougall, 2005).

In either case, poorly conceived and executed technology transfer has the capacity to produce negative outcomes of many kinds (i.e., economic, social, safety, etc.) or to simply be ineffectual. Even understanding if a particular DoD client does poorly with transferred technology (e.g., almost never gets technology past the prototype stage) would greatly inform NSIN in how it selects clients to seek solutions (in the form of IP) for. To that end, while NSIN need not necessarily adopt any particular model, as simply deviating from Out-the-Door should be the principle goal, there are numerous models that will be discussed later such as the Opportunity Cost or Public Value models (see Table 1). These models seek to understand tangible impact on resource-allocation, effectiveness, and societal impact rather than answering the question of whether technology was transferred or not.

Client Context
Key to understanding NSIN's capacity to implement changes is its funding mechanism and history, alongside its base plans in FY 2020. NSIN's budget in its first year, FY 2016, was $5 million, which quickly increased to $25 million in 2017, $25.5 million in 2018, and a brief drop in 2019 to $15 million before returning to $25 million for 2020. All funding comes from the DoD's Research, Development, Transfer & Evaluation (RDT&E) budget and it must be noted that funding is contingent upon meeting the plans and metrics outlined therein (United States, 2020, p. 339-340).

Notably, NSIN's FY 2020 base plans include:

1. Launching the NSAA (NSA2) Network with 10+ university partners with a goal to launch more than 30 dual-use ventures;
2. Establishing four new regional hubs and placing three new University Program Directors;
3. Completion of 10 Hackathons and Hacking for Defense (H4D) at 25 universities, resulting in more than 15 minimum viable products (MVPs) delivered to DoD end users;
4. Three Catalyst program iterations that transition five commercially viable technologies to DoD Major commands (MAJCOMS);
5. Close collaboration with the Defense Manufacturing Institutes to establish a national network of rapid prototyping facilities to increase commercialization of potential dual-use solutions.

Jargon aside, the takeaway here is that all but the final item is wholly predicated on volume of activities, rather than tangible impact thereof, and while MVPs are products that have impact, they are, by definition, the smallest (hence minimum) possible product a person or team can build that delivers value of any kind.

Similarly, their KPIs include:

1. Year over Year Growth of Entrants into the NSIN virtual Platform (Goal of 25%+)
2. Annual Savings from Non-Traditional Problem-Solving Methods (Goal of 10x Budget)
3. Annual Solution Adoption Rate (Goal of 75%+)
4. Year over Year Growth for Technologies Transitioned from DoD Labs (Goal of 25%+)
5. Annual Number of Dual-Use Ventures Launched with Follow-on Funding (Goal of 15+)

Again, we see here that virtually all of NSIN's evaluative criteria imposed on them by the DoD are predicated on volume of activities. The notable exception is KPI 2 which ostensibly would serve as a metric demonstrating cost-saving due to NSIN activities. At present, though, this KPI, though present in the most recent budget, is absent from NSIN's internal KPI memo from June 2020.

In either case, NSIN is implicitly limited by needing to meet, or at least satisfy, metrics that are almost wholly predicated on volume of activities, which would explain their operating so many programs despite open internal discussion that doing them in such a way is wildly inefficient. It also explains why their KPI for Solution Adoption, which one would imagine would be 0-100%, especially given a year-end goal of 75%, is capable of going infinitely high, with an example of 800% adoption in their internal documents. That is, if a technology is adopted by 8 out of 10 clients in a given program, the adoption rate is 800% rather than 80% as we would typically imagine.

So, NSIN operates within an uncharted environment of DIIs and they have been effectively pushed toward easily measurable metrics that tell an aspirational story – broadly speaking, all of the KPIs and Base Plans are volume-based growth metrics and nothing else. That dynamic was predicated on a need to demonstrate tangible value to maintain funding because the time-horizon for technology transfer does not enable an organization to demonstrate that value in a short period, while something like Year over Year Growth of Entrants clearly does. In other words, NSIN focused much of its KPIs on areas that could be measured quarterly and annually, because otherwise they likely would have nothing to report back to the DoD with.

It is likely to remain the case that such metrics will remain important to their ability to keep, and indeed increase, their budget going forward - at least until the DoD pivots toward expecting quantifiable value (Schmid and Wong, 2020). That is not to say that NSIN should continue to confine their metrics to that area, but rather to underscore key limitations and context for why this problem exists and persists to this day. Chief among them being that NSIN operates on a fixed budget that is, to some degree, tied to meeting the goals for which its budget is allocated. We can infer then that, say, cutting programs to increase efficiency and free-up funding for other means might be unworkable if the number of programs is what effectively maintains their funding.

So, while adopting best practices in that vein may increase their quality outputs, if their funding drops the following year because of it then the long-term benefit would likely to be net-zero. The concerning possibility of funding-loss is already evident, with the FY2021 budget stating: “No budget has been allocated by the DoD for NSIN in FY 2021” (United States, 2020, p. 339–340). While NSIN did receive a $15 million Congressional Add, it nonetheless highlights the precarious situation that created and perpetuates the dynamic that has led them to operate purely in a Out-the-Door model and mentality.

Existing Evidence

As mentioned, NSIN finds itself almost entirely within the Out-the-Door framework, although not by any intent to do so. For some institutions, namely Universities, the Out-the-Door makes sense because the role of a TTO is to transfer whatever IP comes through the proverbial pipeline. By extension, Universities tend to consider agent impacts due to their natural focus trending toward licensing revenues (Powers). In that role, Universities tend not to have the capacity to exercise much choice in who IP is transferred to or why, as it is often simply infeasible for an office responsible for transferring IP to also "ensure" its success. As such, the Out-the-Door concept is a mode of evaluation that does not punish, in terms of negative metrics, a TTO for a firm's lack of success, or even failure, to develop, market, and/or manage the IP once transferred.

It is certainly the case that NSIN shares some of those common limitations, perhaps most notably a lack of background in market research and analysis (Franza and Srivastava, 2009). That said, NSIN operates with an express mission to ensure that solutions reach the hands of warfighters (i.e., DoD clients) and so they should find no benefit in the simple transference of IP as a University might. Likewise, because NSIN is in the unique position of being on both sides of the transfer – in that they seek out both IP and its end-users vis a vis DoD client – it lacks the key limitations that tend to justify using Out-the-Door criteria.

So, it is inappropriate for NSIN to use said criteria both for lacking limitations that would encourage or necessitate it and because the information it provides is insufficient, perhaps even incompatible with, their mission. While there is a justifiable logic to using the Out-the-Door model when done with the intent to measure activity rather than outcomes, NSIN's purpose is demonstrably not to reach or maintain any particular level of activity. It is clear then that use, intentional or not, of a model that does not provide any information about impacts or outcomes of technology transfer is inconsistent with NSIN's mission.

It is worth noting, though, that while NSIN's use of Out-the-Door is inappropriate for the reasons mentioned, use of like metrics does tend to occur within organizations with long time horizons for their impacts – in this case, of course, being the potentially many-year long process of getting technology into the hands of warfighters. Still, other models exist in the literature that would potentially better serve NSIN in its attempts to understand and ultimately optimize its technology transfer efforts; Market Impact, Economic Development, Political, Opportunity Cost, Scientific and Technical Human Capital, and Public Value (see Table 1). There is also extensive precedent in the literature for combinations of those models (Bozeman and Crow, 1991; Caldera and Debande, 2010; Carlsson and Fridh, 2002; Edler et al., 2011; Lindelof and Loftsten, 2004; Rogers at al., 2001; Rowe and Temple, 2011; Shane and Stuart, 2002; Siegel et al., 2007).

This leaves the question of what that evidences informs us in terms of improving the operations of a given organization – that is, what can be adopted from those models? Lindelof and Lofsten (2004) showed that new technology firms based out of university science parks have a demonstrable competitive advantage in terms of product development over firms based elsewhere. Shane and Stuart showed that new ventures that see Founder involvement are much more likely to receive funding and less likely to fail. Siegel et al., (2007) show that performance (or lack thereof) can be tied to the creation and implementation of "coherent and feasible" technology transfer strategies within an organization.

Those observations alone could inform NSIN's future activities while actively implementing such evaluative metrics would enable more specific solutions and changes. So, while much of the literature is within the context of Universities and Federal Research Laboratories, the findings and metrics map clearly onto NSIN's activities within the same general space of Technology Transfer. In considering the differences that make NSIN unique (e.g. being on "both sides" of the technology transfer process), they actually might enhance NSIN's ability to self-evaluate and tailor their process to suit their mission and its end-goals due to the increased agency it grants them.

In terms of what practical actions the evidences suggests NSIN could undertake, research shows that, in the University TTO setting, better hiring practices are necessary to ensure staff have sufficient marketing, technical, and negotiation skills (Siegel et al., 2004; qtd. in Bradley et al., 2013). Given that NSIN currently lacks staff with marketing or market analysis, resulting in their delegation of this task to external entrepreneurs, they could utilize this knowledge to enhance their own capabilities as well potentially saving on extraneous spending.

Content area expertise likewise sees attention in the literature, with research demonstrating that a TTO "must" adequately understand a field and be capable of evaluating the future of the technology in order to effectively determine where a patent should be filed (Siegel et al., 2004). By extension, this evidence, itself well established alongside other employment-best-practices, would imply that NSIN would benefit from having relevant knowledge in what technologies are worthwhile to connect with DoD clients.

In the same vein, Powers and McDougall (2005) show that "TTO staff must understand the culture and function of the academic enterprise and of the industry sector to put together licensing deals" and NSIN could undertake similar actions within their context to improve their productivity and efficiency in the same manner (Bradley et al., 2013). And like in the case of Siegel et al., (2007), much evidence suggests that productivity can be greatly enhanced by proper organization in the TTO context and NSIN can easily emulate such a shift given that they are already seeking to do (Debackere and Veugelers, 2005; Bradley et al., 2013).

Similarly, we know that University TTOs focus their efforts on technologies that have, or appear to have, the greatest chance of large (or at least quick) returns, sustained royalty income, or otherwise show promise and increased likelihood of developing into actual products – often within high-technology fields (Lerner, 2005; Litan et al., 2007; Siegel, 2011; Thursby et al., 2001).

In that vein, we might expect NSIN to use such evidence to ultimately act in the same fashion, focusing their limited time and resources on types of technologies that have the highest chance of producing viable and function technologies. Evidence also shows that, in the TTO setting, marketing activities are most important when it comes to areas where there is a weak connection between academia and industry (Colyvas et al., 2002). For NSIN, this evidence could demonstrate that their efforts in that vein should be focused on areas where ties between defense and industry are similarly weak.

Alternatives

Note on Alternatives:
While not all alternatives below explicitly entail adopting principles from models other than Out-the-Door, it is important to note that NSIN intends to deviate away from that specific aspect of its status quo no matter what specific action it undertakes. That is, regardless of the recommendation(s) contained here, should NSIN ultimately adopt the equivalent of Alternative 2 or 3 they will also undertake steps to track the outcomes of transfers as a baseline change. While that may seem a minor step given the institutional change(s) found in every alternative below, that change alone constitutes a notable deviation from operating within Out-the-Door because it explicitly shifts away from only asking the question "did a transfer occur?" and "how many transfers occurred?".

Alternative 1: Let Present Trends Continue
NSIN currently operates in an inefficient, largely ad-hoc manner, from its project creation and technology identification to its contracting of market analysis tasks. Most importantly, NSIN's current activities do not align with its stated mission of ensuring that meaningful technologies are transferred into the DoD because none of their organizational metrics track or measure the value of technology, only whether it was transferred at all.

Alternative 2: Improve Employee Hiring
Like many organizations operating within technology transfer, NSIN has a notable lack of employees skilled in the areas of marketing, strategy, technical analysis, and negotiations, leading to the mentioned necessity of contracting out such tasks. Instead of contracting, this alternative would entail NSIN seeking to fill upcoming positions with candidates holding formal training or education in those areas (e.g., those with MBAs).

Alternative 3: Implement Employee Training
A similar solution to the skill-deficiencies mentioned above is formal employee training and education. Instead of outright hiring better-qualified candidates, NSIN could continue their current hiring practices but send employees to training at a local campus, increasing training across the workforce on an as-needed basis

Alternative 4: Create a Formal, Evidence-Based Identification Process
While NSIN lacks any process by which to identify and assess prospective technologies, there is extensive literature on the means by which Technology Transfer Offices (TTOs) identify and assess the value and viability of technologies. This alternative would entail NSIN creating their own process based on that general model.

Alternative 5: Align Organizational Practices with NSIN's Mission
At present, NSIN has internal metrics that are solely focused on the volume of activity. As discussed, a pen cap that keeps pens from drying out adopted by several DoD clients could see performance of 1,000% under NSIN's current KPIs and thus would be "better" than, say, a technology that literally makes fighter jets invisible. Obviously that particular feat is impossible, but it serves to illustrate how misaligned NSIN's organizational practices are with its mission to get substantive solutions transferred to and adopted by DoD clients. As many current employees note, most of the extant KPIs are viewed as "vanity metrics" originally intended to demonstrate value through volume of activity when NSIN had no other way to justify its budget, and that they have very little to do with NSINs mission.

Evaluative Criteria

Cost

Each alternative will be assessed based on an estimate of the total cost of its full implementation using available values. With those numbers, each alternative will be assigned a score of Low, Medium or High.

Administrative Feasibility

As a governmental agency NSIN remains beholden to its overarching institution (the DoD) as it must continue to justify its budget. As such, administrative feasibility will reflect the degree to which each alternative deviates from NSIN's expected activities and requirements (e.g., it is plainly infeasible for NSIN to shift away entirely from roles that the DoD requires or expects it to fulfill) and, where necessary, short versus long-term feasibility will be discussed. Each alternative will be assigned a score of Low, Medium or High.

Effectiveness

Each alternative will be judged, on a scale of Low to High, by how effective existing evidence suggests it is likely to be in improving NSIN's ability to undertake its technology transfer efforts.

Long-Term Sustainability

It is not enough that an alternative be technically feasible and effective, it must also be capable of lasting for a reasonable period of time without significant changes to the aforementioned criteria (i.e., an alternative that, despite high effectiveness and feasibility today, cannot scale with NSIN's growth is not sustainable over the long-term). Therefore, each alternative will be assessed on its likely long-term sustainability and assigned a score of Low, Medium or High.

Final Scoring

Every alternative will receive a score of Low, Medium, or High which will then be converted to Low = 1, Medium = 3, and High = 5. Each criterion will be weighted equally and the highest cumulative score will determine the recommended alternative.

Findings

Alternative 1: Let Present Trends Continue

Cost

While it might seem that maintaining current trends would imply a low cost, NSIN has indicated that they spend "substantial amounts" each year on contracting individuals with marketing/market analysis skills (among others) due to lacking such expertise within their internal workforce. So, maintaining current trends is actually a **High**-cost venture given that the status quo involves large, ad-hoc spending that scales with activity (i.e., instead of salaried employees being a fixed-cost, they must continuously contract out such tasks).

Administrative Feasibility

As mentioned, NSIN does have standing obligations upon which its budget is contingent. Given that the current benchmarks almost solely include volume-metrics which NSIN's current activities are most aligned with, and because doing so requires no changes in activities or spending, there is high administrative feasibility for maintaining current trends in the short term. That said, long-term feasibility is exceedingly low given that NSIN has yet to demonstrate value outside of volume metrics. In other words, if the DoD requires any metric that captures magnitude of impact, NSIN would have literally no way to measure such outcomes because it does not currently capture any such data – a likely occurrence as NSIN will soon be expected to have available evidence to that end and the DoD ultimately wants accountability in that domain (Schmid and Wong, 2020). Overall, the administrative feasibility of this alternative is **Medium**.

Effectiveness in Improving Outcomes

By its very nature, maintaining current trends has **Low** effectiveness given the current lack of skills and organizational practices that TTO literature show are "essential" for successful technology transfer operations (Bercovitz et al., 2001; Bradley et al., 2013: Debackere and Veuegelers, 2005; Kingsley and Farmer, 1997; Powers and McDougall, 2005; Siegel et al., 2004; Siegel et al., 2007; Thursby and Thursby, 2002). Likewise, NSIN's mission is focused on transitioning meaningful solutions to DoD clients, a goal that cannot be realized under their current model due to, among other things, no long-term verification or assessment of outcomes. In effect, adopting any alternative(s) below would result in notable improvements to NSIN's technology transfer efforts.

Long-Term Sustainability

Current activities are reasonably sufficient in the near term due to the performance thresholds that NSIN must meet pursuant to their DoD Fiscal Year base plan (i.e., the metrics they must satisfy to justify their budget and continue receiving that amount) being rooted in volume metrics. In other words, because NSIN is currently being evaluated on volume metrics (e.g., Annual Adoption Rate of greater than 75% or Year over Year Growth for technologies transition from DoD labs), maintaining current trends – with respect to organizational KPIs, contracting instead of internal skills training, etc. – is not detrimental in the near term. However, maintaining the status quo is not at all viable in the long term given those current trends being incompatible with NSIN's plans to move away from such metrics toward alignment with its broader mission, so maintaining the current trends has **Low** sustainability.

Alternative 2: Improve Employee Hiring

Cost

NSIN's Fiscal Year 2021 (FY21) Human Capital Plan currently lists 26 positions that they intend to fill by fiscal year-end. While the typical entry on the General Schedule (GS) pay scale is GS-12, which equates to a minimum salary of $87,198, there are also a handful of positions that will start at GS-10 (minimum of $66,216) or GS-14 (minimum of $122,530). For this analysis, our baseline salary will be $95,444 which is the average minimum salary between GS-12 and GS-13.

Given that GS-14 is the minimum necessary to attract MBA-holding (or equivalent) candidates, we will also take the average salary between GS-14 and GS-15 which would be $133,329. Of the 26 positions, four would not fall under this umbrella due to not interacting directly with NSIN's technology transfer efforts (i.e., Budget Analyst, Creative Design Specialist, Public Affairs Specialist, and Contracts Manager). So, the increased cost per job would be $37,885, for a total of $833,470 more than the current hiring plan, which gives a total cost of $2,933,238 for those 22 jobs. Importantly, that $2.9 million, the cost of the proposed hiring plan, represents 11.7% of NSIN's $25 million base budget which is an almost 20% increase over the extant plan, which would cost $2,481,544 or 9.9% of the budget. Therefore, this alternative is **High** cost.

Administrative Feasibility

This alternative has **High** administrative feasibility because it does not conflict with any existing organizational timelines, programs or activities. Nothing would change for NSIN internally other than more aggressively recruiting or giving preference to MBA holding (or equivalent) candidates.

Effectiveness in Improving Outcomes

Technology Transfer literature is clear that a lack of employees skilled in the areas of marketing, strategy, technical, and negotiation is a key detriment to the efficient operation of organizations engaged in those efforts. Hiring individuals with formal training and education in those areas is the most direct means by which to ensure new positions are filled with sufficiently skilled employees (Bradley et al., 2013; Powers and McDougall, 2005; Siegel et al., 2004; Thursby and Thursby, 2002). Still, this alternative has only **Medium** effectiveness because it does nothing to improve the skills among the current employees, which would leave the large majority of their workforce still without necessary skills.

Long-Term Sustainability

While current trends entail large, variable costs which can fluctuate based on volume of activities, hiring capable employees once locks in a fixed cost (i.e., their salary). Given a median tenure of 8.2 years for federal government employees, this alternative has High long-term sustainability compared to variable costs that would fluctuate based on industry demand and volume of activities (Bureau of Labor Statistics, 2020). That is especially true given NSIN's desire to rapidly expand its activities – a one-time cost increase for labor going forward is likely substantially cheaper and more sustainable over a 10-year period than continuously ramping up contracting costs. In other words, if NSIN currently spends $1 million per year on contracting services, substantially expanding their activities may require $1.5 or $2 million, which is far more than the proposed hiring plan.

Alternative 3: Implement Employee Training

Cost

At present, NSIN has approximately 100 employees, alongside the minimum increase of 26 employees by the end of FY21. While program lengths and costs vary wildly, we will assume NSIN sends employees to specific courses based on their organizational needs; namely, marketing, strategy, and technical analysis. To estimate the number of employees, we will again use 84% as a baseline for the proportion of employees within NSIN that engage directly with technology transfer efforts. As few business schools publish course prices, we will use the numbers released by the University of Virginia Darden School of Business, a local, top ten program, as our basis (UVA Darden School of Business, 2021).

Assuming that NSIN sends 84% of their employee (including those planned) to a course covering each of the mentioned topics, the cost would be: $2,999 for technical analysis, $1,495 for strategy, and $2,700 for marketing per person. Those course costs would amount to $7,194 per person and $762,564 for 106 employees. Darden does highlight discounts for groups of 5 or more employees and, although they do not publish the discount, I believe an assumed discount of 15% is reasonable – in that case, the costs are $6,115 per person or $648,190 in total. Given that the maximum cost is likely below the status quo, due to it outright replacing the current contracting costs, this alternative is **Medium** cost.

Administrative Feasibility

This alternative scores **High** in administrative feasibility because implementing training does not pose any outright issues for NSIN to tackle as an organization beyond selecting and organizing courses to enroll employees in – which they could accomplish by making it a year-end goal so that employees can enroll individually.

Effectiveness in Improving Outcomes

Much evidence suggests that training and education of employees has "substantial" 'returns to training' and leads to improved performance, productivity and satisfaction (Almeida and Carneiro, 2009; Arthur et al., 2003; Frazis 2005; Lopes and Teixeira, 2013; Stanton and Stanton, 2017; US Department of Labor et al., 2014; What Works Center for Local Economic Growth, 2014). Likewise, literature discussing skill-deficiencies within TTOs demonstrates that improving skills in such areas is key to efficient technology transfer activities (Bradley et al., 2013; Powers and McDougall, 2005; Siegel et al., 2004; Thursby and Thursby, 2002). Given the demonstrated value of such programs and evidence indicating that improved skills and knowledge produce greatly improved outcomes, the effectiveness of this alternative is **High**.

Long-Term Sustainability

As with improved hiring, training is much more sustainable in the long-term than the status quo, however an issue begins as more training becomes desired or necessary. Should a given course be insufficient, NSIN would need to send the employee(s) to another course, resulting in continuous costs that would not be necessary if employees already had said skills from prior education or experience. In other words, an employee with an MBA would likely need only a refresher course, if any, while those unexposed to the mentioned content areas may need training beyond the courses proposed. If so, we can assume that every new course would cost $2,040 per person (the average of the three courses discussed). While it is unclear if or to what degree doing so would be necessary, the potential for accumulating costs over the long-term means this alternative has **Medium** sustainability.

Alternative 4: Create a Formal, Evidence-Based Identification Process

Cost

There is no direct monetary cost associated with creating an evidence-based pipeline for evaluating new technologies and firms. While there is an opportunity cost implied in man-hours spent working on creating such a process, it is unlikely to be measurably costly due to TTOs providing a clear, established model to adopt which enables NSIN to skip many of the foundational steps TTOs had to grow through in preceding decades. Therefore, the cost of this alternative is **Low**.

Administrative Feasibility

This policy has **Medium** administrative feasibility because, despite being compatible with the status quo, likely improving NSIN even within the constraints of current practices, it is nonetheless a non-trivial change that will require buy-in across the organization and there may be some resistance among those that find the current model adequate.

Effectiveness in Improving Outcomes

Technology Transfer literature demonstrates that evidence-based identification processes are fundamental to any effort to accurately select technologies or firms for transfer and outlines efficient ways to do so (Lerner, 2005; Lindelof and Lofsten, 2004; Litan et al., 2007; Siegel, 2011; Shane and Stuart, 2002; Thursby et al., 2001; Thursby and Thursby, 2002). Indeed, the literature is clear that having such a process is already standard practice in virtually all organization that carry out any form of technology transfer, so suggesting NSIN do the same is nothing more than catching up to sector norms. That in mind, effectiveness of this alternative is **High**.

Long-Term Sustainability

While periodically updating the process will be necessary throughout its lifetime – in order to keep up with the evolving literature – nothing inhibits the long-term sustainability of the process once it is created, as evidenced by TTOs having operated in that manner for some 20+ years. Indeed, since almost as long as TTOs have existed in their current from, they have actively pursued and implemented formal processes for identifying the best technologies (Etzkowitz, 1983; Goldhor and Lund, 1983). For those reasons, this alternative has **High** sustainability.

Alternative 5: Realign Organizational Practices with NSIN's Mission

Cost

Realigning NSIN's activities as an organization with its mission (i.e., creating value/impact metrics instead of only measuring volume of activities) is a **Low**-cost endeavor outside of the likely negligible cost of man-hours that would be committed toward creating the new metrics.

Administrative Feasibility

While administrative feasibility is high in the long-term, given its eventual necessity, it remains the case that the metrics that the DoD currently judges NSIN with are exactly in line with NSIN's own current metrics (namely, employee KPIs). In practice, NSIN revamping so many areas before fulfilling its FY21 metrics has low administrative feasibility because they simply cannot afford to do so if they hope to meet the volume thresholds the DoD has set for them (e.g., cutting programs to reorient funding means reduced output in terms of quantity and could result in missing their organizational goals). More broadly, NSIN is not currently in a position to make a 3-5 year plan because of their, at present, year-to-year budget. Because it is unlikely that such a large realignment would even be possible in the near-term, this alternative has **Low** administrative feasibility.

Effectiveness in Improving Outcomes

Like with Alternative 4, the Technology Transfer literature shows that coherent organizational practices are a key determinant of successful technology transfer (Bercovitz et al., 2001; Bradley et al., 2013: Debackere and Veuegelers, 2005; Kingsley and Farmer, 1997; Powers and McDougall, 2005; Siegel et al., 2004; Siegel et al., 2007; Thursby and Thursby, 2002). In short, organizations "must consider a set of key formulation issues involving choices relating to institutional goals and priorities and consequent allocation" (Siegel et al., 2007). At present NSIN does none of those and, as a result, generally fails to understand how its efforts do or do not successfully aid in fulfilling their mission. Realigning with NSIN's mission would see activities carried out to meet organizational goals rather than the current volume-metrics and would also enable accurate assessment of activities once carried out. Given the evidence of success when organizations do exactly this, the effectiveness of this alternative is **High**.

Long-Term Sustainability

By definition, realigning NSIN's activities with its mission is a one-time course of action, outside of attending to new or altered priorities for the organization. So, similar to how NSIN's current organizational practices have been largely unchanged since its inception, there is likewise no reason for change after implementation of this alternative outside of keeping up with potentially evolving "institutional goals and priorities" (Siegel et al.,2007). That said, this alternative has only **Medium** long-term sustainability because of the unrealistic time frame required under NSIN's current constraints - that is, given the degree to which it is unlikely the alternative is doable its sustainability is similarly reduced.

Recommendation

Outcomes Matrix

	Cost	Feasibility	Effectiveness	Sustainability	Total Score
Alternative 1: *Status Quo*	High 1	Medium 3	Low 1	Low 1	6
Alternative 2: *Hiring*	High 1	High 5	Medium 3	High 5	14
Alternative 3: *Training*	Medium 3	High 5	High 5	Medium 3	16
Alternative 4: *Identification*	Low 5	Medium 3	High 5	High 5	18
Alternative 5: *Org. Practices*	Low 5	Low 1	High 5	Medium 3	14

Based on these findings, I recommend that NSIN pursue Alternative 4, creating a formal, evidence-based identification process for technologies to transfer to DoD clients. This alternative is low cost, maintains feasibility, and has high demonstrated effectiveness and sustainability over the long term. While Alternatives 3 rated very similarly based on the evaluative criteria, it does not score well enough to justify undertaking prior to having a system in place to take advantage of more skillful employees. Likewise, Alternative 5, simply cannot be justified due to the existing benchmarks NSIN that cannot afford to risk missing.

Implementation

Path Forward

Fortunately for NSIN, the Identification alternative represents adopting known methods that have evolved within TTOs over almost 50 years. NSIN need only form an internal committee to evaluate the extant literature from TTOs, as discussed throughout this report, and adopt a pipeline based on those known principles. Because that component of the process is well understood, the primary step after creation will be codifying use of the process and facilitating buy-in and understanding of the newly created identification process. To that end, NSIN should ensure that they not only disseminate information about the new process but also hold regular meetings (or incorporate into extant meetings) to ensure that everyone understands the new process.

Stakeholders

As an almost wholly independent program office, NSIN does not need to engage any stakeholders in order to make internal changes of this kind. That said, the crucial stakeholder(s) that can make or break a key part of that recommendation is the DoD clients on the receiving end of the technology transfer(s). As discussed, an important piece of the recommendation is extending the data-collection period of technologies that have been transferred, so as to allow an understanding how the identification process actually performs. At present, that period is just "up to" 12 months, despite the technology process being 2-3 years, so extending that time span is a crucial component of any identification process because otherwise there is no capacity to actually observe the outcomes under the new process.

So, NSIN must engage DoD clients who would ultimately need to agree to supply said data. The first step for NSIN, then, should be in engaging extant clients, ideally those who have not yet met the end of their data collection period, and inquiring about their capacity to track current transfers for a longer period. If that is straightforward, NSIN should request the same from clients that have already reported their 12-month data to, at the least, ascertain the rate at which clients respond positively to such a request, as well as the rate at which they actually follow through and fulfill said request (i.e., to give a sense for how many already track the status of transferred technology without being asked). Finally, NSIN would move on to new/incoming and prospective clients to outline the change and discuss whether it has any impact on their propensity to engage with NSIN.

Worst Case Scenario

While it is theoretically easy to extend the period to 36 months, the willingness and ability for every potential DoD client to accept such a change could potentially be an issue. So, the obvious worst-case scenario here is that clients outright decline to fulfill such a request for whatever reason (e.g., they do not desire to commit the resources necessary to do so). NSIN would presumably make the longer data collection period mandatory, as it already does, but if doing so precludes clients from participating at all then NSIN could end up with not only less data being collected but also fewer solutions being transferred.

That said, this scenario is quite unlikely due to the immense demand from DoD clients; for many programs, NSIN sees several times as many requests as it has capacity for (i.e., 30 requests to be included in a program with 10 spots). So, even in the unlikely case that some non-negligible proportion of clients could not fulfill such a request, it is even more unlikely that the outsized demand would not ameliorate the issue.

Conclusion

Technology transfer has been a staple of US economic development since the passage of the Bayh-Dole Act of 1980, serving to "reverse America's precipitous slide into industrial irrelevance" (Economist, 2002; AUTM, 2021). Today, a similar goal has been touted by the DoD who hope to maintain the "decisive military advantage" that it sees as largely a byproduct of "superior technology capability" (Schmind and Wong, 2020). To the DoD, the expansion of technology transfer within the national security sphere is as critical to the military as it was crucial for industry in the late 70s. And then, like now, the goal is to head off and prevent any type of "slide into irrelevance".

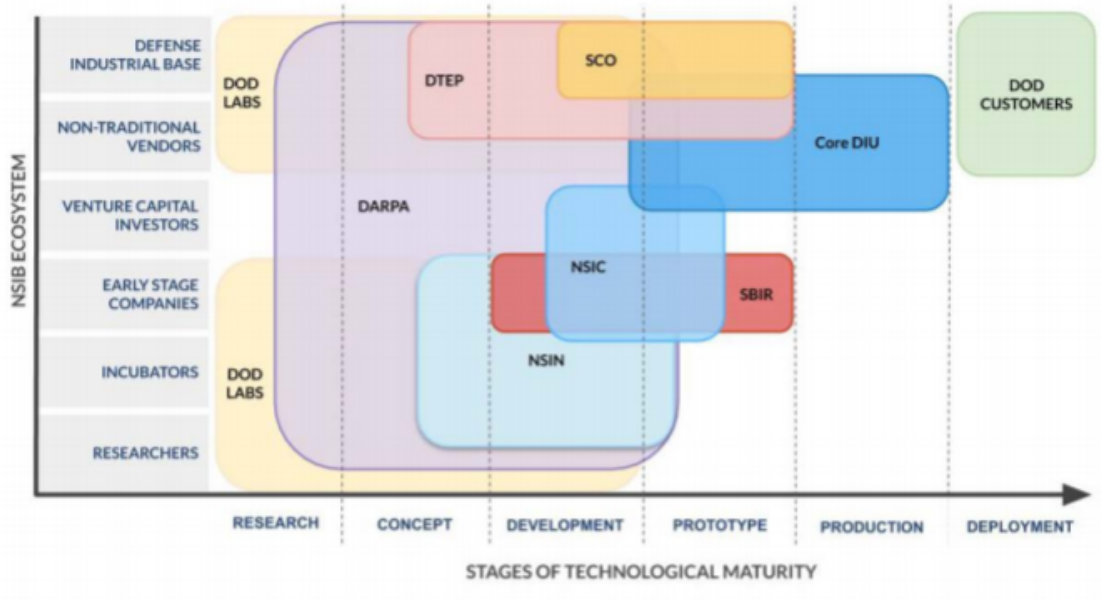
To that end, I have recommended that NSIN take on the Alternative 4: Create a Formal, Evidence-Based Identification Process for technology being transferred to DoD clients. This alternative would position NSIN to transfer the best-suited solutions to DoD clients rather than continuing to operate in ad-hoc manner; likewise, NSIN would begin true outcome-tracking as a part of this alternative which would serve to further distance it from the Out-the-Door model that it currently finds itself operating within.

If successful, NSIN would be well positioned to meet its current goals with the capacity to demonstrate tangible value, beyond simple volume metrics, going forward. Most importantly in the near term, though, NSIN would finally begin to have a picture of what their efforts to date have accomplished. So, where they might currently have a program that saw 900% Solution Adoption as a huge win, outcome tracking may reveal that none of those solutions went into use in the field or ended up being worse, as with the Kingsley & Farmer (1997) case, giving NSIN the ability to meaningfully assess their successes and failures to date.

Appendix

Table 1
Technology transfer effectiveness criteria.

Effectiveness criterion	Key question	Theory base	Major advantage and disadvantage
"Out-the-Door"	Was technology transferred?	Atheoretical or classical organization theory	Advantage: Does not hold transfer agent accountable for factors that may be beyond control. Disadvantage: Encourages cynicism and focuses on activity rather than outcome
Market Impact	Did the transferred technology have an impact on the firm's sales or profitability?	Microeconomics of the firm	Advantage: Focuses on a key feature of technology transfer. Disadvantage: Ignores important public sector and nonprofit transfer; must accommodate market failure issues.
Economic Development	Did technology transfer efforts lead to regional economic development?	Regional science and public finance theory.	Advantage: Appropriate to public sponsorship, focuses on results to taxpayer. Disadvantage: Evaluation almost always requires unrealistic assumptions.
Political	Did the technology agent or recipient benefit politically from participation in technology transfer?	Political exchange theory, bureaucratic politics models	Advantage: Realistic. Disadvantage: Does not yield to systematic evaluation.
Opportunity Cost	What was the impact of technology transfer on alternative uses of the resources?	Political economy, cost–benefit analysis, public choice	Advantage: Takes into account foregone opportunities, especially alternative uses for scientific and technical resources. Disadvantage: Difficult to measure, entails dealing with the "counterfactual"
Scientific and Technical Human Capital	Did technology transfer activity lead to an increment in capacity to perform and use research?	Social capital theory (sociology, political science), human capital theory (economics)	Advantage: Treats technology transfer and technical activity as an overhead investment. Disadvantage: Not easy to equate inputs and outputs.
Public Value	Did technology transfer enhance collective good and broad, societally shared values?	Public interest theory, public value theory	Advantage: Excellent and easily sanctioned criteria for public policy. Disadvantage: Extremely difficult to measure systematically



Note: DTEP: Developmental Test, Evaluation & Prototyping; SBIR: Small Business Innovation Research; SCO: Strategic Capabilities Office.
Defense Innovation Unit (2019)

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