A. INTRODUCTION & EXECUTIVE SUMMARY

Vision: Cyberinfrastructure as the key to research acceleration

The University of Nevada, Reno (UNR), the land-grant institution in the State of Nevada, attracts over $100M annually in sponsored research projects and is rapidly transforming into a Carnegie Highest Activity Research University where significant student participation in research drives next-generation workforce development. Essential to this process is coordinated implementation of a cutting-edge cyberinfrastructure that enables institutional success and accelerates the research process.

> *"Cyberinfrastructure" is defined as a fabric of highly connected systems for information and data acquisition, visualization, computing, storage, and associated human expertise serving end-to-end scientific and engineering workflows to improve scholarly productivity and enable breakthroughs not otherwise possible.*

Advances in technology have shifted the global research paradigm from reliance on individual experience to the need to generate and access large datasets, perform advanced analytics, and produce unique outputs across interdisciplinary teams within and outside institutions. Success in research going forward depends entirely on the efficiencies of data movement, processing, and management – which all require coordinated cyberinfrastructure and institutional investment.

Faculty, staff, and students at UNR perform internationally recognized research in diverse fields such as earthquake engineering, wildfire response, biotechnology, renewable energy, and water resources. In order for these and other research efforts at the University to maintain the highest standards of scholarship, increase in scale and efficiency, and lead in scientific discovery, the expertise, tools, and capacity of a robust and well-designed cyberinfrastructure (CI) remain essential.

Cyberinfrastructure governance and development at UNR

UNR has invested in the building blocks for an effective culture of collaborative CI development across the Offices of Information Technologies (OIT), Research & Innovation (R&I), and the academic community at large. The University established a campus Cyberinfrastructure Committee (CiC) that is led by faculty, reporting jointly to the Chief Information Officer (CIO) and the Vice-President for Research and Innovation (VPRI). OIT received central institutional funding to hire a Director of Cyberinfrastructure starting in 2018. One of the specific roles of this doctoral-level leadership position is to strengthen the institution's comprehensive CI strategy, performing this administrative role while maintaining personal research activity as a stakeholder in the process. The CiC and CI Director work together to ensure that CI resources at UNR meet clear institutional needs, develop in alignment with state and national research priorities, and are grown into a sustainable CI Program with a broad range of accessibility.

This planning document is an evolving strategy tool for UNR OIT, R&I, CiC, and the institution at large that serves to communicate vision, align objectives, guide effort, apply resources, and demonstrate direction. While the primary responsibility to draft and develop the institutional CI Plan falls to the CI Director, the faculty-led CiC provides additional input, discussion, and ultimately approval and consensus after soliciting feedback from the campus at large.

Implementation of CI at UNR is led from within OIT, as the institutional technology architectures of networking, datacenters, and computing are highly centralized. However, the University CI Program is envisioned as a shared responsibility and contiguous group of human and machine resources from the college division level up to central administration, as faculty-facing support roles need to be closely aligned with research domain applications. OIT is pursuing internal technology transformation, which is shifting organizational capability to lead cutting-edge solutions as part of key institutional investments towards a coordinated and shared CI Program.

CI Plan Contents
Sections A-B: Introduction, Vision, & Strategic Objectives
Sections C-D: Current Infrastructure Overview & Projects (*subject to semi-annual status updates*)
Appendices A-B: Detailed CI Program Goals & Elements
Appendix C: CI Committee By-Laws
Appendix D: Program Development Planning Graphics

B. CYBERINFRASTRUCTURE STRATEGIC OBJECTIVES

UNR has identified a number of long-term strategic CI objectives that are essential to achieving greater research capability, regional technology leadership, and institutional risk reduction for research data and processes. Existing, fragmented CI at the institution today can only provide a fraction of needed capability, and so these objectives serve as a basis for a comprehensive UNR CI Program that will serve the entire UNR research community and positively impact the vision of accelerated research and discovery.

Connectivity: Diverse research network connections with highest-possible speed and capacity between on/off campus research endpoints and datacenters, other Nevada System of Higher Education (NSHE) institutions, regional research and engineering partners, and national research fabrics.

Consolidated data centers: Modern colocation facilities for both centrally-managed and researcher-maintained hardware systems that provide reliable power supply, adequate cooling capacity, and secure physical space for a range of server technology needs and support levels.

Computing: Capability and expertise across a range of computing services vital to most research workflows, including: high-performance compute (HPC), interactive/visualization computing, persistent service nodes, throughput computing, and lab-in-a-box servers. Cloud-native presentation and scalability.

Research data storage: Reliable, scalable storage accessible to all researchers, including lab home, HPC scratch, lab workspace, and backup/archival capacity. Cloud-native storage presentation and protection from both disaster and unauthorized access.

Cybersecurity: Facilitation and implementation of methods and practices that ensure compliance and privacy for a range of sensitive research workflows, that do not adversely affect the ability to collaborate, acquire/share data and information, or otherwise hamper other institutional CI systems performance.

Training, education, and transformation: Empowering college division IT professionals, faculty researchers, and students to make best use of available CI resources on and off campus, while preparing the institution for disruptive and emerging technologies and practices. Creating a community of practice where CI users can provide mutual support.

Scalable management: Integration and development of semi/automated systems and management tools designed to scale and smooth research workflows, including: resource provisioning, big data exchange, metadata generation, data visualization, and data/products dissemination.

National platform alignment: Presence and activity on emerging regional and national research CI platforms that link distributed resources across political/geographical boundaries in order to enable discovery, innovation, and expression through collaboration, data exchange, and wider resource pools.

FAIR Data: Development of capabilities and an institutional community of practice that pursues Findable, Accessible, Interoperable, and Reusable (FAIR) data principles in regards to data and metadata capture, organization, documentation, and curation.

Access: Provide a range of common services and technology at "no charge" to all institution researchers, with higher levels of fee-based service and resources available on-demand to funded projects.

Sustainability: Build and sustain a comprehensive CI Program with a robust and dedicated budget responsive to institutional trends and insulated from market perturbation – using a diversity of central monies, research funding, fee-for-use, CI-focused grants, and external donations and endowments.

C. CURRENT INFRASTRUCTURE OVERVIEW

Networking

The campus network core is a diverse series of five routers (Brocade VDX) fully meshed in a VCS fabric with 40GbE links, allowing for data to move through the core at 160 Gbps. These are dispersed around campus to fiber aggregation nodes with UPS and generator back-up. The campus is segregated into 17 regions each having two 10GbE links using single mode fiber to the diverse core allowing for redundancy. Each building has connectivity via fiber with a mix of 1GbE and 10GbE links. Wireless connectivity is integrated as a core part of the total campus network, with wireless access in all research and instructional spaces. Network status and performance is monitored by **SolarWinds**, **Intermapper**, and **perfSONAR**.

UNR is connected to **Internet2** via the Nevada System of Higher Education System Computing Services (NSHE-SCS), which maintains a 100GbE connection to the Internet2 backbone national network. The campus connected in 2016 to the SCS WAN via redundant 20 Gbps connections. IPv6 routing is available from the SCS WAN, but is not employed on campus as of 2018.

There are other university-related networks managed by research units, such as the region-leading wide-area **Research and Hazards Monitoring Network**, which is a mix of landline, microwave backhaul, and local wireless networks that spans the state of Nevada and beyond. It provides transport for sensor data and remote connectivity managed by the Nevada Seismological Laboratory (NSL) and partners at the UNR campus.

Central research computing

UNR OIT manages multiple **datacenter facilities**, with consolidation of research computing resources into two colocation spaces: the on-campus Research Computing Data Center with 15 kW/rack, and off-premise colocation with Nevada industry partner Switch. The Switch Tahoe-Reno Data Center is a world class, Tier-5 Platinum data center with 75 kW/rack capability and is connected (2018) via a 10GbE uplink to campus.

Growing computation and storage demands from researchers has resulted in investment (2017) in a local **batch HPC system** ("Pronghorn") and attached storage. This system, located in the Switch Tahoe-Reno datacenter, is available to all UNR and other NSHE-affiliated researchers both as a fee-for-service and shared-ownership (condominium) model. Limited-scale, free use of the system by researchers and students is planned, but not implemented as of 2018. Pronghorn is comprised of 75 nodes with 32 processors and 256GB memory (11 of those nodes contain Nvidia Tesla P100 NVLink GPUs) and runs across an internal 100 Gb/s Intel Omni-Path network. Pronghorn's 1.1 PB storage cluster has a parallel file system and is primarily used for data staging adjacent to the cluster.

UNR OIT provides as-needed **data storage** access to an existing scale-out NAS solution with over 160 TB of tiered file storage on a redundant platform that supports de-duplication. Redundant SAN's with a dedicated fiber channel storage network provide 78 TB of block storage and is co-located in campus data centers with backup generators, UPS, and environmental monitoring. These storage systems are backed up to a disk de-duplication appliance that is encrypted and replicated to an off-site facility.

For **cloud-hosted data** storage, the UNR NevadaBox service offers file storage and sharing hosted by a third-party cloud provider. This provides unlimited cloud storage to students and faculty with a secure sign-in, ability to store sensitive data, and the ability to share and collaborate with outside entities.

Virtual lab servers and workstations have been in a pilot stage since 2015, when UNR OIT offered a dedicated environment ("Wolfcloud") to provide robust, on-demand virtual server multiple O/S environments to faculty and sponsored students.

Research data management

Research data management currently is not centralized at UNR. The R&I office established a digital repository (ScholarWorks) in 2015 to enhance the research support available to the university's faculty. ScholarWorks assists in collecting, preserving, and distributing the university's intellectual output, with a focus on theses, papers, and other final products. In addition, users are allotted 5 GB of free space for data archival for 5 years to assist in project compliance. Consultation is available for development of data

management plans, metadata issues, long term data storage, and uploading research data into the ScholarWorks repository.

Cyber security

UNR's strategic approach to cyber security is a policy-driven data classification methodology, combined with strong technical safeguards and proactive user engagement. This allows deployment of clear and concise data policies, along with an agile data governance environment, to provide a secure and adaptable framework for increasing the ability to do research on both regulated and non-regulated data.

A robust border network control and monitoring system is in place (since 2016) using a combination of layer 7 application firewalls and network inspection using fiber taps and an SDN switch to distribute flows to a CERT NetSA SiLK capture system. Big data analytic environments built to grow to 40Gbps were installed in 2016 to handle both the campus administrative network and anticipated demands of **a future Science DMZ**. UNR subscribes to the **InCommon** certificate service to increase utilization of encryption for all online services. UNR maintains an inclusive Identity Management System that allows auto-provisioning for students, faculty and staff and accommodating guests, affiliates, and visiting scholars. Shibboleth is the primary authentication gateway for all federated services. A campus wide Active Directory (AD) environment provides a multi-platform authentication and authorization system to all constituents. **Eduroam** authentication was enabled on the campus in 2016.

Human infrastructure

Both central and distributed IT staff have been incrementally increased to support the growing UNR research community. Security staffing doubled in 2015-2018 from 2.5 FTE to 5.0 FTE. Central IT HPC engineering personnel grew to 3.0 FTE in the same time period. The College of Engineering division hired dedicated IT support personnel that collaborate closely with the central IT staff.

A Director of Cyberinfrastructure position in central IT was hired in 2018. This doctoral-level position is funded internally with support from the central administration, and maintains a research-focused relationship with an academic department. The position reports directly to the CIO, and is tasked with defining and pursuing the institutional vision for CI, building significant external engagement, and assisting with high-priority research projects.

The standalone CiC was formed from an HPC subcommittee of the University Technology Committee in fall 2016, reporting jointly to the VPRI and the CIO. A member of this committee also retains a seat on the University Technology Council to provide coordination and communication. In addition to oversight of UNR HPC resources, the CiC provides faculty-led coproduction of the CI vision along with the CI Director, identifying and prioritizing development and training needs and opportunities across the campus (see Appendix C: CiC Bylaws).

Training and support in the use of CI resources on and off campus remains limited for both faculty and students, and this is linked directly to the need for additional human infrastructure with technical expertise, research experience, and institutional knowledge.

Resulting challenges

The current (2018) infrastructure described above, while incrementally helpful, does not adequately address the needs of a rapidly expanding faculty population or alleviate their increasing administrative workloads in the pursuit of leadership in research and teaching. Each of these infrastructure areas requires substantial improvements in support, scale, and accessibility.

UNR's CI Program aspirations face the primary challenges of: 1) historical under-investment in technology statewide; 2) lack of systematic engagement with the national CI community of practice; 3) the explosion of the Internet of Things and digital data sources; 4) recent emergence of national practices and standards for end-to-end data management; and 5) a tight employment market for technology and data professionals in the west coast region. UNR's CI vision includes transforming key organizational strategies and practices to address and overcome these challenges as a Carnegie Highest Activity Research University and flagship higher-education institution in Nevada. A working timeline of necessary investment to coordinate a critical mass of CI resources and launch the CI Program is in Appendix D: Draft Timeline.

D. CURRENT CI PROJECTS & EFFORT (2018-19)

CI Program Development

Development of an institutional CI Program is underway, including updating this document, internal and external engagement, proposal writing, and general pursuit of goals detailed in Appendix A: Detailed Program Goals (2019-2022). During 2018, the new CI director and CiC focused on taking the temperature of the institution and evaluating comprehensive needs relative to current research and institutional trajectory.

Deliverables include development of a CI Program scope (summarized in this document and appendices), submission of proposals to CI-oriented funding programs, internal engagement on CI issues with research division and institutional leadership, representation of UNR as a member of regional and national research CI organizations, and external engagement with local industry and civic partners in CI-related projects.

2018 milestones:

- Establish CiC membership, procedures, and role in campus CI activities – CiC bylaws and policies
- Develop UNR CI Program scope – see full Campus CI Plan and appendices
- Internal engagement with research division and institutional leadership – coordinated planning
- Establish active UNR membership in regional/national CI organizations
- Engage priority projects with CI industry and civic partners
- Extramural infrastructure awards – NSF-CC* Campus Data-Driven Networking grant

2019 milestones:

- Establish CI Program budget, delineate human resources and 5-year funding/development plan
- Establish CI workforce development student track with UNR Graduate School
- Engage internal research community with campus CI workshop and outreach events
- Submit building-block project proposals to CI-focused funding programs
- Participation in collaborative CI platforms, e.g., National Research Platform pilot
- Continue support of priority research projects with CI industry & civic partners

Science DMZ

Creation of fast, dedicated DMZ circuits and security solutions for friction-free research network flows, including large data transfer, specialized instrument connectivity, and research sensor networks. Addition of PerfSonar continuous monitoring and connection into Internet2 and ESNet DMZ networks, Globus data transfer software, and dedicated high performance DTN equipment. Funded by NSF-OAC CC* (#1827186) in 2018 for $495k, project duration 2018-2020.

Colocation services

Establishment of facilities, procedures, and policy for organized colocation of researcher computing equipment in OIT-managed facilities. Colocation access, appropriate use, and eligible equipment decisions are set by OIT data center managers. However, the UNR CiC and divisional IT representatives are the first points of contact for proposals and mediation. Research Colocation Plan document to be approved 2018.

CI Computing services

Operation and expansion of the HPC cluster Pronghorn, using a combination of donation, researcher investment, and central OIT funds. Create 5-year sustainability and lifecycle plan for Pronghorn, including budgetary sources and requirements for human infrastructure for operation and facilitation. Plan draft by early 2019.

Expansion of additional services from OIT Research Computing, including virtual server, remote desktop, and general purpose data storage environments. Pilot provisioning with surplus HPC hardware and incremental researcher investments. Develop requirements for colocation, user access, management, and sustainability of these services, including required human infrastructure to administrate and facilitate use at scale. Pilots operational in 2019, draft plan late 2019. Target funding sources to expand these services to a wider range of campus users.