

# United States Military-Industry-University Nexus: The Sustainable Research and Development Collaboration

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## ABSTRACT

This research explores the effectiveness of collaborative Research and Development (R&D) frameworks within the military-industry-university nexus of the United States, with a focus on innovative technologies that offer sustainable solutions. The paper uses Desktop Review as the research methodology to explore past literature and government reports on best practices and key factors contributing to disruptive technological advancements and sustainable practices within the US military. Some of the findings include best practices that promote collaborative R&D and sustainable innovation within the military such as Federal Laboratory Consortium, Defense Advanced Research Projects Agency (DARPA), The Small Business Innovation Research (SBIR), and Small Business Technology Transfer (STTR). The paper concludes with strategic recommendations and actionable insights aimed at optimizing collaborative R&D approaches to enhance sustainability, efficiency, and impact ful innovation in military technology. In conclusion, the research advances the ongoing dialogue and action aimed at optimizing the synergy between the US military, industry, and academic research institutions. The research intends to harness the potential of academia and industry to drive advancements in military technology while ensuring strategic national capabilities and long-term sustainability.

## INTRODUCTION

### Background

Throughout its history, the United States military has consistently sought partnerships with various institutions, collaborating with industry stakeholders and academic entities to modernize its systems and equipment, thereby bolstering its capacity to safeguard national security. At the heart of this collaborative endeavor lies the military-industry-university nexus, a dynamic alliance that has played a pivotal role in advancing technological innovation within the defense sector. This interconnected network facilitates the synergistic exchange of knowledge, resources, and expertise, catalyzing advancements in defense technology.

The collaboration between the military, industry, and academic sectors in research has not only spurred innovation but has also been a driving force behind the nation's economic growth. The tangible outcomes of these collaborative efforts have significantly contributed to strengthening the United States' national security infrastructure (Stavridis & Farkas, 2012). Within this multifaceted framework, Collaborative Research and Development (R&D) initiatives have emerged as a linchpin, seamlessly integrating the diverse resources of the military, industry, and academic institutions. Recognizing the transformative impact of such collaborative endeavors, this study delves into the effectiveness of these R&D frameworks, aiming to offer insights that can further optimize collaborative efforts and enhance sustainability, efficiency, and impactful

innovation within the defense sector. In the ever-evolving landscape of military technology, understanding and refining these collaborative processes are crucial for maintaining the nation's competitive edge and ensuring robust national defense capabilities.

### **Objectives of the study**

1. To examine the role of collaborative Research and Development (R&D) frameworks in facilitating sustainable innovation within the US military, providing a comprehensive understanding of their impact on technological advancements.
2. To explore exemplary practices within collaborative R&D initiatives in the US military, identifying and scrutinizing critical factors that contribute to both disruptive technological advancements and the establishment of sustainable practices. This objective aims to distill key insights for advancing future collaborative endeavors.

The discussions in this paper provide a framework for leveraging the interrelationship between these three sectors in promoting national defense capabilities, while delineating the precise mechanisms that enhance sustainability, efficiency, and the realization of impactful innovation in military technology. The paper is focussed on the provision of actionable insights and evidence-based recommendations for optimizing collaborative R&D efforts to meet the evolving demands of the defense sector.

## **LITERATURE REVIEW**

### **Collaborative R&D Frameworks in the US Military**

The concept of several sectors or institutions collaborating to implement research and development (R&D) is increasingly being practised due to the current technological advancements (Jara-Olmedo, Quisimalin & Chavez, 2020). The development of such an R&D framework utilizes unique skills and diversity in resources available to the US military, industry, and academia (Mowery, 1998). The R&D framework is facilitated by innovative concepts such as the federal lab consortiums, tech transfer initiatives, and cooperative research and development agreements (CRADA). The US military collaborates with the private sector and academia in the research and development of cutting-edge innovations such as computer information technology, energy, and nanotechnology (Stavridis & Farkas 2012). Research indicates that such collaborations have the potential to drive innovation, reduce costs, and expedite technology transfer (Etzkowitz & Leydesdorff, 2000). A few case examples demonstrate this collaborative R&D framework.

### **Federal Lab Consortiums**

Federal lab consortia have been essentially instrumental in fostering innovation within the defense sector. The consortia facilitate collaborative research and development efforts between military entities, private industry, and academic institutions (United States Government Accountability Office, 2014). Through the consortia, different sectors get a platform to share knowledge, expertise, resources, and facilities. According to the Federal Laboratory Consortium for Technology Transfer (n.d.), the platform plays a critical role in promoting innovation and the development of cutting-edge military technologies. Research by Etzkowitz and Leydesdorff (2000) has shown that these consortiums exemplify the "triple helix" model of university-industry-government interaction, leading to innovation and advancements in military technology. Overall, this comprehensive review highlights the significance of federal lab consortiums as a catalyst for collaboration and R&D advancements that ultimately contribute to national security and economic growth.

### **Cooperative Research and Development Agreements (CRADAs)**

Cooperative Research and Development Agreements (CRADAs) provide frameworks for federal

laboratories to collaborate in research and innovative projects, with partners such as private industries and academic institutions (Rogers, Carayannis, Kurihara & Allbritton, 1998). CRADAs have been pivotal in promoting innovation within the US military sector by establishing a legal framework for sharing intellectual property, data, and resources (Berman, 1997). The partners support each other in joint ventures such as the development of technological solutions (Stavridis, & Farkas, 2012). CRADAs in the US military-industry-university nexus have cost-sharing arrangements that reduce financial burdens on each partner, thereby enhancing efficiency.

### **Defense Advanced Research Projects Agency (DARPA)**

One notable case study that successfully represents the US military-industry-academia nexus is the Defense Advanced Research Projects Agency. The main mission of DARPA is to make pivotal investments in breakthrough technologies and capabilities for national security ([www.darpa.mil](http://www.darpa.mil)). DARPA operates within an innovative ecosystem that involves collaboration with academic, corporate, and governmental partners to create new strategic opportunities and novel tactical options (Challenge, 2019). To promote innovative technological advancements, DARPA organizes events such as workshops and symposia and encourages interdisciplinary synergy across the science and technology ecosystem.

### **The SBIR and STTR Programs**

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are highly competitive programs that encourage domestic small businesses to engage in Federal Research/Research and Development (R/R&D) with the potential for commercialization ([sbir.gov](http://sbir.gov)). One of the themes in the 2023 SBR Competition focused on National Security and global Competitiveness, thus encouraging small businesses to engage in military-related R&D (Agencies, 2014). The STTR program expands the partnership to include joint ventures between small businesses and nonprofit research institutions ([sbir.gov](http://sbir.gov)). These initiatives provide a pathway for the US military to adopt knowledge, technologies, and research findings from small businesses and research institutions.

### **Sustainable Innovation**

Sustainable innovation is characterized by technological advancements that improve military capabilities and adopt concepts that enhance environmental, economic, and societal sustainability. The US military sector's shift towards sustainable innovation is essential in addressing global challenges such as climate change and resource scarcity (Light, 2014). This change is a response to the recognition that US defense capabilities must be aligned with broader global goals, such as reducing carbon emissions and minimizing the ecological impact of military operations. Sustainable innovation as enhanced within the military-industry-university nexus can be realized through different initiatives.

### **Environmental Sustainability**

US military activities, especially activities that involve equipment testing and operations, have historically had a significant impact on the environment. According to the department of defense, sustainable innovation in the defense sector targets increased development of environmentally friendly technologies, sustainable supply chains, and responsible military practices. The overarching goal of such innovative efforts is to reduce negative impacts on the environment (Light, 2014). For instance, advancements in renewable energy sources for military installations and green technologies for vehicles and equipment contribute to environmental sustainability (Light, 2014). As reported in the 2022 Department of Defense Sustainability Plan, the Department of Defense (DOD) invested more than \$168M in sustainability and climate change partnership activities at the local, state, national, and international levels to foster innovative solutions and accelerate progress on sustainability and climate change goals. Additionally, the DoD is also partnering with

the National Renewable Energy Laboratory and Rocky Mountain Institute to establish a net-zero emissions design and conduct a gap analysis of the policies, procedures, and codes needed to meet net-zero emissions (2022 Department of Defense Sustainability Plan).

### **Economic Sustainability**

Economic sustainability in the US defense sector involves collaborative R&D aimed at optimizing resource allocation, reducing wastage, and ensuring the long-term viability of the military (Stavridis, & Farkas, 2012). This encompasses practices such as cost-effective development within the military framework, efficient procurement processes, and support of local industries. According to Butts, Bankus, and Carney (2012), sustainability is further providing a platform for multi-state cooperation on transnational resource issues. According to Stavridis and Farkas (2012), collaboration with private industry players regarding financial fraud and economic espionage enables both government and industry to keep abreast of developing challenges. Economic sustainability contributes to a stable defense sector that is financially responsible and contributes to the broader national economy.

### **Societal Sustainability**

Innovations in the defense sector must also consider societal impacts, particularly in terms of safety, ethics, and social responsibility (American Red Cross, 2011). Collaborative R&D is essential in developing military technologies and strategies. In the process, safeguards for civilian populations and the highest ethical standards in military operations must be upheld (Clapham, Gaeta, Sassòli & van der Heijden, 2015). Collaboration between the three sectors gives the US military access to diverse technologies such as autonomous systems, medical advancements, and disaster response solutions (Callaway & Robben 2024). These innovations are extremely useful when there is a need to assist civilians during conflicts and natural disasters. Societal sustainability thus recognizes that advancements in military technology contribute positively to society at large.

Scholars highlight the dynamic interplay between military, industry, and academic institutions, emphasizing how this nexus can catalyze innovation by blending diverse expertise and resources. Interdisciplinary collaboration is viewed as a cornerstone for tackling complex challenges in defense technology, ensuring that advancements are multifaceted, effective, and ethically sound (Stavridis & Farkas 2012). Additionally, the literature underscores the pivotal role of sustainability in contemporary R&D efforts. With increasing global concerns about environmental impact, scholars such as Light (2014), emphasize the importance of incorporating sustainability metrics in defense technology development. As explained by Clapham, Gaeta, Sassòli and Van der Heijden (2015), this perspective advocates for a holistic evaluation of innovations, considering their ecological, economic, and societal implications to foster long-term sustainability and responsible technological progress. Overall, the literature converges on the imperative of creating a collaborative R&D ecosystem that not only fosters innovation but also upholds ethical standards and sustainable practices in the realm of military technology.

## **METHODOLOGY**

This study adopted a desktop review research methodology in conducting a thorough exploration into the effectiveness of collaborative R&D frameworks within the US military-industry-university nexus and their impact on sustainable innovation. The research type employed was an extensive literature review, encompassing academic articles, and government websites and reports. The research design involved a meticulous evaluation to explore the credibility and relevance of the selected literature and reports, ensuring a robust foundation for the study. The method of data collection consisted of extracting detailed notes from diverse sources identified during the evaluation, facilitating a comprehensive understanding of the subject

matter.

To analyze the amassed information from the review, the research utilized a systematic synthesis and organization of the information to identify patterns. This synthesis was complemented by the interpretation of these patterns within a broader context. The sources of data, drawn from both academic and governmental spheres, allowed for a multifaceted examination of collaborative R&D frameworks. This methodological framework not only provided a nuanced overview of the study but also formed the basis for strategic recommendations. These recommendations are geared towards optimizing collaborative R&D efforts in the defense sector, with a specific emphasis on enhancing sustainability, efficiency, and fostering impactful innovation. The comprehensive nature of the desktop review methodology ensures that the findings contribute meaningfully to the ongoing discourse on military research and development initiatives.

## **FINDINGS AND DISCUSSION**

### **Effectiveness of Collaborative R&D Frameworks**

The study provides valuable insights that explored collaborative R&D frameworks, shedding light on their contribution to sustainable innovation within the US military. The findings of this research suggest that collaborative R&D efforts are viewed positively by stakeholders and have a substantial impact on innovation. The partnerships fostered between the US military, industry and academia provide mutually beneficial resources and expertise. The interrelationship between the sectors has contributed to innovative solutions and sustainability in military technology.

### **Case Studies and Best Practices**

A comprehensive review of successful case studies shows the best practices that contribute to disruptive technological advancements and sustainability in military R&D collaborations. For instance, DARPA encourages cutting-edge innovation by encouraging partnerships with academic institutions and private companies (Challenge, 2019). DARPA's success lies in its ability to bridge the gap between military needs and modern technological innovations. This collaborative ecosystem continues to provide a nurturing environment for the intense creativity that DARPA is designed to cultivate. Another successful concept is the SBIR/STTR program, which encourages small businesses to engage in military-related R&D (Agencies, 2014). These examples illustrate the significance of collaborative R&D, where universities provide unlimited research opportunities, industries apply practical expertise, and the military leverages innovation in the provision of national security. As explained by Etzkowitz & Leydesdorff (2000) sharing technology and continued partnership between the three sectors are some of the best practices in the promotion of this collaboration. Ultimately, this collaborative R&D model showcases how the US Military-Industry-University Nexus cultivates innovation and bolsters national security through synergy and knowledge sharing.

### **Sustainable Innovation**

This is one of the most pivotal findings of this study as it underscores the critical importance of environmentally conscious research and development within the US military. The study has led to the recognition of the significance of reducing the ecological footprint of military operations and aligning it with broader sustainability goals (Ackerman, 2008). According to the department of defense, collaborative efforts between the military, industry, and university have contributed to the innovation of sustainable technologies such as energy-efficient equipment and renewable energy sources in the military. These innovative solutions do not just promote and mitigate environmental impacts but also enhance the efficiency and effectiveness of military capabilities.



## CONCLUSION

In conclusion, this study underscores the pivotal role that collaborative R&D plays in fostering sustainable innovation within the US military-industry-university nexus. The study has provided valuable insights into the effectiveness of existing frameworks, conducted a review of best practices from successful case studies, and put forward strategic recommendations for further enhancing these collaborative efforts. This research seeks to be a catalyst for ongoing dialogue and action aimed at optimizing the synergy between the US military, industry, and academic research institutions. The potential of this collaborative approach, involving various sectors, cannot be understated. The paper advances the promise of not only improving military technology and innovation but also demonstrating the progress made toward safeguarding long-term environmental, economic, and societal sustainability. The US military-industry-university nexus represents a unique and powerful engine for driving disruptive technological advancements while ensuring responsible and efficient use of resources. As the findings of the study suggest, embracing collaborative R&D programs such as CRADAs, DARPA, SBIR, and STTR are essential in addressing the evolving challenges faced by the US military, thereby bolstering the nation's security and global competitiveness.

## RECOMMENDATIONS

1. Strengthening interdisciplinary collaboration between military, industry, and academic partners through dedicated funding and research
2. Setting up technology transfer programs: This initiative will facilitate the sharing and adoption of civilian-developed technologies into military applications. The program will encourage dual-use innovations that contribute to national security and benefit society and the economy.
3. Expanding education and training of R&D personnel. This can be achieved through the development of programs that enhance ethical awareness and technical skills, thus creating a culture of sustainable innovation.
4. Creating innovation hubs across sectors: The establishment of dedicated interdisciplinary innovation hubs, blending the expertise of the US military, industry, and academia will encourage open collaboration and accelerate technology development. This initiative creates opportunities for the exchange of ideas and resources.
5. Prioritizing sustainability metrics: The integration of sustainability metrics into R&D project evaluation will ensure that technological advancements consider environmental and societal impacts. The metrics will be used to assess the carbon footprint, resource efficiency, and long-term consequences of new military technologies.
6. Establishing a framework for the movement of personnel between the military, industry, and academia to promote diversification of skills and optimization of workforce development and adaptability to different sectors. This will lead to the enhancement of talent mobility:
7. Promoting regular ethical audits and reviews: The implementation of a systematic and continuous ethical audit and review process will ensure that R&D projects align with ethical and societal standards in order to safeguard civilian interests.

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