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Lessons from the Manhattan Project:

How to Make Golden Dome a Reality

WRITTEN BY:

Jesse Goldhammer, Ph.D., and Eric Dull

Introduction

By mid-1945, the Manhattan Project was, in a sense, a single, untested continent-spanning machine distributed across three secret cities—Oak Ridge, Hanford, and Los Alamos. It was powered by thousands of American factory workers, scientists, and military personnel working disparate workstreams.

At Oak Ridge, roughly 10,000 “Calutron Girls” tended the Y-12 Electromagnetic Isotope Separation plant, coaxing out precious grams of uranium-235.[1] The enriched metal was sealed in steel cylinders, loaded onto an Army courier train, and whisked from Oak Ridge, Tennessee, to Los Alamos, New Mexico. Simultaneously, DuPont engineers at Hanford’s B Reactor in Washington State chemically separated plutonium from uranium and other radioactive materials before shipping the Plutonium south, to Los Alamos.[2] There, J. Robert Oppenheimer dissolved the customary walls between theory and practice. Through relentless weekly colloquia, he fused theorists, chemists, and machinists into a single problem-solving engine charged with marrying Oak Ridge’s uranium-235 to Hanford’s plutonium inside an implosion device nicknamed the “Gadget”.[3]

When the Trinity fireball lit the Jornada del Muerto desert at 5:29 a.m. on 16 July 1945, its blinding light confirmed that the vast, three-city machine had worked. The Manhattan Project triumphed because its architects learned to do a few critical things at once: integrate people, information, and ideas with new processes to maximize innovation while racing against the clock under a cloak of secrecy.

Eighty years later, the United States faces another urgent national security task: building the nation’s “Golden Dome” to deter adversaries and shield the American homeland from enemy missiles and advanced aerial threats. Golden Dome's success hinges on the ability of US government agencies, military services, academic institutions, and private industry to unite under a cohesive architecture and overcome the typical obstacles that arise when diverse organizations with unique perspectives collaborate on a critical national security mission.

> Golden Dome stands as the United States' most ambitious and complex technological endeavor in the last 80 years.

Shielding the American homeland from enemy missiles and advanced aerial threats is a necessity. Golden Dome stands as the United States' most ambitious and complex technological endeavor in the last 80 years. At the same time, this monumental effort draws a striking parallel to the Manhattan Project, which played a pivotal role in ending World War II by developing the world's first atomic weapons. The Manhattan Project's success, driven by the collaboration of public, private, and academic experts under the orchestration of the US military, established the US as a post-war global leader and remains a powerful testament to American innovation.

This white paper draws valuable lessons from the Manhattan Project (hereafter "The Project") applicable to the Golden Dome program today. The paper assumes the essential technologies for Golden Dome—such as satellite constellations for missile warning, space-based sensors, missile interceptors, and advanced communications systems—already exist and have been tested in limited capacities. Golden Dome's true challenge lies in adapting, scaling, and integrating these technologies, a feat that demands exceptional technical integration and human collaboration.

The Project does not provide direct solutions to these challenges; rather, it offers a framework for understanding the scale of technical integration and human collaboration required, helping us to understand how 21st-century solutions can be used and adapted to the unique and now familiar challenges associated with massive national security projects.

At the core of these lessons is a fundamental truth applicable to both Golden Dome and The Project: achieving technical success necessitates establishing, from the outset, a robust foundation for hundreds of organizations and thousands of individuals to share information securely, collaborate efficiently, and innovate rapidly. To better understand this foundation, this paper explores six critical lessons: 1. Leadership and Vision, 2. Cybersecurity and Counter-Intelligence, 3. Contracting and Acquisitions, 4. Logistics and Supply Chain, 5. Simulation and Force Readiness, 6. Operational Excellence.

Lessons and Recommendations from the Manhattan Project

The Project was one of the most significant military and scientific undertakings in modern American history. While its mission centered on the production of nuclear weapons, The Project offers invaluable lessons, but more importantly, it highlights the necessity of making key decisions correctly at the outset. Failure to do so can lead to avoidable complications later, ultimately hindering progress and threatening overall success.

1. Leadership and Vision

Translate concept to reality

The Project was led by Major General Leslie Groves and J. Robert Oppenheimer, who together provided the charisma, authority, brilliance, drive, and decisiveness needed to coordinate and advance the work of half a million people. Each was highly respected and an expert in his field, capable of motivating many to The Project's cause.

More than respect, Major General Groves and Dr. Oppenheimer shared a powerful vision—and the charisma to inspire tens of thousands to pursue it. Their leadership enabled the realization of the most sophisticated scientific project the US, and perhaps the world, had ever known.

> Leaders will have to turn skeptics into believers and galvanize thousands of scientists, military strategists, politicians, and industry experts under a shared vision, all while serving as the public face of the effort.

Golden Dome leaders will require the same qualities—and more. No initiative of this scale has been attempted since the Manhattan Project—spanning more than a generation—and while many core technologies may exist, the integration required to achieve Golden Dome does not. The leaders' ability to inspire, unify, and define technical and operational requirements will ultimately shape the project's success.

Recommendations

A. Establish Two-in-a-Box Leadership

The DoD is still evaluating how to develop the Golden Dome system; however, it will undoubtedly require blending multiple technical disciplines, industries, and government missions. Like The Project, Golden Dome will require a co-leadership model that marries operational rigor (military lead) with cutting-edge tech vision (civilian/ industry lead).[4] This dual leadership approach, often called "two-in-a-box" in the corporate world, is essential because Golden Dome's leaders must integrate a patchwork of government agencies, military services, established defense contractors, and commercial firms new to national-security work. They must fuse the entire public–private ecosystem into one tightly coordinated enterprise—a challenge that requires exceptional resolve and skill and is likely too great for a leader drawn solely from either the military or the civilian sector. Military leadership will be essential for strategic planning, logistics, security, and day-to-day operations. In contrast, civilian leaders with industry and technical expertise will bring the unique knowledge and foresight needed to develop next-generation technical solutions. Whether implemented through a new dedicated Golden Dome program office or another structure, the two-in-a-box approach will be important for ensuring Golden Dome is developed according to existing guidance.[5] [6]

B. Embrace & Quickly Define the Architecture

Golden Dome's complexity requires critical architectural choices that will impose significant downstream effects on how the missile defense system will be operated and function.[7] Just as DNA encodes the blueprint that determines an organism's growth, capabilities, and limits long after conception, Golden Dome's architectural decisions embed the patterns that govern how the system evolves, performs, and adapts for its lifespan. These early decisions will determine how the system responds to threats, what roles are automated versus human-controlled, and how operators are trained. Luckily, technical architects are experiencing a resurgence, especially in the private sector, where IT projects are becoming increasingly costly and complex. Architecture is essentially the framework and design of technology systems, including the integration of technology components, the management of system operations, and the alignment with mission objectives to drive outcomes. Golden Dome will need a skilled digital architect supported by a highly experienced IT transformation team to design Golden Dome. This will require merging existing systems, like the Missile Defense Agency's Hypersonic Ballistic Tracking Space Sensor system and the Space Development Agency's Proliferated Warfighting Space Architecture, with new systems yet to be developed.[8] More than bandaging them together, the right IT transformation team will need to ensure they operate seamlessly to effectively defend against sophisticated missile threats.

2. Cybersecurity and Counter-Intelligence

Conduct project-wide coordination

Although few Americans recall physicist Klaus Fuchs today, his role in transmitting atomic weapon design secrets to the Soviets serves as a stark reminder: The Project was a prime target for enemy espionage. This breach not only accelerated the Soviet nuclear program but also set the stage for the Cold War, underscoring why robust cybersecurity and counter-intelligence measures will be critical for Golden Dome.

Golden Dome leaders must balance compartmentalizing information for security with openly sharing it for innovation. Unlike The Project, however, which unfolded before modern computing and the internet, Golden Dome will need to enforce stringent cyber protections for government and non-governmental performers alike, a potentially slow and costly process to implement, particularly for commercial organizations outside the traditional Defense Industrial Base.

Recommendations

A. Appoint a Chief Information Security Officer (CISO)

Cyber threats continue to be the most "present and persistent" danger the DoD faces.[9] A critical first step for Golden Dome will therefore be to hire a Chief of Information Security Officer and a team of security professionals dedicated to the Golden Dome project. This team should be comprised of cybersecurity professionals focused on all aspects of cybersecurity, including threat detection, incident response, and continuous monitoring. The team should also include members with other types of intelligence expertise, such as human intelligence (HUMINT) and signals intelligence (SIGINT), to create a fusion-like environment for risk reduction. Finally, the CISO should be dual hatted as the head of counterintelligence for the program to guarantee tight coordination across threat domains.

B. Establish Operational Security 'Rules of Engagement'

Golden Dome should adopt an integrated security framework that pairs rigorous Operational Security (OpSec) practices with the technical controls of a Zero-Trust (ZT) architecture. OpSec governs how individuals handle and share sensitive information; ZT enforces those behaviors in the network by continuously verifying every user, device, and data request. Because a full ZT rollout can take years—time the program cannot spare—the project should create a "virtual Los Alamos": a hybrid secure enclave that front-loads essential ZT features (strong identity, micro-segmentation, end-to-end encryption) while overlaying clear, streamlined OpSec rules. Leveraging existing U.S. Government ZT investments and accredited cloud services, this approach simplifies classification and accreditation, gives dispersed teams a common playbook for safeguarding data, and preserves the speed and collaboration critical to Golden Dome's success.

3. Contracting and Acquisitions

Depend on speed and flexibility for success

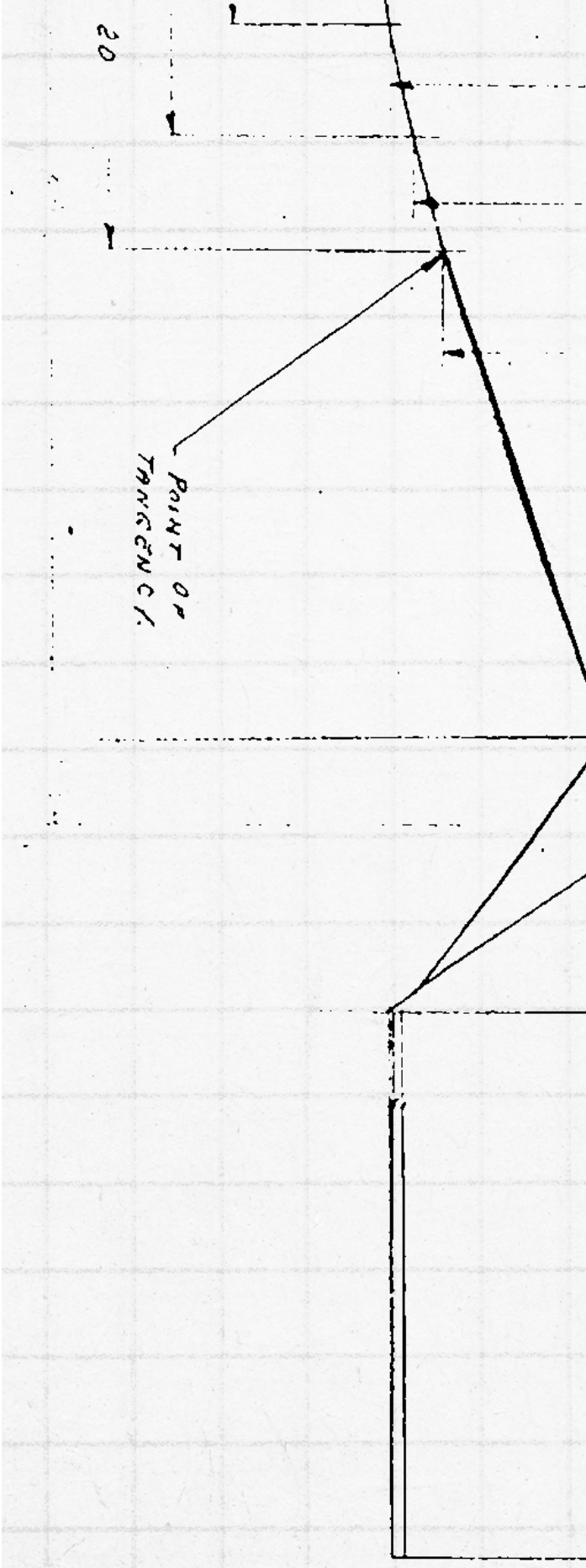
During World War II, The Project pursued acquisitions and contracts with few restrictions, incredible speed, and utmost secrecy. Thanks to the War Powers Act of 1941 and the work of the War Production Board, both of which gave the US government wide latitude to harness private sector industrial capacity, The Project moved quickly to acquire the goods and services needed to achieve its goals. While the Project benefited from a wartime environment, and one of the largest economic interventions by the US government in the country's history, Golden Dome likely won't.[10] While modern peacetime contracting and logistics are rarely fast or flexible, they will need to be.

Golden Dome will need to navigate significantly more complex and cumbersome acquisition and contracting processes than The Project experienced. Still, by employing the newest and most innovative acquisition options available, Golden Dome can integrate native government capabilities, the latest commercial innovations, and the experience of current materiel partners.

Recommendations

A. Embrace Fast Contract Vehicles for Innovation

The sheer volume of contracts and subcontracts required to accelerate Golden Dome capabilities necessitates a best-in-class acquisition function. The ideal contracting structure streamlines multiple solutions and prioritizes Commercial Solutions Opening (CSOs), Other Transaction (OT) agreements, and Software Acquisition Pathway (SWP).[11] These vehicle types can rapidly deliver cutting-edge technology, foster continuous



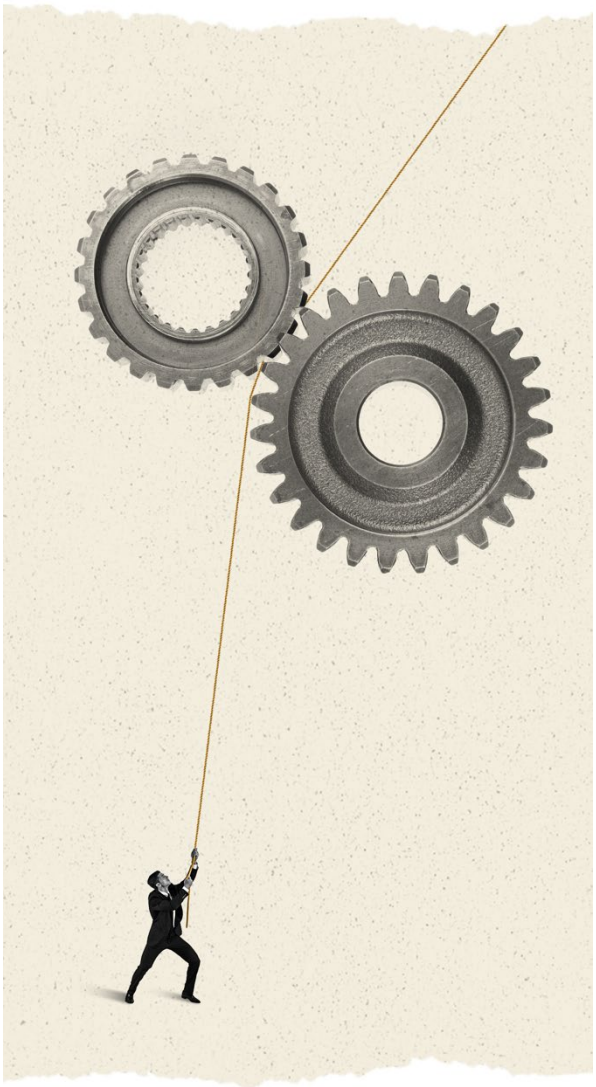
industry innovation, and enable new partnerships with emerging, non-traditional defense contractors. Traditional contracting options like firm-fixed price engagements provide an efficient pathway for the Government to obtain critical talent from commercial entities with minimal administrative investment over time. Conversely, inefficient mechanisms with burdensome labor categories can drive away the Nation's best commercial partners and attract undesirable talent. Marrying these approaches with the deployment of Generative Artificial Intelligence (GenAI) can dramatically optimize the contracting process through enhanced automation that identifies suppliers, writes documents, evaluates responses, issues contracts, and manages elements of Golden Dome contract performance.

B. Enable Integrated Acquisition

Traditional acquisition methods are often geared towards singular, comprehensive solutions with a primary, contracted integrator. Golden Dome's complexity, requirements for persistent iteration, and overlapping, cross-compartmentalized capabilities require a new approach.

> *Golden Dome should own its own contracting and should not be dependent on other military services or civilian agencies.*

The Army Corps of Engineers' Manhattan Engineer District (MED) adopted a similar contracting and procurement approach during The Project and oversaw the design, construction, and operation of The Project's physical plant and process network. Golden Dome leaders could adopt and elevate the Army Corps of Engineers' MED approach with the deployment of cross-functional fusion contracting and procurement centers. Liaisons operating from the fusion centers are uniquely positioned to maintain a strategic view of Golden Dome as it develops while coordinating engineering and scientific activities. Equipping each center with a true acquisitions career professional can enable faster ingestion of the cutting-edge technologies and seamless integration of the acquisition and operational arms of the project.



4. Logistics and Supply Chains

Prioritize security and diversification

The Project featured massively complex logistics and supply chains, including material acquisition, facility and infrastructure construction, transportation and security, coordination and management of a vast network of suppliers and contractors, and decentralized production. Some of the uranium ore sourced for building the first atomic bombs came from outside the United States. Human computers and electromechanical machines were used for calculations.

The Project demonstrates the importance of securing critical resources early and developing alternative sourcing strategies to mitigate risks. It also highlights the need for stringent security measures to protect sensitive information, data, and materials. Furthermore, the Project underscores the value of cross-disciplinary collaboration, leveraging a range of expertise to solve complex problems, and investing in cutting-edge technology and innovation to drive progress.

Today, defense supply chains are more digitally connected and fragile than ever before, adding another layer of complexity to national security. Advanced hardware and software, including artificial intelligence (AI) tools to manage suppliers, track shipments, evaluate security, among other tools, will undoubtedly be needed to help Golden Dome overcome modern logistical and supply chain challenges facing the United States and other countries, like raw material bottlenecks, foreign dependencies, and exposure to external supply chain shocks.[12]

Recommendations

A. Establish a Broad and Secure Supply Chain Pool with Robust Risk Management

Leadership must create a resilient and adaptive supply chain pool to support new technologies and solutions. This pool should include the following:

- Consider alternative suppliers to prepare for swift adaptation to changing circumstances.
- Conduct third-party assessments to understand component sourcing and identify vulnerabilities.
- Utilize bills of material from manufacturers to identify sub-tier suppliers and mitigate risks associated with unknown or unreliable suppliers.
- Prioritize sourcing from within the United States first, and then from close allies or partners, to enhance national security and minimize reliance on potentially risky foreign entities.
- Conduct regular audits to verify supplier integrity and reliability. Diversify the supply chain to reduce disruption risks.

B. Secure the Cyber-Supply Chain

Cyber-supply chains are home to a diverse set of risks that may originate from the software associated with suppliers, service providers, and their technology products. As the DoD accelerates its acquisition and development of Golden Dome systems and assets, senior leaders should have a thorough understanding of their cyber-supply chains, which currently present a unique challenge for the acquisition community. Senior leaders should consider secure software development and C-SCRM practices, as written within NIST SP 800-218 and SP 800-161, to evaluate the integrity of cyber-supply chains. Further, DoD leaders should utilize software bill of materials (SBOMs) to identify and manage critical software vulnerabilities and dependencies that may inhibit the sustained operation of a weapon or national security system.

5. Simulation and Force Readiness

Implement high-fidelity simulators and model-based enterprise

The Project relied on extensive training programs, such as the "Los Alamos Primer" lecture series for new scientists and rigorous operational training for bomb assembly crews.[13] Additionally, it utilized early Monte Carlo simulations and hand computations to model nuclear explosions and understand chain reactions and neutron behavior.

Like The Project, Golden Dome will require comprehensive training and simulation capabilities to allow technologists and operators to effectively test system architectures, model human-system interactions, and train using near-real simulations. Golden Dome should use modern advancements in modeling tools and simulations to run advanced simulations and calculations on larger scales than before to adapt to the latest threats. Golden Dome Operators will need access to accurate, timely information to make informed decisions under extreme pressure, often with only minutes to respond. Force Readiness will depend on training that helps operators understand what tactical information is critical, how to interpret it, and how to access the data under various conditions. Given the high-stakes nature of missile defense, simulations will replicate these time constraints, supporting operators to make swift, effective decisions.

Recommendations

A. Incorporate Advanced High-Fidelity Simulators

Golden Dome should develop a simulation environment that closely mirrors real-world conditions using modern high-fidelity advanced simulators—the Army's Synthetic Training Environment and the Missile Defense Agency's Objective Simulation Framework program offer useful places to start and potentially evolve to accommodate Golden Dome's unique training and simulation needs.[14] Advanced simulations can run complex scenarios, highlight critical outcomes, and inform mission readiness and response. These environments can allow operators to practice and refine their skills in realistic and diverse threat scenarios.

B. Implement Model-based Enterprise

To respond quickly to new and changing threats, a model-based enterprise comprised of digital threads, digital twins, predictive analytics, and model-based methodologies should be developed to create a seamless and interconnected system for Golden Dome. A digital engineering ecosystem is essential because it ties together requirements, architecture, design, validation, and the ecosystem's underlying tools while facilitating near real-time data sharing and collaboration among industry partners, academia, and government entities. In other words, it facilitates rapid prototyping, testing, and evaluation, which Golden Dome will require.

6. Operational Excellence

Strengthen interdisciplinary collaboration

Operational excellence—driven by strong military and scientific leadership—was essential to the success of the Manhattan Project. It enabled leaders to navigate the tension between secrecy and scientific discovery and to coordinate efforts across military, civilian, and academic institutions. They did this not only through sheer determination but by uniting participants around shared mission-first values. Golden Dome leaders will need to cultivate similar excellence. By aligning all contributors around mission-first values, embracing flattened hierarchies, and prioritizing digital-first operations, they can build lean, efficient teams capable of executing across government, industry, and academia. This approach will drive collaboration, accelerate delivery, and ensure the program remains focused and agile.

Recommendations

A. Mission First Values, Not Silicon Valley Platitudes

Golden Dome's leaders should consider avoiding platitudes such as "failing fast" and instead identify which mission-first traits, including behaviors and values, the program truly needs. From there, they can weave those traits into project teams by adjusting doctrines, training, and organizational structures, building the right values from the ground up rather than forcing together mismatched cultural archetypes or expecting existing cultures among disparate organizations to suffice.

B. Create a Golden Dome Boot Camp

When "culture can eat strategy for breakfast",[15] developing mission-first values should be a priority. Golden Dome leaders can move quickly to establish the right values through a Golden Dome Boot Camp. While this Boot Camp won't look like the training course used to turn civilians into soldiers, Sailors, Airmen, or Marines, it should achieve similar, transformative results. To start, it should clarify the values, goals, and perspectives that are critical to the mission, and what living those values look like. The Boot Camp should also provide its trainees with potential interventions to ensure each can assess and offer corrections should culture start to fade.

By aligning all contributors around mission-first values, embracing flattened hierarchies, and prioritizing digital-first operations, they can build lean, efficient teams capable of executing across government, industry, and academia.

The Next Six Months

The first six months will be critical for laying Golden Dome's foundations and preparing to scale it. The successful Manhattan Project offers Golden Dome's leaders a window into what that start-up process must entail and highlight the fact that organizing people will be among the greatest challenges. The recommendations above aim to provide Golden Dome's leaders with a quick reference to the lessons from World War II. And, even among those, three should be prioritized:

Recommendation 1A:
Establish Two-in-a-Box Leadership

Recommendation 2A:
Appoint a CISO

Recommendation 6B:
Create a Golden Dome Bootcamp

Beyond these immediate steps, there is much work to be done. The level of complexity, integration, and innovation required for Golden Dome demands rapid alignment of US government agencies, military services, academic institutions, and corporations around shared objectives. Private industry has already begun to mobilize. The faster the US Government can create conditions for a modern-day Manhattan Project, the faster Golden Dome will become a reality.

Get in touch

For more information, contact our team:

Jesse Goldhammer, Ph.D.
Managing Director
jgoldhammer@deloitte.com

Eric Dull
Managing Director
edull@deloitte.com

Carey Miller
Managing Director
caremiller@deloitte.com

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