HYPERION RESEARCH

White Paper

To Out-compute is to Out-compete: National Security Interests in Public Health & Safety and Commerce & Finance

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HYPERION RESEARCH OPINION

When the term "high performance computing" is used in the same sentence as national security, thoughts typically turn towards military, defense, and homeland security. National security, however, encompasses more than just physical and border security. Public health and safety, and secure commerce and financial systems, also play key roles in a providing for the well-being of a nation. HPC plays as fundamental a role in enabling a nation's security and competitiveness in these areas as it does in military defense.

Many elements are under the broad umbrellas of public health and safety, and commerce and finance. Public health and safety includes preventing and curing disease, emergency and crisis response to natural disasters, environmental sustainability, and weather prediction, to name a few. Several areas under commerce and finance include anticipating and responding to economic downturns, security of financial markets, creating and maintaining physical infrastructure, and investing in long-term research. Each area is critical for supporting a consistent safe environment for citizens to conduct their business and live their lives. Each area also has its own unique set of challenges and opportunities that drive a diverse range of advanced computing requirements to address them.

While most U.S. governmental entities rely on HPC to meet their most critical mission requirements, more could be done. The severity and paths of several recent severe North American weather events were more accurately predicted and with more lead time by European weather models. Several APAC nations are widely considered to be in leadership positions relative to environmental sustainability in smart cities and urban design. The U.S. is at risk at ceding competitive advantage and suboptimizing national welfare interests in these areas without increased investment to address these challenges.

The U.S. government has several avenues available to support the needs of scientists, researchers, and engineers tackling these issues. In considering its approach, the government should consider partners that offer a broad range of HPC solutions and services for both on-premises and cloud resources. Dell Technologies, with its broad product and services portfolio, in conjunction with its technology providers, such as AMD, is an example of a partner capable of providing solutions that can address the advanced computing challenges of public health and safety, and commerce and finance.

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EXECUTIVE SUMMARY

A primary role of government is to provide for the common good and protection of its citizens. This role goes well beyond military defense and border protection. Ensuring a stable economy and supporting equal opportunities for all citizens, while preventing widespread illness and providing ample warning of and protection against natural disasters, are as important as military defense for a nation to safeguarding the welfare of the public.

Leadership in these areas not only provides security for a nation, but also for global security, health, and sustainability. Many of the 17 goals defined in the [United Nations' 2030 Agenda for Sustainable Development](#) related to public health and safety can benefit from science and research enabled by advanced technical computing:

- Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
- Goal 3: Ensure healthy lives and promote well-being for all at all ages.
- Goal 6: Ensure availability and sustainable management of water and sanitation for all.
- Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all.
- Goal 8: Promote sustained, inclusive, and sustainable economic growth, full and productive employment and decent work for all.
- Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable.
- Goal 12: Ensure sustainable consumption and production patterns.
- Goal 13: Take urgent action to combat climate change and its impacts.
- Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- Goal 15: Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
- Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.

Components of Public Health & Safety and Commerce & Finance

Many factors fall under the umbrella of public health and safety. A partial list includes:

- Public health
- Emergency and crisis response
- Weather and climate

Likewise, commerce and finance encompass several areas, including:

- Anticipating and responding to economic downturns

- Ensuring security of financial markets and integrity of currencies
- Providing and maintaining physical infrastructure (e.g., smart cities, national power grid)
- Encouraging speculative long-term investment

Each of these facets are worthy of further exploration. This paper will focus on several deemed to provide the greatest impact on the public and provide the greatest opportunities for the U.S. government to address.

THE MARKET OPPORTUNITY FOR HPC IN PUBLIC HEALTH & SAFETY AND COMMERCE & FINANCE

In addition to serving the nation in contributing to its health, financial well-being, and economic competitiveness, vendors who can provide the necessary solutions and support to the various government departments and agencies chartered with that mission can achieve significant economic returns. Table 1 summarizes the U.S. technical server market opportunity by industry vertical. Many (highlighted in light gray) contribute in some fashion to public health & safety and commerce & finance.

TABLE 1

U.S. Technical Revenue Forecast by Industry Vertical ($M)

	2021	2022	2023	2024	2025	2026	CAGR 21-26
Bio-Sciences	$571	$605	$662	$728	$732	$774	6.2%
CAE	$717	$761	$832	$914	$919	$971	6.3%
Chemical Engineering	$105	$106	$115	$127	$128	$135	5.2%
DCC & Distribution	$503	$534	$583	$641	$645	$682	6.3%
Economics/Financial	$523	$551	$602	$661	$665	$702	6.1%
EDA	$505	$541	$591	$650	$654	$690	6.4%
Geosciences	$300	$306	$335	$367	$370	$390	5.4%
Mechanical Design	$21	$20	$22	$25	$025	$026	4.4%
Defense	$832	$891	$975	$1,070	$1,077	$1,138	6.4%
Government Lab	$750	$1,117	$1,220	$1,340	$1,348	$1,424	13.7%
University/Academic	$778	$888	$971	$1,066	$1,072	$1,133	7.8%
Weather	$345	$372	$407	$447	$450	$475	6.6%
Other	$55	$54	$59	$64	$065	$069	4.5%

TABLE 1

U.S. Technical Revenue Forecast by Industry Vertical ($M)

	2021	2022	2023	2024	2025	2026	CAGR 21-26
Total	$6,006	$6,747	$7,373	$8,100	$8,148	$8,609	7.5%

Source: Hyperion Research, September 2022

The U.S. government composed approximately one third of U.S. technical sever market in 2021, including areas related to public health and safety, and commerce and finance. Table 2 shows the U.S. technical server market forecast by sector.

TABLE 2

U.S. Technical Server Revenue Forecast by Sector ($M)

	2021	2022	2023	2024	2025	2026	CAGR 21-26
Government	$2,107	$2,571	$2,810	$3,086	$3,105	$3,280	9.3%
Defense	$832	$891	$975	$1,070	$1,077	$1,138	6.4%
Labs	$750	$1,117	$1,220	$1,340	$1,348	$1,424	13.7%
Weather	$310	$335	$366	$403	$405	$428	6.6%
Bioscience	$143	$151	$165	$182	$183	$193	6.2%
CAE	$072	$076	$083	$091	$092	$097	6.3%
Industry	$3,120	$3,363	$3,674	$4,037	$4,061	$4,255	6.4%
Academia	$778	$888	$971	$1,066	$1,072	$1,133	7.8%
Total	$6,006	$6,747	$7,373	$8,100	$8,148	$8,609	7.5%

Note: The lightly shaded rows are application areas within the government sector that utilize HPC. They sum to the Government total.

Note: The Weather, Bioscience, and CAE application areas include only the government component of those respective verticals.

Source: Hyperion Research, September 2022

Diverse Requirements Presented by Public Health & Safety and Commerce & Finance

The DOE's national labs garner a lion's share of the media and technical community's attention relative to HPC due to the extreme scale of performance capabilities and dollars spent on their leadership-class machines. Frontier, the most recently installed DOE supercomputer at the Oak Ridge National Lab (ORNL), cost upwards of $600M for the supercomputer. But not all HPC workloads require such scale. Many workloads require less capabilities than the leadership-class supercomputers provide. More than half of the U.S. market for technical servers are for systems that cost less than $500K USD. Table 4 provides a Competitive Segment view of the U.S. technical server market.

TABLE 4

U.S. Technical Server Revenue Forecast by Competitive Segment ($M)

(USD)	2021	2022	2023	2024	2025	2026	CAGR 21-26
Supercomputer (> $500K)	$2,556	$3,007	$3,317	$3,698	$3,740	$4,038	9.6%
Divisional ($250K-$500K)	$1,295	$1,415	$1,546	$1,706	$1,768	$1,842	7.3%
Departmental ($100K-$250K)	$1,561	$1,732	$1,886	$2,036	$2,000	$2,152	6.6%
Workgroup (< $100K)	$594	$593	$624	$661	$640	$577	-0.6%
Total	$6,006	$6,747	$7,373	$8,100	$8,148	$8,609	7.5%

Source: Hyperion Research, September 2022

Requirements also greatly differ within the spheres of public health & safety and commerce & finance. Each area requires different architectural emphases to address the unique challenges each is aiming to solve. Elements such as scale, compute types, data and storage, and security needs are but a few that drive different requirements in each area.

Public Health and Safety

Science and research supporting public health and safety needs greatly benefit from broad collaboration. Research based on the largest datasets from the most diverse data sources conducted by the widest array of subject matter experts can provide more accurate and confident results than that based on smaller and less diverse data from fewer researchers. This level of collaboration, however, requires acute attention to security and protection of individual identification information.

A prime example of collaboration for public health and safety was the global response to the COVID-19 pandemic in the form of the COVID-19 High Performance Computing Consortium. The stewards of many of the world's fastest supercomputers, along with HPC systems and solutions providers, came together to make the pooled resources of supercomputers readily available to the worldwide research community. The community, in turn, made the wide variety of subsequent research publicly available for the global common good.

The datacenters participating in the collaborative response to COVID-19 each made available a broad range of HPC infrastructure and experts to support the diverse needs of the researchers. The U.S. government played a strong role in making the DOE's fastest supercomputers available free of charge for work being done to combat COVID-19. This also supported the DOE's Office of Science mission to deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States.

Commerce and Finance

Collaboration is less pervasive in commerce and finance. Advanced computing is utilized more to model potential macroeconomic responses to policy decisions and smooth, efficient movement of financial markets. More directly related to the U.S. government's interest and purview is detection and prevention of counterfeiting and attacks on financial market infrastructure. These areas require less collaboration and more real-time monitoring, detecting, and analysis.

Threats and Opportunities

Despite possessing the top spot on the current Top500 list and the broad mission of the DOE, all is not well across the broad spectrum of U.S. government investment in HPC. For example, European weather models are generally considered better at predicting the magnitude and path of U.S. hurricanes than current U.S.-based models. Additionally, Singapore is recognized as being the current global leader in understanding and advancing smart city research and applications.

There is no specific root cause of these deficiencies, but major growth in purchases is required to keep pace. That said, a combination of delayed upgrades to hardware infrastructure and postponed efforts to modernize application codes are likely contributing factors.

HPC SOLUTIONS AND DELL TECHNOLOGIES

The TOP500 class HPC systems aren't required to address all of the HPC applications and workloads required by the various U.S. government agencies involved with public health & safety and commerce & finance. Many of these workloads can be run on smaller HPC clusters comprised of less expensive and less experimental hardware infrastructure that many enterprise IT datacenters employ.

Dell Technologies is a leading provider of enterprise IT solutions across a broad range of IT infrastructure categories (e.g., servers, converged, hyperconverged, storage, and AI). Within the global HPC market, Dell Technologies is the second leading provider of HPC technical servers, with a 21.8% on-premises market share, and the most preferred HPC storage vendor, being deployed at more than 18% of HPC sites in 2021, according to Hyperion Research market studies.

Coupling their industry enterprise IT expertise with their HPC technologies and solutions makes Dell a great partner for both industry and the U.S. government to support its efforts to grow the country's industrial economic competitiveness and provide for the nation's public health & safety. Dell's strong

portfolio of HPC products and solutions, augmented with corresponding support and choices of access methods, includes:

- **Dell PowerEdge Servers:** With a broad array of servers from which to choose, including the R7525, R7626, and C6525 based on the AMD EPYC™ processors, Dell has an HPC node to satisfy whatever scale users' workloads demand.

- **APEX High Performance Computing:** While some HPC workloads are being migrated to the cloud, there is still demand for on-premises or single-tenant co-located HPC infrastructure. Single-tenant users do, however, recognize the advantages of a cloud-like business model based on OPEX and a pay-as-you-go approach, as opposed to a CAPEX-heavy investment model. APEX provides users with a flexible approach to gain access to bare metal HPC resources with 1- year, 3-year, and 5-year pricing options.

- **HPC On Demand:** The cloud is increasingly being adopted as an HPC resource incremental to on-premises infrastructure to address periodic demand surges, among other reasons. Dell partners with leading CSPs, automation vendors, and managed service providers to offer pay-as-you-go hourly, monthly, or yearly pricing options for HPC cloud-based solutions to support customers with cloud-native, hybrid-cloud, and multi-cloud applications.

- **Cybersecurity Solutions:** Addressing challenges such as data backup and recovery, threat vulnerability detection and response, supply chain integrity, and managing 24x7 security operations, Dell provides a wide range of solutions for managing the increasing cybersecurity-related threats and breaches. Providing cyber resilient security relative to protecting, detecting, and recovery, Dell's PowerEdge servers extensive use of intelligence and automation helps you stay ahead of the threat curve, and to enable the scaling demanded by ever-expanding usage models.

- **HPC & AI Innovation Lab:** This team of engineers and subject matter experts collaborates with customers and partners to move beyond individual products and develop targeted solutions HPC & AI workloads. The Lab is available for customers to evaluate new technology or develop focused solutions for a specific outcome, or virtually via access on-line resources for best practices and benchmark results.

- **Customer Solution Centers:** Resourced with Dell personnel, these centers provide customer and partners free hands-on access to Dell infrastructure and the opportunity to interact directly with Dell for demos and testing before buying. Interaction with the HPC & AI Innovation Lab for advanced solution engineering and performance testing is also available through these centers.

- **HPC & AI Centers of Excellence:** With almost a dozen locations around the world, these third-party centers develop and maintain local partnerships, test new technologies, share best practices, and function as entry-points for customers to provide feedback and influence future product roadmaps.

- **The Dell HPC Community:** Dell Technologies' HPC Community is a worldwide technical forum that facilitates the exchange of ideas among researchers, computer scientists, executives, developers, and engineers, and promotes the advancement of innovative, powerful HPC solutions. Through both weekly online and periodic face-face events, the HPC Community seeks to foster sustained discussions among experts that lead to the design, deployment, operation, and usage of the most effective HPC solutions. Members share expertise, insights, observations, suggestions, and experiences to improve current HPC solutions and to influence future technology capabilities & impact.

SITUATIONAL ANALYSIS

Providing for the welfare the nation is one of the primary roles of the U.S. government. Virtually every department and agency are tasked in some way in this regard, including relative to public health & safety and commerce & finance. The following table summarizes the requested U.S. government budget for 2023, highlighting *(bold italics highlighted in gray)* those agencies and departments tasked and budgeted with some type of technical computing infrastructure to address these needs.

TABLE 5

Proposed 2023 U.S. Government Federal Budget

Base Discretionary Funding Area	Requested Amount ($B USD)
Cabinet Departments:	
Agriculture	*28.5*
Commerce	*11.7*
Defense	*773.0*
Education	88.3
Energy (DOE)	*48.2*
Health and Human Services (HHS)	*138.0*
Proposed IHS Shift to Mandatory (non-add)	(9.1)
HHS, BA excluding IHS (non-add)	(128.9)
Homeland Security (DHS)	56.7
Housing and Urban Development (HUD):	60.8
Interior (DOI)	17.9
Proposed BIA Shift to Mandatory (non-add)	(0.5)
DOI, BA excluding BIA (non-add)	(17.5)
Justice	37.7
Labor	14.6
State and International Programs	67.6
Transportation	*26.8*
Treasury	*16.2*

TABLE 5

Proposed 2023 U.S. Government Federal Budget

Base Discretionary Funding Area	Requested Amount ($B USD)
Veterans Affairs	*135.2*
Major Agencies:	
Corps of Engineers (Corps)	*6.6*
Environmental Protection Agency	*11.9*
General Services Administration	1.3
National Aeronautics and Space Administration	**26.0**
National Science Foundation	**10.5**
Small Business Administration	0.9
Social Security Administration	10.1
Other Agencies	28.1
Changes in mandatory program offsets	−34.7
Subtotal, Base Discretionary Budget Authority (BA)	1,582.0
Subtotal, BA excluding programs shifted to mandatory	1,572.4

Source: Hyperion Research, January 2023 (adapted from Budget of the U.S. Government, Fiscal Year 2023, Table S-8)

While the budgeted line items are large, more can be done to allocate and prioritize the funds for the greatest public good. Leveraging common infrastructure, developing the mechanisms to share data and research, and effectively communicating results should be common goals for cross-department and cross-agency collaboration.

Public Health and Safety

Public health and safety cover a broad range of areas aimed at providing for the health and welfare of the nation. While the U.S. Department of Energy (DOE) is a leading contributor of important research to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions, many other areas of the U.S. government provide for the health and welfare of the country.

Disease Prevention and Cure

The COVID pandemic further clarified the critical role that the government plays in ensuring the health and welfare of the population. Identifying the cause of disease, investing in and supporting the development of effective treatments, vaccines, and potential cures, and creating measures for prevention and transmission of future disease all benefit from focused government investments. The following non-exhaustive list provides a glimpse of the breadth of government departments and agencies funding and employing HPC infrastructure in the prevention and cure of diseases:

- Center for Disease Control (CDC)
- Health and Human Services (HHS)
- Institute of Human Virology (IHV)
- National Cancer Institute (NCI)
- National Institute of Allergy and Infectious Diseases (NIAID)
- National Institute of Health (NIH)
- National Science Foundation (NSF)
- U.S. Army Medical Research Institute for Infectious Diseases (USAMRIID)

Other agencies are also involved in adjacent medically related areas that can leverage advanced computing. Veterans Affairs applies scientific knowledge to develop effective individualized care solutions, biomedical lab, artificial limbs, and related research to support veterans. The National Institute of Science and Technology (NIST) supports the development of emerging technologies in healthcare, including medical device interoperability, medical imaging quality, and pervasive health monitoring.

Response to Crises and Emergencies

HPC techniques may not be the first tools that come to mind in responding to emergencies and natural disasters but they are critical tools in preventing and recovering from them. Floods can destroy levees and important transportation infrastructure. Weather events, economic distress, and armed conflict can create movements of displaced people, stressing supply chains and access to required food and shelter staples.

The U.S. Army Corps of Engineers is tasked with modeling and improving levees, both temporary ones installed immediately after river breeches and permanent ones to better protect against future water events. Advanced technical computing provides the resources necessary for the requisite modelling and simulation for improved levee design for future flood mitigation and prevention.

Advanced computing can support techniques to predict migration models for people displaced for any reason, including weather, economic, and political events. The models support optimized decision making to place appropriate resources in areas most likely to be impacted.

Weather and Climate Forecasting

Severe weather events such as tornados, hurricanes, and blizzards can cause catastrophic damage and loss of life if the public cannot be warned with sufficient lead time to protect themselves. Ongoing draughts can create dangerous conditions to allow fires to start and spread uncontrollably.

Several U.S. agencies develop weather and climate models to provide national and regional forecasts for commercial and personal consumption, including National Aeronautics and Space Administration

(NASA), National Center for Atmospheric Research (NCAR), National Oceanic and Atmospheric Administration (NOAA), and the National Weather Service (NWS). The U.S. Geological Survey (USGS) supports the mapping and projections of projected burn areas and fire spread.

Despite investment to support each of these organizations and their HPC infrastructures, evidence that could be indicative of lagging investment is emerging. Investment to upgrade and modernize U.S. weather and climate infrastructure and codes could minimize property damage and potential loss of life precipitated by weather events.

Commerce and Finance

Less visible than public health and safety areas but no less important to the national welfare is effective national commerce and finance. HPC plays a vital role in its consistent and efficient operation.

Anticipation of and Responding to Economic Downturns

The global economy is a complex system with many moving parts. Having the ability to project outcomes based on different policy and decision scenarios can allow the U.S. government to optimize the impact of its actions on the population. HPC can be leveraged to create economic models to run the complex simulations or train AI-based models for high-speed inferencing.

Financial Market Security

Stable financial markets are key for a nation's economic welfare. Trading needs to be fast, accurate, and secure. Public trust in organizations involved in security and currency exchanges (whether tangible or crypto) is vital.

Several government entities are involved with the security of financial markets:

- Securities and Exchange Commission (SEC) for detecting and protecting against anomalous, fraudulent trading.
- Treasury Department in identifying and protection against counterfeiting.
- Internal Revenue Service (IRS) in ensuring identification and timely collection of revenues.

Modern infrastructure is essential for optimized operation of financial markets and minimization of criminal and fraudulent activity.

The National Infrastructure

A reliable, secure, and consistent flow of goods and services is essential for a vibrant national economy and the ability to attain commercial and personal financial prosperity for the citizenry. This includes physical transportation systems, connectivity for e-commerce, and the power and energy required for their continued operation.

HPC is required for each of these areas. Modeling the interconnectivity of physical transportation systems such as roads, railways, and aviation can optimize the delivery time of goods and identify choke points in times of disruption. Support for and research into alternative fuel sources can protect against potential future fossil fuel scarcity.

Inadequate government funding and support in these areas could lead to opportunities for bad actors to disrupt supply chains and power sources for continued commerce. Competing suppliers from other

nations could also emerge to create an unhealthy increasing dependency of the U.S. on other nations for its economic prosperity.

Domestic Long-term Research

A long-term horizon is necessary for incubation of speculative energy and health-related areas before they can become commercially viable. Modeled after the U.S. Department of Defense (DoD) Defense Advanced Research Projects Agency (DARPA), other entities have been created to fund non-military advanced research projects that leverage advanced technical computing:

- Advanced Research Projects Agency for Energy (ARPAe)
- Advanced Research Projects Agency for Health (ARPA-H)

Increased fortitude and commitment to this long-term investment in highly speculative areas can help ensure U.S. leadership in development and commercialization of innovations to serve the public good.

FUTURE OUTLOOK

Public health & safety and commerce & finance are equally as critical to national security and welfare as military defense. U.S. government investments in HPC resources to support innovations and advancements in these areas is vital for it to provide for the nation's security and global leadership.

In the past, the U.S. government has demonstrated the resolve to invest in these resources and will likely continue to do so. It needs multiple, viable partners to provide state-of-the-art HPC solutions that meet the various departments' and agencies' requirements, particularly those that are strong in the divisional and departmental competitive segments of the HPC market. Dell Technologies, in conjunction with technology partners such as AMD, is one example of such a strategic partner. With its leadership positions in several enterprise IT and HPC infrastructure categories coupled with its support of various business delivery models and support levels demanded by HPC users, Dell Technologies is well-positioned to support the U.S. government in its critical mission of providing for the nation's security and welfare.

About Hyperion Research, LLC

Hyperion Research provides data-driven research, analysis and recommendations for technologies, applications, and markets in high performance computing and emerging technology areas to help organizations worldwide make effective decisions and seize growth opportunities. Research includes market sizing and forecasting, share tracking, segmentation, technology and related trend analysis, and both user & vendor analysis for multi-user technical server technology used for HPC and HPDA (high performance data analysis). Hyperion Research provides thought leadership and practical guidance for users, vendors and other members of the HPC community by focusing on key market and technology trends across government, industry, commerce, and academia.

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