

Department of Energy Laboratory Plan – TJNAF

July 3, 2018

I. Mission/Overview

The Thomas Jefferson National Accelerator Facility (TJNAF), located in Newport News, Virginia, is a laboratory operated by Jefferson Science Associates, LLC for the Department of Energy’s (DOE) Office of Science (SC). The primary mission of the laboratory is to explore the fundamental nature of confined states of quarks and gluons, including the nucleons that comprise the mass of the visible universe. TJNAF also is a world-leader in the development of the superconducting radio-frequency (SRF) technology utilized for the Continuous Electron Beam Accelerator Facility (CEBAF). This technology is the basis for an increasing array of applications at TJNAF, other DOE labs, and in the international scientific community. The expertise developed in building and operating CEBAF and its experimental equipment has facilitated an upgrade that doubled the maximum beam energy (to 12 GeV (billion electron volts)) and provided a unique facility for nuclear physics research that will ensure continued world leadership in this field for several decades. TJNAF’s current core capabilities are: Nuclear Physics; Accelerator Science and Technology; and Large Scale User Facilities/Advanced Instrumentation.

The Lab supports an international scientific user community of 1,597 researchers whose work has resulted in scientific data from 183 full and 25 partial experiments (including 5 full and 15 partial in the 12 GeV era), 426 Physics Letters and Physical Review Letters publications and 1,461 publications in other refereed journals to-date at the end of FY 2017. Collectively, there have been more than 147,000 citations for work done at TJNAF.

Research at TJNAF and CEBAF also contributes to thesis research material for about one-third of all U.S. Ph.D.s awarded annually in Nuclear Physics (46 in FY 2017; 608 to-date; and 211 more in progress). The Lab's outstanding science education programs for K-12 students, undergraduates and teachers build critical knowledge and skills in the physical sciences that are needed to solve many of the nation's future challenges.

II. Lab-at-a-Glance

Location: Newport News, Virginia

Type: Program-Dedicated, Single-purpose lab

Contract Operator: Jefferson Science Associates, LLC (JSA)

Responsible Site Office: Thomas Jefferson Site Office

Website: <http://www.jlab.org>

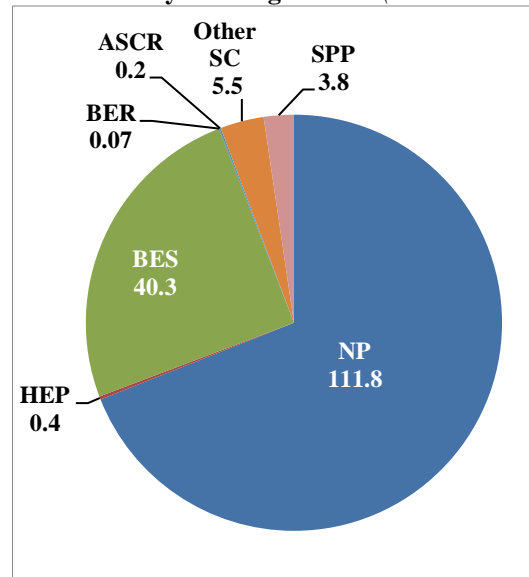
Physical Assets:

- 169 acres and 69 buildings
- 883,000 GSF in buildings
- Replacement Plant Value (RPV): \$416M
- 0 GSF in Excess Facilities
- 83,542 GSF in Leased Facilities

Human Capital (period ending 9/30/17):

- 678 FTEs
- 27 Joint faculty
- 34 Postdoctoral Researchers
- 8 Undergraduate and 45 Graduate students
- 1,597 Facility Users
- 1,438 Visiting Scientists

FY17 Costs by Funding Source: (Cost Data in \$M)



Lab Operating Costs: \$162.1

DOE Costs: \$158.3

SPP (Non-DOE/Non-DHS): \$3.8

SPP as % Total Lab Operating Costs: 2.3%

Total DHS costs: \$0.0

III. Core Capabilities

1. Nuclear Physics (funded by DOE Office of Science (SC) – Nuclear Physics (NP))

TJNAF is a unique world-leading user facility for studies of the structure of nuclear and hadronic matter using continuous beams of high-energy, polarized electrons. The completion of the 12 GeV Upgrade project enables many outstanding new scientific opportunities. The 2015 NSAC (Nuclear Science Advisory Committee) Long Range Plan clearly stated that its highest priority was to capitalize on this investment: “With the imminent completion of the CEBAF 12 GeV upgrade, its forefront program of using electrons to unfold the quark and gluon structure of hadrons and nuclei and to probe the Standard Model must be realized.”

The Continuous Electron Beam Accelerator Facility (CEBAF) electron beam can be simultaneously delivered to the experimental halls at different energies. With the completion of the 12 GeV Upgrade the beam energy can be up to 12 GeV, converted to 9 GeV photons for experimental Hall D, and up to 11 GeV to Halls A, B and C. Each experimental hall is instrumented with specialized experimental equipment designed to exploit the CEBAF beam. The detector and data acquisition capabilities at TJNAF, when coupled with the high-energy electron beams, provide the highest luminosity ($10^{39}/\text{eN}/\text{cm}^2/\text{s}$) capability in the world. The TJNAF staff designs, constructs, and operates the complete set of equipment to enable this world-class experimental nuclear physics program. With more than 1,500 users annually, of which roughly 2/3 are domestic, TJNAF supports one of the largest, if not the largest, nuclear physics user communities in the world.

The CEBAF science program spans a broad range of topics in modern nuclear physics. Recent lattice QCD (Quantum Chromodynamics) calculations predict the existence of new exotic hybrid mesons that can be discovered with the new 12 GeV experiments and elucidate the nature of confinement. New phenomenological tools have been developed that produce multidimensional images of hadrons with great promise to reveal the dynamics of the key underlying degrees of freedom. A surprising connection between the role of nucleon-nucleon interactions and the quark structure of many nucleon systems discovered at TJNAF earlier, needs to be understood. Development of measurements of exceptionally small parity-violating asymmetries with high precision has enabled major advances in hadronic structure, the structure of heavy nuclei (through measurement of the neutron distribution radius), and precision tests of the standard model of particle physics, including a measurement of the electron’s weak charge.

A comprehensive theoretical effort provides leadership across nuclear physics by pulling together state-of-the-art theoretical, phenomenological and computational approaches, including effective field theory techniques, QCD global analyses, and non-perturbative Lattice QCD calculations. TJNAF deploys cost-optimized High Performance Computing for Lattice QCD calculations as a national facility for the U.S. lattice gauge theory community that complements DOE’s investment in leadership-class computing. Computational techniques in Lattice QCD now promise to provide insightful and quantitative predictions that can be meaningfully confronted with and elucidated by forthcoming experimental data.

Excellent synergy exists between the TJNAF experimental and theoretical programs. The *Joint Physics Analysis Center* (JPAC) develops theoretical and phenomenological understanding of production and decays of hadron resonances, which helps bridge the analyses and interpretation of experimental data from TJNAF with the results of Lattice QCD calculations. TJNAF scientists are heavily engaged in the community effort and its phenomenological studies to help develop the strong science case and unique detection capabilities for a future Electron-Ion Collider (EIC).

TJNAF has consolidated our efforts in the development of the science program by forming an Electron Ion Collider Center (EIC²). Seminars, visiting fellows, and workshops will be among the components of this new Center.

2. Accelerator Science and Technology (funded by DOE SC – Nuclear Physics, High Energy Physics)

TJNAF has world-leading capabilities in technologies required for superconducting linacs; notably:

- i) Complete concept to delivery of superconducting linear accelerators and associated technologies
- ii) State-of-the-art SRF fabrication and assembly capabilities
- iii) Unrivaled design, commissioning and operations experience in large cryogenic plants
- iv) World-leading polarized electron injector capabilities
- v) Low-level RF and controls
- vi) Accelerator and large-scale control systems.

These world-leading capabilities are evidenced by the production of more than 100 cryomodules produced and in continuous operation today. The ability to deliver large projects on time and on budget is evidenced by our involvement in major superconducting projects for SRF and cryogenics, including SNS, LCLS-II, for which TJNAF is responsible for construction of half (2 GeV) of the superconducting accelerator, as well as the two cryogenic refrigerators, and the FRIB helium refrigerator.

In addition, TJNAF has pioneered Energy Recovery Linac (ERL) concepts and technologies, holds the record for recirculated beam power (1.4 MW), and has been a world leader in high-power free electron lasers based on ERL technology.

TJNAF, through its Center for Advanced Studies of Accelerators, possesses world-leading capabilities in beam dynamics aspects of linear accelerators, energy-recovery linacs, free-electron lasers and colliders.

Advanced Electron Ion Collider (EIC) Design

The Accelerator Division, in partnership with the Physics Division and collaborators at other national laboratories, has been developing a design concept for a Jefferson Laboratory Electron Ion Collider (JLEIC). A design report for JLEIC was published in 2012, to respond to the energy and luminosity requirements of the EIC physics White Paper. The JLEIC design team, composed of TJNAF personnel and strategic national and international collaborators, is now developing a pre-Conceptual Design Report (pre-CDR) by the end of FY 2018, with a CDR to follow in ~2-3 years. Design and R&D efforts towards the CDR are consistent with the critical decision timeline for the EIC project and with the requirements for DOE Order 413.3.

3. Large Scale User Facilities/Advanced Instrumentation

Experimental Nuclear Physics (funded by DOE SC – Nuclear Physics)

TJNAF is the world's leading user facility for studies of the quark structure of matter using continuous beams of high-energy, polarized electrons. CEBAF is housed in a 7/8 mile racetrack and was built to deliver precise electron beams to three experimental End Stations or Halls. The electron beam can be converted into a precise photon beam for delivery to a fourth experimental Hall D. Accelerator instrumentation is installed to deliver beams to all four Halls simultaneously.

CEBAF provides a set of unique experimental capabilities unmatched in the world:

- Highest energy electron probes of nuclear matter
- Highest average current
- Highest polarization
- Ability to deliver a range of beam energies and currents to multiple experimental halls simultaneously
- Highest intensity tagged photon beam at 9 GeV for exotic meson searches
- Unprecedented stability and control of beam properties under helicity reversal for high precision parity violation studies.

Hall D is dedicated to the operation of a hermetic large-acceptance detector for photon-beam experiments, known as GlueX. Hall A houses two high-resolution magnetic spectrometers of some 100 feet length and a plethora of auxiliary detector systems, including the large-acceptance Super BigBite Spectrometer. Hall B is home of the CEBAF large-acceptance spectrometer (CLAS12) with multiple detector systems and some 100,000 readout channels. Hall C boasts two roughly 80-foot long high-momentum magnetic spectrometers that allow for precision scattering experiments, and has housed many unique large-installation experiments. Maintenance, operations and improvements of the accelerator beam enclosure and beam quality, and the cavernous experimental Halls and the multiple devices in them, are conducted by the TJNAF staff, to facilitate user experiments. Important capabilities related to the experimental program include state-of-the-art particle detection systems, high-power cryogenic targets, polarized targets, high-speed readout electronics, and advanced data acquisition technology.

CEBAF Operations (funded by DOE SC, Nuclear Physics)

As mentioned above, CEBAF has been recently upgraded to provide an electron beam with energy up to 12 GeV, a factor three over the original 4 GeV CEBAF design. In addition to the increase in beam energy, the maximum number of simultaneous experiments that CEBAF can support increased this year from three to four, with the completion of a four-laser injector upgrade. With the completion of the 12 GeV Upgrade, TJNAF will continue to be the world's premier experimental QCD facility.

With 418 installed SRF cavities, CEBAF operations represent a significant fraction of the world-wide SRF performance data set. Some of the CEBAF SRF cavities have been operating for more than 20 years. The CEBAF data set and operational experience is a valued resource for new or existing SRF based accelerators. TJNAF has the ability to conceive and design large accelerator facilities, building upon 6 GeV CEBAF operations and augmented with the ongoing 12 GeV Upgrade.

Accelerator Technology (funded by DOE SC – Nuclear Physics, Basic Energy Sciences, High Energy Physics, DOD ONR, Commonwealth of Virginia, and Industry)

The ability to use the TJNAF Low Energy Recirculator Facility (LERF) as an accelerator R&D test-bed for Energy Recovery Linacs and techniques required to establish cooling of proton/ion beams, for example, provides a mutual beneficial cross-fertilization between the TJNAF LERF and Nuclear Physics. The LERF vault has recently been configured to enable higher throughput of cryomodule testing for LCLS-II. In addition, the possibility of utilizing LERF in isotope production applications has been evaluated, and a proposal submitted accordingly.

As a result of the development, construction, and operation of CEBAF, TJNAF has developed world-leading expertise in superconducting RF linear accelerators, high intensity electron sources, beam dynamics and instrumentation, and other related technologies. These capabilities have been

leveraged to develop new technologies relevant to other disciplines beyond nuclear physics as well as applications to areas of national security.

TJNAF is applying its accelerator technology to collaborate with four other national laboratories to realize the Linac Coherent Light Source II, at the Stanford Linear Accelerator Center (LCLS-II at SLAC). TJNAF is responsible for construction of half (2 GeV) of the superconducting accelerator as well as the two cryogenic refrigerators.

Cryogenics (funded by DOE SC, Nuclear Physics)

Over the last two decades, TJNAF has developed a unique capability in large scale cryogenic system design and operation that is a critical resource for the US national laboratory complex. The TJNAF cryogenics group has been instrumental in the design of many construction projects requiring large scale cryogenics: (SLAC (LCLS-II), Michigan State University (FRIB), Oak Ridge National Lab (SNS), TJNAF (12 GeV Upgrade), and NASA (James Webb Space Telescope) as well as improving the cryogenic efficiency of existing systems (Brookhaven National Laboratory). In the process, many inventions have been patented, and one has been licensed by Linde (one of two companies that build cryogenic systems) for worldwide applications on new and existing cryogenic plants. This work has also resulted in many Masters theses to ensure the continuity of this expertise in the coming decades.

The group is presently responsible for designing, specifying, procuring and commissioning the two CHLs for LCLS-II, based on the successful CHL2 design for the 12 GeV Upgrade and designs developed for FRIB. The FRIB refrigerator installation is nearing completion along with TJNAF's scope of work supporting the project.

IV. Science and Technology Strategy for the Future/Major Initiatives

The TJNAF science strategy for the future has a strong foundation based on the advancement of the US nuclear physics program (as embodied in the 2015 NSAC Long Range Plan) and the support of Office of Science accelerator projects utilizing TJNAF's expertise in Superconducting RF and cryogenics technologies.

With the completion of its 12 GeV Upgrade Project, TJNAF is now well positioned to continue its world leadership in hadronic nuclear physics. The upgraded CEBAF along with the enhancements in experimental equipment, offer many opportunities for major advances in the understanding of the substructure of the nucleon, the fundamental theory of the strong force QCD, aspects of nuclear structure relevant to neutron star physics, and high precision tests of the standard model of particle physics. Full exploitation of the upgraded facility will require robust CEBAF operations, as well as construction of new experimental equipment. TJNAF has two proposed MIE projects (MOLLER and SoLID) that have received strong endorsement from the nuclear physics community.

The 2015 NSAC Long Range Plan (LRP) strongly supports the robust operation of CEBAF necessary to deliver the long-awaited science program: "With the imminent completion of the CEBAF 12 GeV Upgrade, its forefront program of using electrons to unfold the quark and gluon structure of hadrons and nuclei and to probe the Standard Model must be realized." In addition, the LRP recommends "increasing investment in small-scale and mid-scale projects and initiatives" and we hope this can help realize the new MIE projects at TJNAF.

The 2015 NSAC LRP also recommends "high-energy high-luminosity polarized EIC as the highest priority for new facility construction following the completion of FRIB." TJNAF is well positioned to provide the US nuclear physics community with a highly capable option for an EIC based on the cost-

effective use of CEBAF as a source of highly polarized 12 GeV electrons. TJNAF continues to develop its novel figure eight collider ring design, known as JLEIC, and believe this represents an excellent opportunity for the US nuclear physics community and for the long-term future of TJNAF.

The 2015 NSAC LRP also identifies a theory initiative, “new investments in computational nuclear theory that exploit the U.S. leadership in high-performance computing”, that offers an opportunity to greatly advance progress in Lattice QCD calculations. TJNAF is continuing to develop expertise in advanced computer science, visualization and data management. TJNAF is a world leading center of Lattice QCD (LQCD) computing, and extending this competency to the experimental program complements the lab’s mission to maximize the scientific productivity of the nuclear physics community.

TJNAF also possesses key capabilities and competencies in accelerator science and in the application of modern accelerator technologies. Continued development of these capabilities is one of the major initiatives integral to this strategic plan. In addition to providing world leading facilities and expertise to meet the identified needs of the nuclear physics research community, TJNAF has identified collaborative roles that it can play in the realization of facilities elsewhere associated with the Office of Science (e.g., Basic Energy Sciences and High Energy Physics) and other agencies. Most recently, this has involved the Lab’s contributing to the FRIB and LCLS-II construction projects. It is anticipated that TJNAF will contribute to other Office of Science projects, and also perhaps projects beyond SC, through future partnerships. TJNAF is continuing to develop expertise in advanced computer science, visualization and data management. TJNAF is a world leading center of Lattice QCD (LQCD) computing and a partner in the Exascale Computing Project. TJNAF is extending this competency to the experimental program which complements the lab’s mission to maximize the scientific productivity of the nuclear physics community.

During the last year, TJNAF has developed the FY18 Laboratory Agenda to delineate major initiatives associated with strategic objectives in Science and Technology as well as Operations. The Agenda was constructed around a set of four Strategic Outcomes that deliver on the mission of the laboratory. These Strategic Outcomes are:

1. *Enable scientific discoveries by the Nuclear Physics User Community through our unique, world leading facilities and capabilities*
2. *Plan for future facilities and capabilities to realize the long-term scientific goals in Nuclear Physics research*
3. *Provide technology solutions that support the NP community, the larger DOE mission and societal needs*
4. *Provide, protect, and improve the human, physical and information resources that enable world class science*

V. Infrastructure

Overview of Site Facilities and Infrastructure

Thomas Jefferson National Accelerator Facility (TJNAF) is located on a 169 acre DOE-owned federal reservation within the City of Newport News in southeast Virginia. Adjacent to the federal reservation is the Virginia Associated Research Campus (VARC), a five acre parcel owned by the Commonwealth of Virginia and leased by SURA, the managing member of the JSA joint venture, which sub-leases five acres to DOE for use by TJNAF. Also adjacent to the federal reservation is an 11 acre parcel owned by the City of Newport News that contains the Applied Research Center (ARC) within which JSA leases additional office and lab space. Southeastern Universities Research Association (SURA) owns 37 acres adjacent to the TJNAF site where it operates a 42-room Residence Facility at no cost to DOE.

The TJNAF complex consists of 68 DOE-owned buildings comprising 882,990 SF of office, shop, technical, and storage space. JSA leases an additional 37,643 SF of office and shop space from the Commonwealth of Virginia in the VARC and 26,869 SF of office and lab space from the City of Newport News in the ARC. JSA also leases 19,030 SF of storage space in two off site storage warehouses within 12 miles of TJNAF. These areas are gross, usable space is summarized in Table 1.

The TJNAF complex provides office and work space for 760 Federal Government and JSA contractor and subcontractor employees, a transient population of 1,530 users, and a total of 1,350 visiting scientists for periodic technical meetings and seminars hosted during a typical year. Facility space is well utilized with a current asset utilization index of 98.6%. Distribution of space by use is summarized in Table 1.

Table 1: Distribution of Usable Space by Type of Use

Type of Use	Total Square Feet (SF), Usable Space, Owned and Leased
Technical and Laboratory	258,768 (39%)
High Bay	150,198 (23%)
Office	101,987 (16%)
Storage	92,847 (14%)
Common	53,839 (8%)
TOTAL	667,639 (100%)

The condition of TJNAF facilities is generally good (Table 2). Of the 74 DOE owned or leased buildings, 65 are rated adequate, eight substandard, and one inadequate. There are no longer any office trailers on site. Of the 36 other structures and facilities (including OSF 3000 series assets) assessed, 33 were rated adequate and three substandard. A total of 3,240 SF of space is currently rated as underutilized. These spaces will be fully utilized once capital funds are received and construction is complete. There are currently no excess facilities at the Lab and none are expected within the next ten years. There are 55 shipping containers representing 17,000 SF of storage space in use at TJNAF. TJNAF plans to remove 10 of these containers by the end of FY 2018.

Table 2: TJNAF Facility Rating and Utilization Assessment

Condition		Mission Unique Facilities		Non-Mission Unique Facilities		Other Structures and Facilities	
		Number	SF	Number	SF	Number	SF
Rating	Adequate	36	339,976	29	360,697	33	N/A
	Substandard	0	0	8	259,221	3	N/A
	Inadequate	0	0	1	6,638	0	N/A
	TOTAL	36	339,976	38	626,556	36	N/A
Utilization	Underutilized	2	3,240	0	0	0	N/A
	Excess	0	0	0	0	0	N/A

TJNAF is entirely dependent on public utility service. JSA sources power from Dominion Virginia Power at an average rate of \$0.06/kWh, water from The City of Newport News at an average rate of \$5.08/kgal, and disposes of waste water through the Hampton Roads Sanitary District at an average rate of \$10.82/kgal. Utility service meets mission requirements although occasional unplanned power commercial power outages periodically disrupt accelerator operation.

A current copy of the TJNAF [Land Use Plan](#) can be found on the TJNAF Facilities Management website and is summarized in Enclosure 1. Two real estate actions were completed in FY 2017. The

first was a two year renewal of the lease for office space in the ARC along with a reduction in 15,772 SF of space and a requirement to transition facility O&M to the City of Newport News within two years. The second was a reduction of 1,481 SF of leased storage space at the Warwick facility. In FY 2018, discussions are underway with the City of Newport News about possibly relocating staff currently in the SSC to the ARC (including possible purchase of the building) to permit expedited commercial development of SSC property.

Campus Strategy

The S&T strategy described in Section 4 of this plan dictates the campus investment plan. Working with the CRO the facilities planning team reviews the capabilities of the current infrastructure against the S&T strategy to identify current and projected gaps. TJNAF then performs an analysis of alternatives (AOA) to select the optimum solutions to close the gaps between mission needs and infrastructure capability. The selection of solution and time phasing is driven by mission priority and constrained by the projected levels of indirect, GPP and SLI program funding.

This plan reflects the heightened urgency to improve infrastructure reliability given the recent trend of increasingly disruptive failures impacting experimental schedules. Accelerator reliability is the product of the joint availability of all component systems (cavities, magnets, controls, infrastructure, and so forth). To meet the CEBAF 85% availability goal Accelerator Division has allocated facilities infrastructure an availability requirement of >98% which translates to <107 hours of total downtime over a 32 week experimental period.

The recent failure history suggests substantial improvement in infrastructure reliability is needed to reach this availability requirement. The spring 2017 experimental run was terminated nine days early due to a cold compressor failure in the aging Central Helium Liquefier (CHL) 1 plant. During preparation to start the fall 2017 experiment run, a 21 minute power outage to the CHL1 controls resulted in a substantial loss of liquid helium which triggered a cascading series of events including warming of some cryomodules delaying the start of the fall experiment run and loss of 70 experiment days. This was followed by the failure and permanent damage to one of three CHL1 high pressure motor start transformers that eliminated redundant capability on CHL1 (2 of 3 compressors is now 2 of 2). The spring 2018 experimental run ended prematurely on 5 March due to failure of a 5 MVA transformer supplying power to CHL1. The transformer was replaced on 23 March after a national search located a suitable replacement in Texas. Analysis of the failed transformer is ongoing but early indications are the failure was accelerated end-of-life due to heavy utilization and extended preventive maintenance intervals due to operational demands.

Presented in Table 3 is the correlation between S&T mission requirements, required infrastructure capability, current shortfall in this capability, and optimum solution which then becomes the basis for the infrastructure plan detailed in Enclosure 2.

Table 3: The campus strategy reflects a set of realistic solutions to address shortfalls in infrastructure capability needed to meet the TJNAF S&T strategic objectives.

S&T Strategic Objective	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date (Project titles map to the Infrastructure Investment Table in Enclosure 2)
Enable scientific discoveries by the Nuclear Physics User Community through our unique, world leading capabilities	Central helium liquefier capable of supply CEBAF with 9400W of 2K cooling and 22 g/s of LHe at >85% reliability	Two plants, CHL1 and 2 must operate to meet the 2K cooling requirements but CHL1 is unable to meet the up time requirements due to its aging cold box.	Complete replacement of the CHL1 2K Cold Box . Need is immediate and project is underway as a FY17 SLI-GPP project.
	End station refrigeration capable of supplying Halls A, B, and C with 4000W of 4K cooling and 40 g/s of LHe at >85% reliability	Current End Station Refrigerator serving Halls A, B, and C only has 1500W of 4K cooling and 11 g/s of LHe, has been operating nearly continuously for 20 years and is near end-of-life	Complete installation of the SSC Cold Box to activate End Station Refrigerator (ESR) 2 , will close the capability gap and provide a long-term solution to meet the experiment plan. Need date is immediate.
	35,000 SF of environmentally controlled high bay and storage space for each of four experiment halls to assemble and check out experiments being staged for experimental operation 32 weeks/year.	117,000 SF of high bay and storage space is currently assigned to Physics Division which is insufficient space for the planned experiment schedule. Overcrowding increases the safety risk to staff and visiting scientists.	Build a Physics Technical Support Building near the CEBAF experiment halls to provide an additional 18,000 SF of environmentally controlled storage and work space near Halls A, B, and C. Need is near-term, desired completion by FY23.
Plan for future facilities and capabilities to realize the long-term scientific goals in Nuclear Physics research	Up to 220,000 SF of office space meeting DOE high performance building standards to house laboratory technical and management staff, students, and visiting users	A large fraction of the existing CEBAF center (138,000 SF) is substandard due to aging mechanical systems that require immediate replacement. Additionally, 45,000 SF of office space is leased in adjacent buildings at disadvantageous rates.	Construct two new office additions, Wing D (14,000 SF) and Wing E (70,000 SF) then renovate the original portion of CEBAF Center (68,000 SF). Consolidate staffing and vacate leased space. Need is near-term, desired completion by FY24.
	Meeting and collaboration space in CEBAF center for 700 staff members, 1,500 user community members, and regular conference and review teams.	Existing conference and collaboration space is heavily utilized and does not offer state of the art teleconferencing capability.	Repurpose the vacant computer center to create 3,700 SF of Meeting and Collaboration Space with state of the art teleconferencing capability. Need is immediate.
	Provide 10,150 SF of suitable office and workspace for the Cryogenic Engineering staff adjacent to the cryogenics plant	Current facility was originally built as shop space and is now substandard due to expanding cryogenics staffing	Refurbish Cryogenics Engineering Center (Building 89) to meet DOE standards. Need is immediate.

S&T Strategic Objective	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date (Project titles map to the Infrastructure Investment Table in Enclosure 2)
	Provide 9,500 SF of office and shop space for facilities O&M closer to the accelerator site and Test Lab	Existing facilities O&M office and shop space is located on the opposite side of campus from the accelerator site and Test Lab in aging metal sheds	Completion of the proposed Physics Technical Support Building creates an opportunity to add a second floor inside the Experimental Equipment Lab (Building 90) thus permitting relocation of Facilities Office and Shop closer to the main work centers and permitting demolition of the existing metal sheds. Need date is FY25 or sooner if practical.
	The Experimental Equipment Lab (EEL) provides 54,800 SF of office and shop space for physics, accelerator, and facilities staff and is integral to our campus space utilization plan.	The EEL cladding is approaching the end of its serviceable life and requires replacement within the next 8-10 years to maintain effective use of this facility	Experimental Equipment Lab (EEL) Modernization. Need date is FY26.
	Provide an isolated and secure facility to calibrate radiological instruments and house rad waste processing equipment and work in process	Campus growth is encroaching on the existing calibration lab and making it more susceptible to storm water flooding. Further, rad waste processing equipment and work in process are located in part of the Equipment Storage Building assigned to Physics, once consolidated, frees up needed space for Physics Division	Construct a new RADCON Calibration Laboratory and Rad Waste Processing work center in a more remote area adjacent to the Central Material Storage Area (CMSA). Need date is FY28 or sooner if practical
	Laboratory entrance sign appropriate for a major national nuclear physics R&D facility	Existing entrance sign was designed and built when TJNAF was first opened and no longer reflects the scope and capabilities of the site or its important technology anchor role in the community	Replace Site Entrance Signage. Need date is FY26 or sooner if practical.

S&T Strategic Objective	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date (Project titles map to the Infrastructure Investment Table in Enclosure 2)
	Suitable access roads, parking, and storm water management to meet safety and regulatory requirements	Continued expansion of the TJNAF campus as outlined in this plan along with development of property immediately surrounding TJNAF requires expansion and alteration of campus access, parking, and storm water management structures to maintain compliance with safety and regulatory requirements	Site wide storm water, road, and parking area improvements (proposed as two projects). Need date is FY30.
Provide technology solutions that support the NP community, the larger DOE mission, and societal needs	Provide LHe to the Test Lab to enable the development, production, and test of SRF components and complete cryomodels, both for use by TJNAF in CEBAF and under WFO projects for other Labs.	The Cryogenics Test Facility (CTF) has experienced heavy utilization due to the CEBAF upgrade and large WFO projects. Approximately \$5M of system components have reached end-of-life and others require upgrading to maintain adequate capacity for projected workload.	Complete the Cryogenics Test Facility (CTF) Recapitalization . Need date is FY22 or sooner if practical.
	Provide adequate cooling water for the Test Lab R&D equipment, Computer Center, and some accelerator systems with >98% availability.	Existing Central Utility Plant (CUP), which provides cooling water to the Test Lab, Computer Center, and certain accelerator systems is receives power from only one of three primary distribution paths to the TJNAF campus. This introduces a single point failure that limits CUP reliability and complicates downtime planning for maintenance.	Central Utility Plant (CUP) Power Diversity project adds a connection to the 40MVA substation to eliminate the single point failure mode by relying on only the 22 MVA substation. This is part of our large scale power redundancy improvement project to increase critical system reliability by eliminating single point failures. Need date is immediate and project is scheduled to being in FY18.
	Provide sufficient storage space for material and tooling needed to design, produce, and test SRF components and systems.	18,000 SF of current technical storage is leased warehouse space remote from TJNAF. This introduces additional labor and time requirements to control and access this high value material.	Construct a 14,000 SF Equipment Storage Building adjacent to the Test Lab to relieve the demand for remote, offsite leased storage for SRF components, tooling, and work in process. Need date is FY25 or sooner if practical.
	Provide 1,900 gal/hr of chilled water to cool R&D equipment in the Test Lab,	Existing Test Lab chilled water system uses cooling fluid that will be no longer	Replace Test Lab Basement Chillers . Need date is FY30

S&T Strategic Objective	Infrastructure Requirement	Current Shortfall	Optimum Solution and Need Date (Project titles map to the Infrastructure Investment Table in Enclosure 2)
	EEL, CEBAF Center, and Accelerator Service Buildings.	available after FY30 requiring replacement prior to this date.	
	To meet DOE sustainability goals for 2025 TJNAF must reduce potable water consumption by 36% relative to 2007 baseline.	Must reduce potable water consumption from current intensity of 63.5 gal/GSF to 41 gal/GSF.	Cooling Tower Reuse Water project develops a 40 Mgal/year alternate water source for use in cooling towers.

The gaps identified above can be closed using a combination of SLI, SLI-GPP, and NP-GPP funding totaling \$128M. A majority of the above mentioned gaps can be closed over the next ten years. When complete these projects will eliminate \$4.5M of deferred maintenance annually.

The most recent TJNAF Asset Condition Index is 0.99. However, this is expected to decline markedly in coming years since facilities O&M funding has been limited to 1.5% of replacement value over the past 5 years. Recent construction of new facilities through SLI and GPP has reduced the deferred maintenance value, decreasing from \$15.8M to \$6.2M. Over the next few years deferred maintenance is expected to decrease as JSA increases facility maintenance spending to 2% of RPV along with the capital spending reflected in the Integrated Facilities and Infrastructure Crosscut table provided in Enclosure 2. The primary focus of our facilities operations and maintenance program is to increase the mean time between failure of facility systems through accelerated replacement of end-of-life systems and adding redundancy for critical systems to eliminate downtime from single point failures. Similarly, when failures occur TJNAF will reduce the mean time to repair by making sure sufficient stock of critical spares is on hand to immediately restore operation rather than accept lengthy downtimes to source replacements.

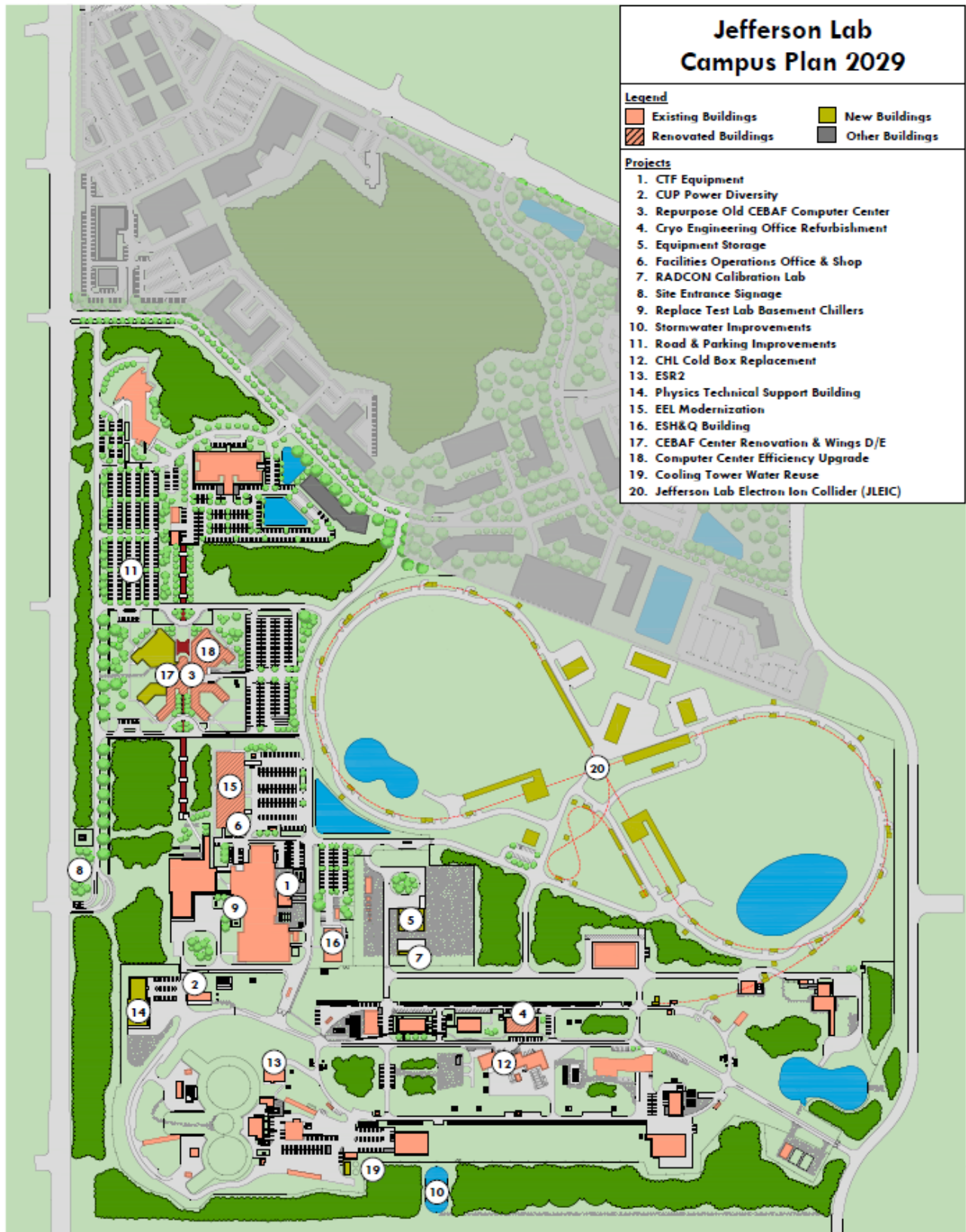
Infrastructure Investment Table

The TJNAF Infrastructure Investment Table and Campus Plan is provided in Enclosure 2 at the end of this plan.

Integrated Facilities and Infrastructure Crosscut Data Table

The TJNAF Integrated Facilities and Infrastructure Crosscut Data Table are provided in Enclosure 2 at the end of this plan.

Enclosure 1 – Land Use Plan



Enclosure 2 – Infrastructure Investment Table

Thomas Jefferson National Accelerator Facility

Infrastructure Objectives:	Construct and upgrade facilities and utilities to fully support mission objectives
	Replace substandard, temporary, and leased space with permanent facilities
	Increase energy efficiency and support DOE sustainability goals and requirements

Project Title	\$000														Funding Type	Funding Program	Primary Core Capability	Supports which SC Program?	Project Category	Anticipated Reduction in Deferred Maintenance (\$000)	Removes unneeded assets and/or improves utilization?	Addresses those "Mission Critical" assets under "SC25 Enabling Infrastructure" rated Inadequate?	Will change Overall Asset Condition of 1 or more assets
	Total	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29									
Cryogenics Test Facility (CTF) Equipment Recapitalization	5,200	500	500	200	2,000	1,000	1,000								GPP	NP	SC01	NP	Util		No	No	Yes
Central Utility Plant (CUP) Power Diversity	600		600												GPP	NP	SC16	NP	Util		No	No	No
Repurpose Old CEBAF Computer Center	1,200		900	300											GPP	NP	SC16	NP	Bldg Reno		Yes	No	Yes
Cryo Engineering Office Refurbishment	1,200			1,200											GPP	NP	SC16	NP	Bldg Reno	561	Yes	No	Yes
Equipment Storage Building	4,500			300		500	1,100	2,200	400						GPP	NP	SC25	NP	N Bldg		No	No	No
Facilities Operations Office & Shop	4,000									1,800	2,200				GPP	NP	SC25	NP	Bldg Reno		No	No	Yes
RADCON Calibration Lab & Waste Processing	1,900										100	1,800			GPP	NP	SC25	NP	N Bldg		No	No	Yes
Site Entrance Signage	600											600			GPP	NP	SC25	NP	Other		No	No	No
Replace Test Lab Basement Chillers	1,600												1,600		GPP	NP	SC16	NP	Util		No	No	Yes
Stormwater Improvements	2,700											900	1,800		GPP	NP	SC25	NP	Other		No	No	Yes
Road Improvements	3,300											700	2,600		GPP	NP	SC25	NP	Other	435	No	No	Yes
Upgrade Cryogenics Infrastructure (CHL 1 Cold Box Replacement)	8,000	8,000													SLI-GPP	SLI	SC16	NP	Util		No	No	Yes
Upgrade Cryogenics Infrastructure (End Station Refrigerator 2 (ESR2))	9,900			9,900											SLI-GPP	SLI	SC19	NP	Util		No	No	Yes
Physics Technical Support Building	7,400				7,400										SLI-GPP	SLI	SC19	NP	N Bldg		No	No	No
Experimental Equipment Lab (EEL) Modernization	22,000									22,000					SLI-LI	SLI	SC19	NP	Bldg Reno	573	Yes	No	Yes
Environmental, Safety, Health & Quality (ESH&Q) Building	250	250													GPP	NP	SC25	NP	N Bldg		Yes	No	Yes
CEBAF Center Renovation, Wings D & E	62,000				40,000	22,000									SLI-LI	SLI	SC25	NP	N Bldg	2,943	Yes	No	Yes
Computer Center Efficiency Upgrade	250	250													GPP	NP	SC25	NP	Other		Yes	No	Yes
Cooling Tower Reuse Water	600					600									GPP	NP	SC25	NP	Util		No	No	No

Enclosure 2 (cont'd) – Integrated Facilities Infrastructure (IFI) Crosscut Data Table

Thomas Jefferson National Accelerator Facility SC Integrated Facilities and Infrastructure (IFI) Crosscut Data Table													
Capital Investments (summarized from Investment Table)	2017* Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
SLI Line Items				40,000	22,000			22,000					
SLI GPP	8,000		9,900	7,400									
GPP	1,000	2,000	2,000	2,000	2,100	2,100	2,200	2,200	2,300	2,400	2,500	2,500	2,600
Total DOE Capital Investment	9,000	2,000	11,900	49,400	24,100	2,100	2,200	24,200	2,300	2,400	2,500	2,500	2,600
IGPP													
Total Capital Investment	9,000	2,000	11,900	49,400	24,100	2,100	2,200	24,200	2,300	2,400	2,500	2,500	2,600
Predictive, Preventive and Corrective M&R (incl. DM Reduction) (For Federally Owned Facilities)	2017* Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Direct Funded	223	165	170	175	180	185	190	195	202	208	215	220	225
Indirect Funded	5,165	8315	8,600	8,850	9,700	10,000	10,300	10,600	10,950	11,300	11,650	12,000	12,400
Total Predictive, Preventive and Corrective M&R	5,388	8,480	8,770	9,025	9,880	10,185	10,490	10,795	11,152	11,508	11,865	12,220	12,625
Annual Required Maintenance <i>(Should be consistent with 1/31/2018 definition of ARM data in FIMS Data Dictionary)</i>				6,733.7									
Operation, Surveillance & Maintenance (OS&M) of Excess and Unutilized Facilities	2017* Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Direct Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Indirect Funded	0	0	0	0	0	0	0	0	0	0	0	0	0
Total OS&M of Excess and Unutilized Facilities	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Maintenance and Repair & OS&M	5,388	8,480	8,770	9,025	9,880	10,185	10,490	10,795	11,152	11,508	11,865	12,220	12,625
Disposal and Demolition	2017* Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Direct Funded													
Indirect Funded											80		
Total Disposal and Demolition	0	0	0	0	0	0	0	0	0	0	80	0	0
Other Data Required to Characterize the Campus Strategy reflected in the Infrastructure Investment Table	2017* Actual	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Deferred Maintenance Projection (\$000)**	6,224	6,411	6,603	6,801	7,005	3,711	3,823	3,937	3,482	3,587	3,695	3,805	3,485
Replacement Plant Value Projection (\$000)***	415,771	428,244	441,391	454,633	495,968	511,147	526,482	543,432	559,735	578,095	596,344	614,234	634,661
Building Area Increases (Total GSF)					82,000	18,000			14,000	9,000	4,000		
Building Area Removals (Total GSF)											3,933		
Excess facilities (Total GSF)	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating Assets with Utilization Under 25% (Total GSF)	117	0	0	0	0	0	0	0	0	0	0	0	0
Operating Assets Classified as "Adequate": # of	90	90	90	91	94	97	98	99	100	100	99	99	99
Operating Assets Classified as "Adequate": RPV (\$000)	334,727	344,769	355,412	373,088	418,685	474,064	490,020	505,877	548,639	566,666	584,572	602,109	633,420
Operating Assets Classified as "Adequate": GSF	661,368	661,368	661,368	683,406	790,044	928,107	932,205	946,205	1,000,993	1,010,493	1,014,493	1,014,493	1,014,493
Operating Assets Classified as "Inadequate": # of	1	1	1	1	1	0	0	0	0	0	0	0	0