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December 1, 2021

The Honorable Luke E. Torian
Chair, House Appropriations Committee
General Assembly Building, Room W1304
Richmond, Virginia 23219

The Honorable Janet D. Howell
Chair, Senate Finance and Appropriations Committee
General Assembly Building, Room E509
Richmond, Virginia 23219

Dear Chair Torian and Chair Howell:

The 2021 General Assembly approved Item C-68.50, directing Virginia Commonwealth University to convene a multi-university workgroup to develop a plan for the Commonwealth Center for Cloud Computing (C4). In addition to VCU, other universities in the workgroup include the University of Virginia, Virginia Tech, Old Dominion University, Virginia State University, Longwood University and George Mason University.  Partners also include the Commonwealth Center for Advanced Logistics, the Commonwealth Center for Advance Manufacturing, and the Commonwealth Cyber Initiative.

The workgroup's plan is required to submit a report by December 1, 2021, to the Chairs of the House Appropriations Committee and the Senate Finance and Appropriations Committee.

I am pleased to attach that report.

This report is required in order for the General Assembly to take further steps to release to VCU the authorized $6,880,000 noted in Item C-68.50.

Virginia Commonwealth University and the other members of the workgroup look forward to working with you in the 2022 General Assembly session to discuss our plan to develop the Commonwealth Center for Cloud Computing.

In the meantime, should you have questions or require additional information, you can reach me at (804) 828-0190 and bboyan@vcu.edu.

Sincerely,

Barbara D. Boyan, Ph.D.
Dean, College of Engineering
Virginia Commonwealth University

cc:     Anne Oman, Staff Director, House Appropriations Committee
        AOman@hac.virginia.gov

        April Kees, Staff Director, Senate Finance and Appropriations Committee
        Akees@sfac.virginia.gov

# Commonwealth Center for Cloud Computing

## Work Group Report

## December 1, 2021

This document represents the report of a workgroup established to develop a plan for the Commonwealth Center for Cloud Computing as described in the enabling legislation described below. This report presents guiding principals for the creation and expansion of a Commonwealth Center for Cloud Computing, operational cost estimates for the first three years, cost sharing strategies to leverage partnerships with the private sector, and more broadly, key findings of the workgroup.

## Background Legislation Approved February, 2021 (redacted)

https://budget.lis.virginia.gov/item/2021/2/hb1800/reenrolled/2/c-68.50/

*Virginia Commonwealth University is hereby authorized $6,880,000 the first year from bond proceeds of the Virginia College Building Authority to provide funds for the support, acquisition and installation of High-Performance Computing tools for the development of the Commonwealth Center for Cloud Computing (C4). G. The conditions required in order to receive the allocation from paragraph F. 2. of this item are:*

*1. Virginia Commonwealth University shall convene a "Workgroup" comprised of the University of Virginia, Virginia Tech, Old Dominion University, Virginia State University, Longwood University, and representatives from the Commonwealth Center for Advanced Manufacturing (CCAM) and the Commonwealth Center for Advanced Logistics for the expressed purpose of developing a plan for the Commonwealth Center for Cloud Computing (C4). [Note: George Mason University was added to this initial Workgroup.]*

*2. The Plan shall identify areas of research relevant to the C4, guiding principles to ensure continued collaboration between and among the partnering entities, opportunities for potential expansion of other institutions and entities, linkages with the Commonwealth Cyber Initiative, the Cyber Range and the Greater Washington Partnership, operational cost estimates and cost sharing strategies between and among the partnering institutions and entities to include potential for leveraging private sector partnerships.*

*3. The workgroup shall submit the report by December 1, 2021 to the Chairs of the House Appropriations and Senate Finance and Appropriations Committees and the Governor.*

*4. After adoption of the report by the General Assembly, the funding provided in paragraph F.2. shall be released to Virginia Commonwealth University to support the creation of the operations of the Commonwealth Center for Cloud Computing (C4).*

**RECOMMENDED ACTIONS:  COMMONWEALTH CENTER FOR CLOUD COMPUTING**

1. Adopt the report of the workgroup and release $6.8 million in capital bond funding to Virginia Commonwealth University as described in the enabling budget resolution contingent upon:
    A. legislation enabling the Virginia Innovation Partnership Authority ("VIPA") to oversee the activities of the Commonwealth Center for Cloud Computing.
    B. Confirmation of private sector commitments to provide a minimum of $10 million in donated technology.
2. Provide operating funds for the first three years of operation, $2.0 -3.0 million/year for a total of $7.5 million over 3 years.  Within the first year of operation, the established working group will develop and initially implement a technology deployment plan as described below.  The goal is also to leverage the initial capital of $6.8 million with additional support from each of the Universities (amount to be determined) as the C4 program will help to solve existing, unmet computing needs at the R-1 universities and other four-year institutions, including HBCUs. The program also will enable community colleges to access the resources provided by C4.

Upon creation of the Commonwealth Center for Cloud Computing, the Virginia Commonwealth University will:

 i. Form a C4 "Organizing Committee " composed of representatives from VCU, ODU, GMU, VSU, UVA, VT, and Longwood, as well as CCI, CCAM, CCALS, and VEDP. The immediate objective of the Organizing Committee will be to recruit and establish a C4 Board of Directors with equal number of representatives from the private sector and higher education institutions, plus VEDP, CCI, CCALS, and CCAM.  Private sector representatives may include participation from NVTC, RVA757connect, and other similar organizations.  This Organizing Committee will be chaired by Dr. John Leonard, Professor of Computer Science and Executive Dean, College of Engineering at VCU.  It shall establish the governance and operating capabilities, including development of a Charter and the recruitment of an Executive Director (and the initial staff) that aligns with purposes and proposed budget described in this document.

**ii.** The Organizing Committee will establish a "C4 Technical and Applications Committee(s) "composed of industry and university representatives with the specific goal to create a "Rapid Execution Plan" based on the Framework described in this document.


**INTRODUCTION**

This document presents a Statewide framework to create the Commonwealth Center for Cloud Computing (C4), an ecosystem of highly advanced, networked, geographically-dispersed computing resources and programming initiatives to support extensive academic-private sector collaboration for academic (talent development) and application research purposes.  The overarching objective is to enhance high-value economic development across the Commonwealth to ensure we remain competitively positioned in an era of rapid change that is catalyzed by development and commercialization of advanced digital technologies.  *We need to do more to ensure Virginia's universities, government agencies and the private sector are more fully engaged in this dynamic, advanced digital ecosystem.*

As part of the enabling legislation, the General Assembly charged VCU to convene a workgroup of partner universities and state entities, and develop a plan for C4. The Workgroup embraces close interconnection between C4, the Commonwealth Cyber Initiative (CCI), the Commonwealth Center for Advanced Manufacturing (CCAM), the Commonwealth Center for Advanced Logistics Systems (CCALS), Cyber Range, the Virginia Innovation Partnership Corporation (VIPC; formerly CIT) and a major new Commonwealth initiative involving data science/artificial intelligence ("Data Science Moon-shot"). This will be done in a manner that is outside of firewalls, which will provide critical computing resources (skills, systems and data management) to geographically dispersed institutions that struggle to keep pace with technology innovation.

Over the past several months members of the Workgroup also examined the computing resources available in other "mega-regions" across the United States, including Research Triangle Park; Boston, Northern California, and Texas. We believe there is urgent need to build the C4 "Tech Sandbox" in order to provide operating resources that will fully enable extensive collaborations across a broad range of "user" communities (private and public) on an easily accessible, low cost, globally-networked private-cloud and hybrid-cloud computing ecosystem that bring new capabilities across Virginia.
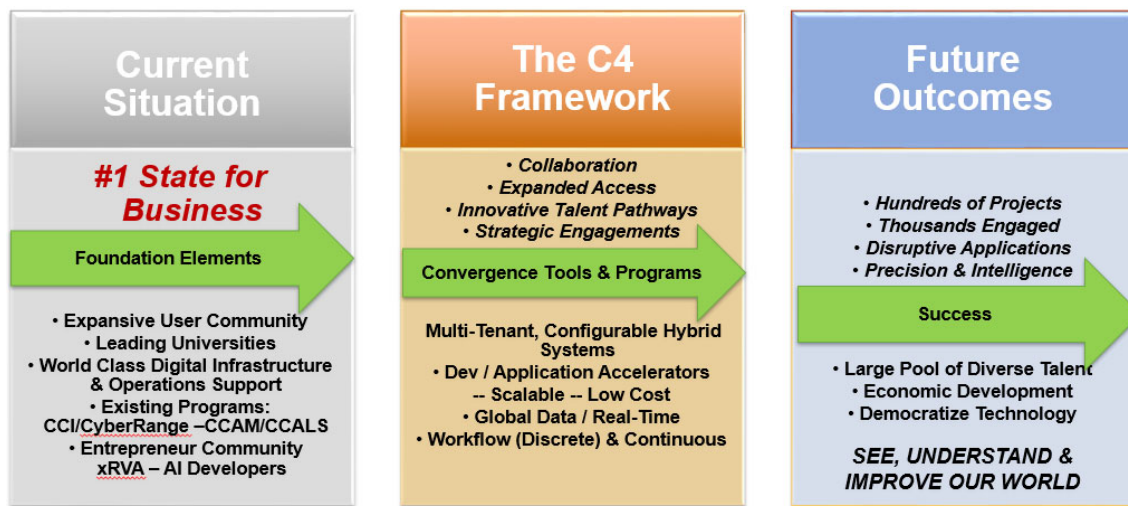


*Figure 1 - Mapping current situation to future outcomes*

The Workgroup believes incremental evolution within existing structures will not bring these resources to a greater number of higher-ed institutions, community colleges and beyond. Everyone is aware of the broadband divide, but there is also a notable high-tech digital divide affecting both the private sector and public sector. Widespread adoption of new technologies requires broader understanding and "democratization" of technology, particularly as we look forward and plan for the explosive growth of advanced data analytics and AI. Across every part of society, we need to put better tools and more data into the hands of more people.

This proposed C4 framework is designed with input from both the academic community and technology companies involved with highly advanced data analytics, computing hardware and software, and network infrastructure and data centers.  The Workgroup confirmed that the technology community will provide low cost (selected no-cost) resources for academic and applications development purposes.  As a starting point, we have indicative commitments that will leverage the initial capital appropriation of $6.8 million to over $25 million of technology resources that bring new capabilities across the Commonwealth, while also connecting to global data resources. This is just the start.  Organizations such as the *Northern Virginia Tech Council (NVTC)* and *RVA757connect* strongly endorse the C4 initiative.

The Virginia Economic Development Partnership (VEDP) and local economic development agencies also endorse the requests outlined in this document, particularly as it relates to programs designed to greatly expand collaborative platforms that will produce additional highly-skilled talent and support new and existing enterprises.  ***Virginia is fortunate to have world-class digital infrastructure coupled to an extraordinary network of data centers and edge computing resources.  However, virtually all of these assets have limited access and are restricted behind fire-walls.***  C4 will provide a capability to strategically assemble and balance resources to enable large-scale data analytics/AI coupled to a multi-tenant, highly configurable, world-class, networked technology that permits ultralow latency, big data computing for education and collaboration on a large scale. Figure 2 below provides a visual of the design elements associated with complex, commercially available system; note that data acquisition, management and storage is an essential element in today's real-time environment.
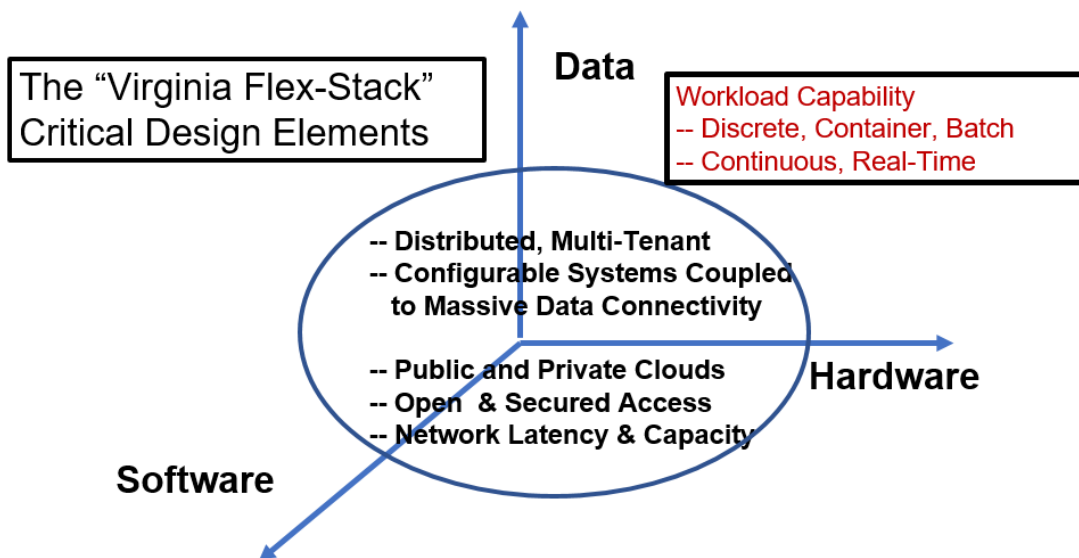


*Figure 2 - C4 Flex-Stack design elements*

The Workgroup, in collaboration with the technology community, has created a Tech Deployment Plan that involves an initial capital program to:

1.  Expand network capabilities and protocols (state-wide) in order to support enhanced data access and collaboration between the higher-ed institutions, community colleges, Virginia Innovative Partnership Authority (VIPA) centers of excellence (CCI, CCAM, CCALS) and other initiatives such as the Assuring Controls Compliance of Research Data (ACCORD) program and the newly formed Virginia Office of Education Economics (VOEE). Where possible, leverage existing networks (i.e. MARIA) and create strategic model across Virginia's educational institutions.     Budget Estimate $!.0 - $1.5 million

2.  Install massively connected, state of the art computing capabilities (IBM and partners) to create thousands of private clouds at the globally-connected Network Access Point in Henrico County (QTS).     Budget Estimate $2.0 - $3.0 million

3.  Install highly configurable processing technology ("Virtual Stacks") at numerous geographically dispersed locations across the Commonwealth.
     Budget Estimate $2.0 - $3.0 million

4.  Fund industry expertise to ensure compatibility with business sector users and applications developers.     Budget Estimate $0.3 - $0.8 million

The Framework is designed to have multiple, configurable "stacks" that have broad capabilities and levels of sophistication, connect hundreds of businesses, run hundreds of projects at a time, and permit thousands of people to engage with projects and programs every day!   We expect the technology, user and entrepreneurial communities to contribute expertise in addition to the hardware, software, data platforms and other technology.
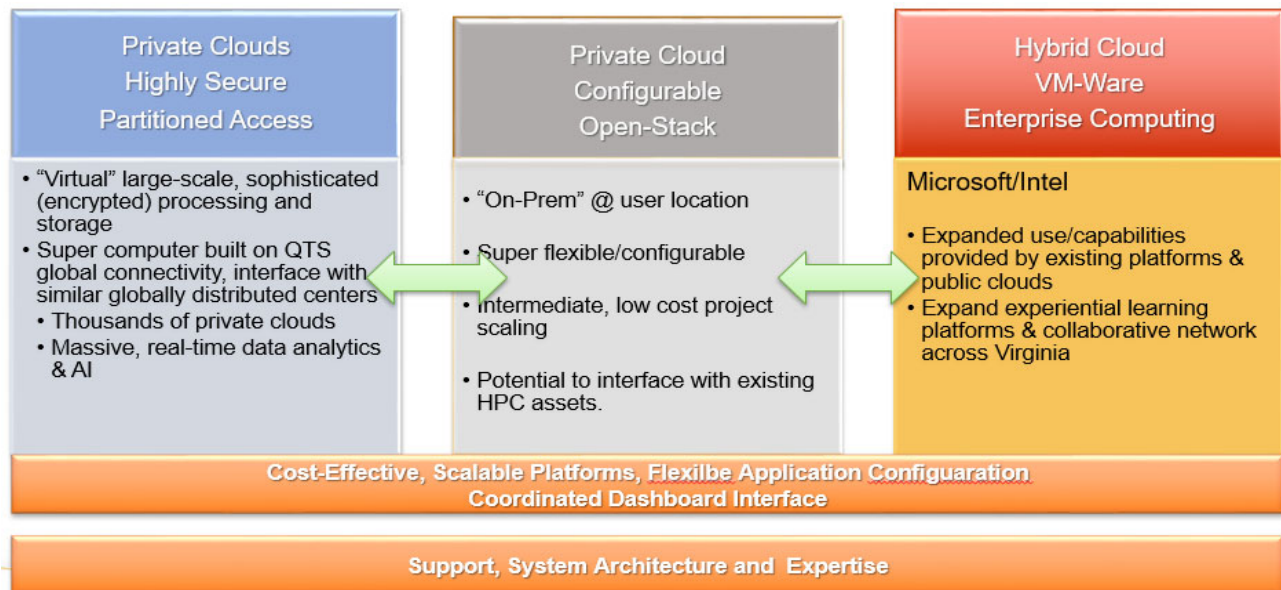


*Figure 3 - C4 Flex-Stack Logical Architecture and User Applications*

***Our Goal: Ensure Virginia is increasingly recognized as the best State for network and data center infrastructure that supports high-impact economic development that is enabled with advanced technology applications, data science and AI.***

There are literally hundreds of expert comments regarding the importance of building these soft and hard resources, but this quote from the National Cyber Security Forum Directorate is instructive: *"Building out AI capabilities is a national security imperative. The rate of adoption of AI across government is increasing and the vast amounts of data collected can deliver tremendous insights to enhance security, improve citizen services, and transform decision making processes."*

**KEY WORKGROUP FINDINGS**
**COMMONWEALTH CENTER FOR CLOUD COMPUTING**

1. There is a wide-scale, unmet need for highly advanced, ***open access*** computing tools and resources that are supported by trusted organizations, particularly across regions outside of Northern Virginia. ***This is an academic, industry and government sector request.*** Virginia has a world-class digital ecosystem and data centers, a large, digitally-enabled user-base in Northern Virginia (public and private), and an enviable network of educational institutions. However, there is a need to intentionally bring these capabilities together with open-access digital tools that will support more sectors of the economy and expand geographic reach.

2. The adoption of virtual, subscription-based cloud computing and network technology has created extraordinary benefits across society but these resources are managed by a limited number of private sector companies. Technology exists to bring lower cost, highly flexible private clouds, and the associated software and data management platforms, to an even larger user community. Improving the ***cost, accessibility and configurability*** of advanced computing and data storage will improve collaboration, create a better prepared workforce and accelerate technology development and commercialization.

3. The private sector technology community will engage with the Commonwealth to provide low-cost (or even no-cost) computing tools and other resources for academic and applications development purposes provided there is a commitment from the State and academic community to support a comprehensive framework as proposed in this paper. Other mega-regions across the United States have already embarked on similar programs, but even though we may be slower to get started, our digital infrastructure puts us in a unique, advantageous position provided we create a cohesive Virginia-wide framework to rapidly deploy the resources needed to create broad-based collaboration.

4. Existing collaborative programs, such as CCI, CCAM, Cyber Range and the specific efforts associated with the Tech Talent Investment Pipeline (TTIP) have proven, in general, to be effective but the scope (applications development across all economic sectors) and scale (numbers and type of digital skill worker) ***must be expanded*** (think 100x) to meet workforce requirements that are essential to support economic growth. It will be important to create additional, geographically dispersed User Communities to close the ever-widening digital divide as the advanced digital User Communities are concentrated in select urban regions and are generally not accessible to under-represented communities.

5. There appears to be a need to create more extensive private-public engagement to provide a more comprehensive (heterogeneous) educational experience, create innovative talent pathways, and better understand how to navigate the dynamic digital change that is taking place all around us. The high-growth, high-innovation digital ecosystem is based on a massive array of complex engagements and novel partnerships based on trusted relationships; many of *our education institutions need to develop a higher level of strategic engagement within this ecosystem*. Technology, particularly data science and AI, is advancing faster and broader than generally recognized and it is difficult for most educational institutions, businesses, and government agencies to comprehend the impact let alone try to keep up. C4 has the potential to be a window on leading-edge deployment of advanced technology for healthcare, education, advanced manufacturing/logistics, energy/sustainability and government services.

**The Workgroup unanimously endorses a spirit of collaboration and support beyond anything that exists today.** We cannot attract advanced digital tech companies without a workforce equipped with the exposure and knowledge using advanced digital tools.

## DISCOVERY PROCESS, WORKGROUP COMPOSITION, SELECTED UNIVERSITY COMMENTS

For over four years, numerous individuals have observed the development and use of highly advanced computing tools, support resources and collaboration networks that exist in high growth technology-driven regions such as Silicon Valley, Austin Texas, Boston Massachusetts and beyond. The massive investment in data centers in Central Virginia (Facebook, QTS, Bank of America) and formation of the Internet Ecosystem Innovation Committee (IEIC) catalyzed additional efforts and opened the door to an additional network of global technology companies. This initial work group commenced a "discovery process" to better understand the types of advanced computing tools available and compared the potential capabilities against the resources that currently exist for "academic and application development computing" that are fundamental to drive economic growth. (Note: this exercise did not go into deep investigation of "research computing" resources except to note *that most in-state researchers who need to access sophisticated computing acquire access from out-of-state organizations and Federal labs*).

Importantly, a growing list of industry contacts provided detailed information related to commercially available technologies that have been implemented, or are planning to be implemented, at collaborative institutions with workforce and economic development objectives similar to those proposed for the Commonwealth Center for Cloud Computing. Most of these large-scale collaborative organizations bring together new technologies that blend hybrid capabilities, operate within multi-tenant, distributed networks and provide a virtual focal point to bring private sector technology developers and users together with university researchers and students via projects and programs. It was also clear they impacted virtually all economic sectors from finance, healthcare, advanced manufacturing, etc. and the collaborative networks fuel entrepreneurial ecosystems that create new companies with extraordinary value (the "Unicorns").

Upon learning the Commonwealth endorsed creation of C4, a process commenced to add additional members to the informal Work Group, solicit additional perspective and advance

the discovery process. Initially, members were primarily engaged with Virginia's academic community, and many of them also have roles at both their respective institution and in collaborations such as CCAM, CCALS, CCI and organizations such as the MAREA Alliance, CymanII and IEIC. The Work Group was further strengthened with input from technology system consultants who immediately understood the need to create something larger across Virginia. Over the past two months, organizations such as the Northern Virginia Technology Council and RVA757connect have created more awareness and interest in C4.

Workgroup participants helped to create a set of "attributes" that helped to guide discussions; including:
- Must create a framework to gain access to "domain-specific", private sector technology experts; must have industry-led projects,
- Critical to incentivize (even force) large scale collaboration
- Must have capability to assemble systems that are not available or immediately known
- Must build-in dynamic flexibility, expandable connectivity and plan for rapid evolution
- Developers and entrepreneurs need to be able to upgrade scale and complexity of computing without delay and keep processing and storage costs as low as possible
- Permit existing assets to be better utilized – optimize resources

While the concept of C4 is new to Virginia, there are several examples of similar programs that have been instrumental in driving economic growth and creating high-value spin-offs. Most notable are the platforms at universities in Texas, Maryland, Tennessee, Florida and Illinois. In particular, Texas has been able to attract large digitally-dependent companies due to the wide-scale availability of talent that have experience with advanced computing tools, and Maryland just announced the Nation's first center for quantum computing. North Carolina and South Carolina are in the process of creating platforms with similar objectives to C4.

A number of the work group participants have created similar collaborative organizations in other regions or within complex organizations. The following is a quote from a program that originated at one site in Illinois, was expanded to multiple University of Illinois sites, and is now expanding on a mega-region, multi-state basis (Illinois and Texas).

> "The mission of the [Institute] is to bring together excellence in multiple domains – on campus as well as at other academic institutions, government research labs, companies and non-profits – and apply data science tools, techniques and technologies to problem solving, enabling greater insights and knowledge. [Institute] amplifies the impact of its core mission with its educational mission, applied to all workforce dimensions – education, training, advancement, and mentoring – for undergraduate and graduate students, collaborators and the general public. The [Institute] has always looked 10-15 years into the future, and is driven by the needs of its collaborators; success is achieved in developing, disseminating and commercializing new hardware and software and in building national and international user communities. Industry collaboration enables them be more competitive in the global marketplace. The [Institute] community, faculty and staff identify new technologies and then inquire how to use them in ways that companies had not intended."

This paper will not go into technical detail, but we continually try to translate highly complex lexicon into easy to understand concepts. It is useful to describe some of the current, advanced technology in the historic context of a "Stack" that was defined historically as a

relatively inflexible (non-configurable) system composed of hardware and software that would perform computing tasks on a batch workload process.  Current technology permits highly configurable, virtual stacks with incredible access to data and data storage, all seamlessly interconnected to high capacity, low (and ultra-low) latency global networks.  Our Plan proposes to deploy new C4 resources to upgrade existing capabilities and to create new platforms that provide easy access, low cost highly advanced hybrid computing.

The Workgroup anticipates that C4 will be engaged with CCI and the VA Cyber Range, sharing resources to create more impactful private sector relationships.   As one example, the VA Cyber Range is based on technology provided by one public cloud provider and it has become clear this single-technology platform is not sufficient in the current environment.  A much larger, diverse network of technologies needs to be deployed and used as test-beds and for applications development.  It is important to recognize the proposed C4 technology platforms can be used for cyber, data analytics, network technology development and many more applications.   In addition, the Sandbox will support very large-scale data architecture platforms that are essential to unlock new value across academia and the private sector.

The Work group has identified technologies that bring new functionality (AI/ML, data architecture) for academic programs, applications development, healthcare and education and simultaneously provide the powerful network to better utilize existing resources.  It is increasingly important to take advantage of the internet ecosystem that exists in Virginia by expanding linkages with the private sector as well as with governmental agencies.

The Work Group wants to stress an important principle:  we cannot wait to define every aspect of the C4 technology platform.  Rather, the expenditures will be used to create highly flexible (configurable) platforms that can be used in numerous applications and we will strive to create a dynamic capability that will grow and evolve.  It is critical to note that computing technologies have a life-span measured from 2 to 5 years – there is continuous innovation and improvement.  ***It is essential for Virginia's academic institutions to have active, strategic relationships with the private sector technology developers and users; we must move beyond purchasing computing time and equipment.***

## CAPITAL DEPLOYMENT AND OPERATING EXPENSE PROJECTIONS

VCU Engineering and VCU Technology Services, together with industry collaborators, developed an initial estimate of the anticipated hardware, software and related infrastructure costs to deploy the initial $6.8 million allocation.   These estimates are derived from indicative discussions with strategic vendors and the scope is based on network upgrades, an IBM mainframe installed at the QTS data center in Sandston, VA, and deployment of highly configurable compute management tools at 6 user sites, including VSU (CCAM/CCALS), GMU (CCI Node), VCU (CCI Node), VT Blacksburg (Cyber Range/CCI Node), ODU (CCI Node) and UVA.   Note that these initial "distributed" locations bring additional computing resources to both the university and a named organization such as a CCI node.  After review of multiple technology options, the work team believes that the latest hybrid-cloud technology commercially available from IBM and IBM partners provide cost-effective, long-term core capabilities and the distributed tools will also support "on-premise stacks" that have potential to link to other assets at the distributed locations.  ***There remains significant work to fully define this "deployment template" and cost structure.  It is presented as a logical framework to***

***rapidly bring additional networked computing resources to the Commonwealth, and these systems are currently deployed in other, similar consortia environments.***

The Commonwealth of Virginia and selected universities have existing relationships with IBM, IBM partners and the proposed distributed tool vendors.  The work team believes it will be possible to negotiate for highly valued capabilities, such as Watson artificial intelligence, network upgrades and extended maintenance contracts, once there is evidence of C4 moving forward. Network expenses have been estimated using recent experience with a VA Supreme Court project whereby an IBM production mainframe is hosted at QTS with high capacity user capabilities located in Richmond.  The budget estimate includes funding for highly regarded systems architects who assisted in the Supreme Court project and also installed distributed, networked, academic/applications development systems in other states.

As reference, this mainframe (Z-15, T-2) and distributed network equipment (known as Power9 or Power 10 HPC's) have the ability to support multiple user networks and thousands of concurrent Linux virtual servers (the Linux Foundation has pledged operating support and expertise). This capacity alone can satisfy most development, data science and academic computing needs associated with large scale, real time workloads.   In addition, there are new technologies provided by companies such as Liqid that permit highly configurable (flexible) workloads and can connect with an extensive range of computing technology (including IBM) as well as devices that range from genome sequencers to Siemens process controllers:

| HARDWARE | PROJECTED COST |
|---|---|
| Storage and Backup (3/5 petabytes) | |
| IBM ESS Storage | $1.6 million |
| Compute Power | |
| IBM Z Mainframe + Power9 / 10 modules | $1.5 million |
| Networking Equipment | |
| 100 GbE Switch x 6 | $1.0 million |
| User Location Allowance (Liqid) | |
| 6 sites @ $300k each | $1.8 million |
| **TOTAL ex project management costs** | **$5.9 million** |
| **Project Management Costs** | **$0.6 million** |

The Commonwealth Center for Cloud Computing will require dedicated administrative and technical support staff and a network of "shared" staff that focus on project management combined with competency and expertise in working with big datasets/AI, finance technologies, bioinformatics & genomics. Where possible C4 should leverage capabilities that exist within CCI, such as AI assurance infrastructure  and selected system expertise.

Modeled after similar collaborative computing centers at other top tier research universities, C4 would be expected to recruit and hire approximately 10 dedicated staff to support the academic and economic development mission.  The following chart presents a conceptual list of positions to create and grow a dynamic computing resource that interconnects across dozens of sites and engages with hundreds of users.

| Position | Area of Focus |
|---|---|
| 1. Director, Commonwealth Center for Cloud Computing | Administration, Business Development, Consulting, Cloud Architect |
| 2. Systems Administrator | Systems administration, operations management, applications support, hardware acquisition and licensing |
| 3. Systems Specialist with Domain Expertise | Project Support & Systems Configuration |
| 4. Systems Specialist – Jr. | Networks & Systems Configuration |
| 5. Systems Specialist - Jr | Data Storage and Systems Configuration |
| 6. Domain Consultant | Financial Services, Insurance, Real Estate |
| 7. Domain Consultant | Advanced Manufacturing |
| 8. Domain Consultant | Life Sciences & Genomics |
| 9. Education Program Director | STEM education specialist |
| 10. Administrative Assistant | cloud computing architect, applications development and custom programming |
| 11. Private Sector – Professor of the Practice | |

Preliminary estimated staffing costs, year 1

| STAFFING Conceptual | PROJECTED COST (salary+fringe) |
|---|---|
| 1. Director, C4- | $ 300,000 |
| 2. Systems Administrator | $ 200,000 |
| 3. Systems Specialist - Sr | $ 175,000 |
| 4. Systems Specialist- Jr | $ 150,000 |
| 5. Systems Specialist - Jr | $ 150,000 |
| 6. Administrative Assistant | $ 100,000 |
| 7. Domain Consultant X 3 | $ 400,000 |
| 8. Education Program Coordinator | $ 150,000 |
| 9 Program Support – Experiential Learning | $ 150,000 |
| 10. Stipend: Professors of Practice x 3 | $ 300,000 |
| **TOTAL** | **$2, 075,000** |

In addition to the personnel costs and based on CCAM experience, the projected administrative costs will be $500,000/year and other support costs (events, travel, etc) are projected to be $400,000/year.

These costs will ramp-up over a three-year time horizon:

Year 1      $2.0 million
Year 2      $2.5 million      Three Year Total $7.5 million
Year 3      $3.0 million

## PROPOSED C4 CHARTER, USER GROUPS AND BUILDING SUSTAINED CAPABILITIES

This document calls for a formal Organizing Committee to define the Center's mission, organization and initial programming activity.   Subject to additional discussion and approval, it is anticipated that the initial governance for C4 will fall under the direct responsibility of VIPA as there will be extensive interface with CCI, CCAM, CCALS and other public-private activity in the Commonwealth.  There also needs to be an early discussion on the breadth of the C4 mission; in particular the academic institutions (universities, colleges and community colleges) who should be founding members.

As a start, we propose the Organizing Committee create an outline for an initial Charter and develop the criteria to recruit and select a Founding Executive Director, approve/endorse overall strategy, develop initial policies and formally identify an initial cohort of private sector partners. The Organizing Committee will need to address operating costs, controls and compliance while creating open access, define intellectual property development, purchasing and licensing of technology, etc.

To provide more context, a preliminary set of guiding principle is presented below. We hope C4 creates an academic-private sector-government ecosystem of technology developers, users, providers of digital infrastructure and educators connected by numerous program initiatives, impactful projects and outreach. As mentioned previously, there are several models that exist in other states, and members of the Work Group have experience

The Charter will need to recognize that the universities have well established organizations such as their respective Chief Information Offices, existing external relationships, and resources centered around research-oriented high-performance computing (HPC) for use in individual research laboratories. C4 is not intended to replace these activities but rather will seek to bring new capabilities that complement existing organizations and computing resources. C4 should also engage with entities such as the global Internet Ecosystem Innovation Committee (IEIC), the Greater Washington Partnership and the Federal programs such as cloud computing initiates managed by NIST and the CymanII programs that engage a range of National Laboratories.

The Charter should be designed to:

- **Build trusted, valued partnerships between academia, business and government:** This element underpins the entire C4 concept. It will be important to create an innovative, dynamic capability that blends access to talent, expertise (academic and private) and project management with strong incentives to collaborate and engage in virtual partnerships.

- **Align academic computing programs and talent production with economic development objectives**: It is well established that a major (perhaps *the* major) limiting factor to economic growth is the availability of skilled talent (re-skilling and new graduates) with the direct knowledge of advanced systems, devops, data science and real-world applications experience. C4 is an opportunity to creating special learning environments and innovative talent development pathways. The recent VEDP-led efforts to create additional data science talent is an impressive start whereby the participating institutions (R-1 and community college) have close alignment on how to improve and expand production of skills associated with data science / AI.

  This is an immense opportunity that should be captured for Virginia; we must expose increasing numbers of students and researchers to development activity associated with AI / ML, sophisticated data analytics, advanced cyber security, visualization and virtualization, advanced fintech, personalized medicine, advanced manufacturing and logistics, as well as applications associated with the interconnected economy known as the "Internet of Things". *We need to support equity and diversity opportunities.*

- **Seek to become a strategic partner in the development of new digital technologies (not just applications development):** The internet ecosystem, with a major presence in Virginia, has built real-time, large scale data analytics capability that is being used to

digitize all aspects of society.  We hope C4 is an opportunity to create a more robust digital strategy for the State, bringing more, diversified technologies and resources to a broader geographic footprint.  and provide Data can now be acquired from any source platform, and processed with ML /AI techniques and tools to provide benefits that are only beginning to be realized.  This is an immense opportunity that should be captured for Virginia but we are lagging behind states such as Texas, Illinois and Maryland; but we can rapidly catch-up with a vision **to position the Commonwealth at the convergence of digital technology infrastructure, development and applications.**

- **Cyber/Systems Cyber:**  The concept of cyber security continues to evolve and has become much more complex.   While individual systems will continue to be hacked, the major issue has become the linkages with each layer of technology provided by unrelated vendors, from software to hardware (and components) and the expanding network of interdependencies (computing, storage, networks, dev-ops, etc).  C4 should be established with strong linkages to CCI (especially with the Nodes) to bring more resources to the user community (particularly high-impact infrastructure, local governments and other under-resourced entities).   There is a major opportunity to understand and better characterize the linkages/interfaces across these massive systems and help to create improved security and validation of information.

- **Engagement and Relationships:** leading edge research and applications development is increasingly undertaken in large, well- funded consortia that have the ability to attract leading expertise and can undertake high-impact, large scale projects. C4 has the opportunity to create a new set of engagements and partnerships as a public-private entity. Private industry has joined with us to provide a home for a hybrid-cloud mainframe computer at QTS, which is the heart of the fiber optic network in Henrico County.  VCU will provide management through its team of IT specialists, in partnership with representatives from all participating universities in CCALS and CCAM.  A critical aspect of the initial activity will be engagement with private sector companies such as AWS, Microsoft, Siemens, Bank of America, Dominion, Anthem, CoStar and others. These companies appear open to providing expertise (program directors, professors of the practice, etc.) and operational funding to launch C4.  It is expected these industry partners will nominate members to a Technical Advisory Board and the Leadership Council.

- **Create major new linkages:** the C4 Charter must be designed to invite engagement and projects from the private sector, non-profits and government agencies.  As resources permit, there should be relevant cross-functional domain expertise coupled with the advanced technology skills and resources enabled by C4.  The workgroup particularly identified user communities involved in life sciences/healthcare, financial technology ("Fintech"), advanced manufacturing and logistics, government services as well as venture and entrepreneurial activities across the Commonwealth.

There is much work ahead to create the large-scale, sustainable center of excellence as described in this paper.  There is a wonderful spirit of collaboration and desire to get started, and we look forward to working with the Commonwealth to bring this initiative to life.

Respectfully submitted on behalf of the C4 work group, respectfully Submitted,

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