Developments and Implications of Novel DARPA-like Project Management Innovation Agencies in the United States (Postprint)

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Abstract

Against the backdrop of great power rivalry, the science and technology domain has increasingly become the primary battlefield and contested arena for major powers, with the new technological revolution reshaping the rise and fall of national economic competitiveness and the global competitive landscape. To compete for the increasingly contested technological high ground, the United States has drawn upon and emulated the successful experience of the Defense Advanced Research Projects Agency (DARPA), which remains active and has achieved numerous technological innovation breakthroughs. The U.S. has actively planned and promoted the establishment of new innovative project management agencies—the Advanced Research Projects Agency for Health (ARPA-H), the Advanced Research Projects Agency for Climate (ARPA-C), and the Advanced Research Projects Agency for Infrastructure (ARPA-I)—in domains such as health, climate, and infrastructure. These initiatives aim to accelerate deployment in emerging and frontier technologies, adopt mission-oriented R&D organizational models and highly flexible management approaches, achieve major disruptive breakthroughs to seize technological advantages, and strive to grasp the initiative in global technological competition. This article briefly outlines the three novel DARPA-like models and, taking the early pilot implementation of ARPA-H as a case study, introduces its establishment background, mission and organizational framework, operational mechanisms, and funding directions. It also summarizes the management innovations of these new DARPA-like agencies to derive corresponding insights, with the aim of providing policy recommendations for technological innovation and disruptive technology project management in China.

Full Text

Preamble

Under the support of President Eisenhower, the Defense Advanced Research Projects Agency (DARPA) was established. Over several decades, DARPA continuously nurtured transformative technologies such as the internet, the Global Positioning System (GPS), and stealth fighter technology, making monumental contributions and generating tremendous influence. This model has been highly revered and emulated by major world powers. Entering the 21st century, the United States has faced new challenges in homeland security, global energy crises, and climate change. Drawing upon the DARPA model, the U.S. successively established agencies such as the Homeland Security Advanced Research Projects Agency (HSARPA), the Intelligence Advanced Research Projects Agency (IARPA), and the Advanced Research Projects Agency–Energy (ARPA-E) to consolidate and expand its technological leadership and safeguard national security, thereby forming a unique technological innovation system. Historical experience shows that whenever the United States encounters crises, it establishes special institutions to overcome bureaucratic obstacles and accomplish strategically significant missions. Therefore, it is necessary to introduce these newly established DARPA-like agencies, examine the already operational ARPA-H as a case study, and analyze its establishment background, mission, organizational framework, operational mechanisms, and funding directions to derive management innovation insights. Finally, we propose recommendations for China's science and technology project management innovation.

1 ARPA-C

Today, climate change has become a critical issue in global governance, and establishing international norms for climate governance concerns each country's position and role in the long-term institutional arrangements of the international order and system. In 2021, the Biden administration announced the United States' re-entry into the Paris Climate Agreement and committed to achieving "net-zero carbon emissions" by 2050. To seize this new opportunity, the Biden government closely linked "technological innovation" and "energy transition" with climate policy, attempting to achieve new breakthroughs through a new round of technological revolution to realize tremendous transformations in green technology. The goal is to seek truly sustainable alternative clean energy sources, develop asymmetric competitive advantages for rapid deployment against adversaries, and ultimately expand discourse power in climate governance to pursue leadership in global climate governance. Consequently, the Biden administration planned to establish a new cross-disciplinary and cross-sectoral ARPA-C within the Department of Energy [1]. ARPA-C focuses on eight key areas: achieving grid-scale battery energy storage at 10% of current lithium-ion battery costs; constructing small modular nuclear reactors at 50% of today's reactor construction costs; developing refrigeration with no global warm-

ing potential; achieving zero net-energy buildings at zero net cost; producing hydrogen from renewable energy at the same cost as shale gas; decarbonizing the entire production process for construction materials such as steel, concrete, and chemicals; decarbonizing the food and agriculture sector and agricultural carbon storage; and carbon capture and sequestration from power plant emissions. Although ARPA-C's focus areas complement those of ARPA-E by targeting carbon emission reduction through lower energy storage costs and improved efficiency, significant overlap exists between the two agencies' work and missions. Consequently, ARPA-C's establishment has faced congressional opposition and slow progress.

2 ARPA-H

As the world's largest economy, the United States has long suffered from outdated, aging, and vulnerable infrastructure, posing enormous risks and challenges to its global competitiveness and security. On November 15, 2021, President Biden signed the Infrastructure Investment and Jobs Act, representing a $1.2 trillion investment—the largest infrastructure legislation in nearly half a century. The Act aims to create numerous employment opportunities, promote economic recovery and sustainable growth, and ensure U.S. leadership in global economic competition through investments in traditional infrastructure including transportation, energy, water, and telecommunications. To achieve the goals of the Infrastructure Investment and Jobs Act and the 2050 net-zero carbon emissions target, the Biden administration established ARPA-I within the Office of the Assistant Secretary for Research and Technology (OST-R) of the Department of Transportation, authorized by the Act. ARPA-I strengthens infrastructure development to create the world's safest, most efficient, and greenest transportation system [2]. By supporting transformative technologies in infrastructure and transportation, ARPA-I aims to reduce costs in infrastructure planning, construction, and maintenance; extend transportation infrastructure lifespan; reduce carbon emissions; enhance infrastructure resilience; and ensure U.S. global leadership in transportation infrastructure-related technologies and materials. ARPA-I's key focus areas include zero-carbon materials, zero-carbon structures, and zero-carbon emission construction in infrastructure; mobile digital infrastructure; ground-air-sea automated transportation; and related cross-cutting and enabling technologies. In fiscal year 2023, ARPA-I received its first appropriation of $3.2 million and began recruiting program managers and executive directors [3].

The success of Moderna's COVID-19 vaccine demonstrated the importance of disruptive technological innovation and made the Biden administration realize that small upfront investments in disruptive technologies and products, under the DARPA model, can generate positive impacts on the entire national economy and play a tremendous role in driving technology spillovers to other technical and commercial fields. Drawing on DARPA's successful experience and model, the Biden administration passed legislation in 2022 to first establish the

Advanced Research Projects Agency for Health (ARPA-H) within the National Institutes of Health (NIH), while also planning to create ARPA-C dedicated to climate change and ARPA-I to ensure U.S. infrastructure leadership. These initiatives demonstrate the Biden administration's determination to overcome bureaucratic drawbacks through special institutions when facing crises to accomplish strategically significant missions.

2.1 ARPA-H's Core Characteristics

ARPA-H was officially authorized on May 25, 2022, with its research priorities established to drive breakthroughs in cancer, diabetes, Alzheimer's disease, and other conditions to achieve transformative outcomes and accelerate applications in public health [5]. ARPA-H's mission is to undertake high-risk, high-reward technology development for the most challenging medical problems, seeking rapid and efficient solutions to better protect human life and health. While ARPA-H's goals align with those of NIH, ARPA-H differs by focusing on mission-oriented research targeting major technical challenges, rapidly supporting biomedical technologies with enormous disruptive potential, promoting the construction of health big data platforms, and fostering partnerships and collaboration among government, academia, industry, and other sectors to accelerate the translation of scientific and technological achievements across the "valley of death."

2.1.1 Organizational Framework ARPA-H has established 14 offices, with its organizational structure shown in Figure 1 [Figure 1: see original paper] [6]. Except for the Therapeutics Innovation Office (TIO) as the program office and the Innovation and Entrepreneurship Office (IEO) as the technology translation office, most other offices are support offices that facilitate TIO and IEO operations. Since health issues often span disciplines, departments, and regions, ARPA-H's technical offices require support from the remaining twelve functional departments to provide robust support for biomedical technology and project screening, identification, management, cross-sector coordination, communication, and legal regulations. Additionally, each ARPA-H office has the responsibility to provide recommendations on the current state of health fields, major challenges faced, and development trends, with offices performing their respective duties while cooperating to form a complete project management innovation model encompassing "scouting technical needs—analyzing operational requirements—developing guidelines—project initiation—contract signing—fund disbursement—project performance evaluation and monitoring—achievement translation."

2.1.2 Flat Management Model ARPA-H inherits many successful elements from the DARPA model, adopting DARPA's flat organizational structure with only three levels: Director—Office Director—Program Manager. The ARPA-H Director is appointed by the U.S. President or the Secretary of Health and Human Services (HHS) and can report directly to the HHS Secretary, with a typical

term of five years and one possible reappointment. Based on the agency's mission, the ARPA-H Director and Deputy Director are responsible for developing and reviewing R&D plans, making budget decisions, setting R&D priorities to timely adjust portfolio balance, ensuring alignment with ARPA-H's overall goals and mission, as well as hiring and training program managers and supervising project operations. In project implementation and management, program managers are responsible for developing technical visions, project initiation, project advancement and termination, and technology translation methods to conduct innovation activities.

2.1.3 Highly Autonomous Authorization Mechanism Initially, public debate focused on whether ARPA-H should be established within NIH or as an independent agency under HHS. After comprehensive consideration of input from multiple parties including the White House Office of Science and Technology Policy, NIH, academia, and biomedical enterprises, the Biden administration legislatively placed ARPA-H within NIH but under the direct jurisdiction of HHS, ensuring ARPA-H's independence and autonomy [8]. Although ARPA-H possesses high degrees of autonomy in innovation management and technology R&D, as well as organizational decision-making authority, ARPA-H's financial budget is packaged within NIH's total budget, with NIH providing appropriations and audit supervision to ARPA-H. This institutional design, which incorporates external financial constraints and oversight, was adopted based on lessons learned from fraud, waste, and corruption in the U.S. health system. Furthermore, to minimize NIH's intervention and influence on ARPA-H's operational authority, personnel authority, and management rights, ARPA-H is being established away from NIH's Bethesda, Maryland location.

Locating ARPA-H within NIH enables the agency to leverage NIH's accumulated basic medical research achievements and relationship networks and other innovation elements, breaking down explicit and implicit barriers that constrain technological innovation, avoiding duplicate funding, and accelerating support for high-risk, high-reward disruptive technologies. ARPA-H operates with program managers at its core, granting them full authorization. Program managers are only responsible to ARPA-H office directors, subject to project supervision, auditing, and evaluation. However, program managers possess highly autonomous decision-making authority in recruiting R&D team members, allocating and cutting project funds, and managing the entire R&D process, free from administrative interference to ensure timely decision-making and maintain a flexible, liberal innovation environment.

2.2 ARPA-H's Funding Directions and Operational Mechanisms

2.2.1 ARPA-H's Funding Directions Currently, ARPA-H has established four key research areas. (1) Future Health Sciences to expand technology applicability: Accelerate progress in research fields and seek health solutions by developing tools and platforms broadly applicable to disease diagnosis and treat-

ment. (2) Scalable Solutions for Universal Access: Address challenges including geography, distribution, manufacturing, data and information, and economies of scale to develop impactful, timely, and equitable solutions. (3) Proactive Prevention to Stay Healthy: Enhance detection and prevention capabilities for health threats including viruses, bacteria, chemicals, physics, or psychology; improve treatment levels; and reduce disease probability. (4) Building a Resilient Integrated Healthcare System: Enhance capacity to respond to social unrest, climate change, economic crises, and pandemics; develop appropriate business models; and construct a comprehensive medical system with joint construction, governance, and sharing.

ARPA-H's current typical demonstration projects include research on major diseases such as cancer and Alzheimer's disease (Table 1) [9]. ARPA-H's focus areas also include hypertension, infectious diseases, and population-level behavioral interventions, ultimately establishing and developing platforms for disease prevention, diagnosis, treatment, care, and rehabilitation.

2.2.2 Program Manager-Centered Operational Mechanism A consistent practice in establishing and managing new DARPA-like agencies is to hire outstanding program managers from existing DARPA or DARPA-like institutions. On September 12, 2022, the Biden administration appointed Renee Wegrzyn as ARPA-H's inaugural Director [10]. Renee Wegrzyn previously worked at DARPA and IARPA, received a Senior Public Service Medal during her tenure as a program manager in DARPA's Biological Technologies Office (BTO), and has worked at the National Academies' Army Research and Development Board, the Air Force Research Laboratory (AFRL), and the Innovative Genomics Institute (IGI). On January 6, 2023, Susan Monarez was officially hired as ARPA-H Deputy Director [11]. Previously, Susan Monarez served as HSARPA Program Manager at the Department of Homeland Security, inaugural Director of the Health Resources and Services Administration's Innovation Center (HRSA), and held positions including Assistant Director for National Health Security and International Affairs at the White House Office of Science and Technology Policy and Director for Medical Policy at the National Security Council, participating in the development of multiple national health-related strategies, policies, and action plans.

Program managers are the core critical factor for DARPA to maintain its institutional vitality and ensure smooth operation. Similar to the DARPA model, ARPA-H has two key decision-making levels: management decisions and technical decisions. Management decisions are made top-down by the Director through developing S&T project plans and supervising implementation; technical decisions are made by program managers who identify innovative inspiration, determine technical solutions, select project execution teams, and supervise project progress. In the flat organizational structure, ARPA-H's core research processes revolve around and depend on program managers, who are granted tremendous autonomy to improve decision-making speed and efficiency. ARPA-H program

managers typically serve 2–3 year terms, with one possible reappointment. Program managers possess highly autonomous decision-making authority, strong professional skills, and industry network organization capabilities to better manage high-risk, high-reward R&D projects in relevant health fields. Program managers highly value their reputations and must account for and explain the reasons for project outcomes. Therefore, in project selection, they must consider not only project translation potential based on their professional knowledge, skills, and project investment experience but also applicants' capabilities to select the most suitable project teams. Once projects are launched, program managers must conduct full-process tracking and "milestone" management to ensure completion within limited terms. Additionally, if problems arise during R&D, program managers must promptly report project status to the ARPA-H Director to ensure rapid advancement or timely termination.

During project management, ARPA-H program managers also need to leverage the PATIO platform and intermediary agencies to complete translation from concept R&D to outcomes. The services and support provided by the PATIO platform include: (1) Identifying customer needs: PATIO maintains close contact with end users, deeply understanding the gap between technology and demand to provide commercially viable solutions for program manager vision validation. (2) Market assessment: PATIO evaluates ongoing R&D projects, strictly assessing project teams' commercialization capabilities and technology translation potential to provide references for program managers. (3) Ecosystem building: PATIO constructs a national professional network and platform comprising top investors, entrepreneurs, and technical experts to provide program managers with opportunities to drive technology commercialization. (4) Business guidance: Program managers are typically technical talents from different fields without successful commercialization experience. PATIO provides business mentors to guide program managers in accelerating technology translation and commercial application during project management. (5) External capital linking: PATIO connects program managers with external capital through public-private partnerships to accelerate S&T achievement translation. (6) Broad Agency Announcements (BAA): PATIO issues open tenders through BAA, assists program managers in identifying promising project teams, and conducts venture capital (VC) due diligence. After project teams pass minimum viable product (MVP) testing, PATIO can provide customized business strategies, intellectual property protection, legal, and marketing services for startups. PATIO then exits promptly, allowing Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR), and non-profit funding to continue incubating high-quality startups.

To accelerate achievement translation, ARPA-H also collaborates with private sector partners to establish technology transition and translation intermediary platforms. Through intermediary services, ARPA-H achieves high matching between program managers and project teams for commercialization. Furthermore, ARPA-H must cooperate with other key departments or agencies in the public health ecosystem (such as FDA, CDC, CMS) on complex issues like pub-

lic health infrastructure or medical regulation to adapt to new environments and demands in interdisciplinary, cross-entity complex public health systems.

3 Enlightenment and Recommendations from DARPA-like Agency Models

ARPA-H, as a pioneering new DARPA-like agency under the Biden administration, has attracted widespread attention and high hopes. Meanwhile, ARPA-I and ARPA-C are also under active development. Although ARPA-I, ARPA-C, and other DARPA-like agencies have different missions, they all operate differentially based on matrix organizational structures, flat management models, and the program manager system. This approach can both escape inherent administrative system dilemmas and leverage the vitality and unique advantages of new agencies. As a source of innovation, DARPA's widely emulated organizational structure and operational mechanisms are only the basic elements and characteristics of new DARPA-like agencies' success, not the essence of DARPA's success. ARPA-H, ARPA-I, and ARPA-C still face numerous challenges and tests as new DARPA-like agencies, and the path to achieving DARPA-matching accomplishments remains long and arduous.

Currently, the world is experiencing unprecedented changes, with intensifying global S&T development and competition. Simultaneously, we are in a period of opportunity for a new round of S&T revolution and industrial transformation. As a critical lever in competition among major powers, disruptive technological innovation plays a tremendous role in accelerating the construction of a strong S&T nation and achieving China's high-level S&T self-reliance. Based on DARPA's successful historical experience and the progress and patterns of current DARPA-like agencies, we propose three recommendations to explore the genes that created DARPA's glory, thereby enhancing China's capacity for forward-looking major S&T innovation layout, promoting disruptive technological innovation, and seizing the initiative in new-round competition.

(1) Cross-department joint 攻关 (attack) model to activate China's disruptive technology identification, support, and cultivation mechanism. Unlike DARPA whose ultimate user is the Department of Defense, ARPA-H, ARPA-I, and ARPA-C cannot ignore human behavior and social needs. They must comprehensively consider the multi-mission, long-cycle chain, and persistence of national major S&T tasks to develop solutions adapted to current research paradigms, fully utilize innovation networks, and coordinate S&T resource allocation to introduce innovation achievements from laboratories to markets. For example, ARPA-H must cooperate with other key departments or agencies in the public health ecosystem on complex issues like public health infrastructure or medical regulation. Given disruptive technologies' characteristics of high uncertainty, high risk, and unclear short-term effects, China must organically combine qualitative and quantitative technology forecasting, identification, and assessment methods to form a normalized disruptive technology monitoring mechanism. Strengthen strategic coordination and policy alignment

in S&T fields, coordinate cross-departmental and cross-regional S&T forces, strengthen strategic S&T task layout, optimize innovation resources, and improve innovation resource allocation efficiency to accelerate the incubation of potential disruptive technologies. Additionally, strengthen public-private sector cooperation, leverage government agencies' pioneering role to incentivize and encourage private capital's follow-on investment in disruptive technologies, and promote commercialization of disruptive technologies.

(2) China should emphasize inter-departmental collaborative innovation mechanisms and balance competitive and cooperative relationships between new agencies and existing government institutions. After ARPA-H's incorporation into NIH, not only do their health budgets affect each other, but their research directions may also directly compete. In fiscal year 2022, NIH's total budget included ARPA-H's budget, but after excluding ARPA-H's budget, NIH's own budget only increased by $274 million [12]. Some worry that ARPA-H will shift federal attention from health field investment to applied research, reducing NIH's basic research funding. Additionally, the planned ARPA-C has high mission and focus area overlap with the already established ARPA-E. While drawing on its disruptive technology breakthrough experience, China should emphasize unified coordination, construct a development pattern where each department has its own innovation characteristics, coordinate relationships between disruptive technology funding and other programs, and pool superior innovation resources for key S&T 攻关 (breakthroughs) to achieve strategically significant missions.

(3) Explore flexible project management models to activate program managers' innovation vitality with a favorable innovation environment. Avoiding organizational structure rigidity and operational 僵化 (stiffness) while protecting program managers' disruptive ideas and extremely high self-drive is key to successful R&D models. Based on the new national system, China can explore flexible project management models during development: (1) Increase diversity of experts and talents in disruptive technology project management agencies and teams, form multidisciplinary innovation teams, and achieve innovative integration of talent, knowledge, skills, and resources from basic R&D to applied development. (2) Explore flexible project management models: Adhere to mission orientation, establish flexible funding mechanisms such as "horse-race systems" and "open competition for leadership," strengthen full-process tracking management of projects, and timely adjust funding amounts based on project progress. (3) Emphasize trust and tolerance for failure: Improve and perfect exemption mechanisms in project management that allow trial-and-error on different technical routes and tolerate failure due to technical risks. (4) Establish open innovation platforms: Through open cooperation and shared resources, encourage innovative development. Platforms can enable different organizations and individuals to jointly participate in technological innovation, forming a collaborative and competitive ecosystem that promotes rapid technology development and iteration. (5) Establish sound policy and legal environments: The government can protect innovators' rights and interests

through intellectual property protection mechanisms and legal systems, encouraging more resources and energy to be invested in technological innovation.

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Abstract

In the context of major-power interactions, the science and technology domain has increasingly become the main battlefield and inevitable arena for competition among major powers. The new scientific and technological revolution will reshape the rise and fall of countries' economic competitiveness and the global competition landscape. To compete for increasingly contested technological commanding heights, the United States has emulated the successful Defense Advanced Research Projects Agency (DARPA), which remains active and has achieved numerous scientific and technological innovation accomplishments. The U.S. is actively planning and promoting the establishment of new project management innovation agencies—the Advanced Research Projects Agency for Health (ARPA-H), the Advanced Research Projects Agency for Climate (ARPA-C), and the Advanced Research Projects Agency for Infrastructure (ARPA-I)—to accelerate the deployment of emerging and cutting-edge technologies. By adopting mission-oriented R&D organizational models and highly flexible management approaches, these agencies aim to achieve major disruptive breakthroughs to capture technological advantages and strive to seize the initiative in global S&T competition. This article briefly outlines the three new DARPA-like models and takes the pioneering ARPA-H as a case study to introduce its establishment background, mission, organizational framework, operational mechanisms, and funding directions. We analyze the risks and challenges faced

by ARPA-H as a new DARPA-like agency and summarize management innovation insights. Finally, we provide several policy recommendations for China's management innovation in disruptive technology projects.

Keywords: Defense Advanced Research Projects Agency (DARPA); science and technology project management; Advanced Research Projects Agency (ARPA)

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