Department of Energy Laboratory Plan –TJNAF
June 30, 2017

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: experimental, theoretical and computational Nuclear Physics; Accelerator Science and Technology; and Large Scale User Facilities/Advanced Instrumentation.

The Lab supports an international scientific user community of 1,530 researchers whose work has resulted in scientific data from 181 full and 13 partial experiments (including 3 full and 3 partial in the 12 GeV era), 398 Physics Letters and Physical Review Letters publications and 1,377 publications in other refereed journals to-date at the end of FY 2016. Collectively, there have been more than 130,000 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 (31 in FY 2016; 562 to-date; and 200 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)

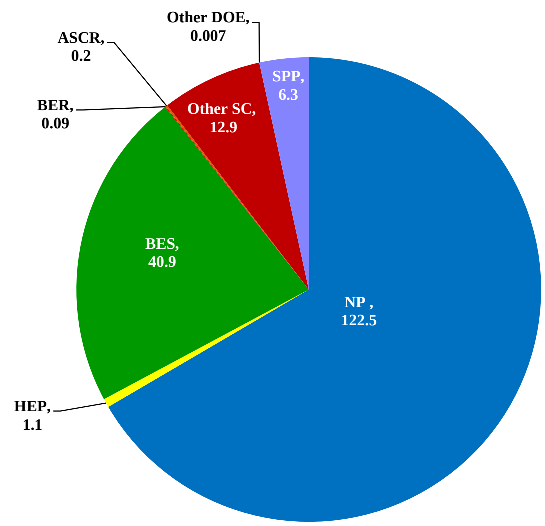
Responsible Site Office: Thomas Jefferson Site Office

Website: http://www.jlab.org

Physical Assets:
- 169 acres and 68 buildings and 4 trailers
- 880,269 GSF in buildings
- Replacement Plant Value (RPV): $415M
- 0 GSF in Excess Facilities
- 83,542 GSF in Leased Facilities

Human Capital (period ending 9/30/16):
- 699 FTEs
- 26 Joint faculty
- 28 Postdoctoral Researchers
- 9 Undergraduate and 39 Graduate students
- 1,530 Facility Users
- 1,368 Visiting Scientists

FY16 Costs by Funding Source: *(Cost Data in $M)*



Lab Operating Costs: $184.1
DOE Costs: $177.8
SPP (Non-DOE/Non-DHS): $6.3
SPP as % Total Lab Operating Costs: 3.4%
Total DHS costs: $0.0

III. Current Laboratory Core Capabilities

The following core capabilities distinguish TJNAF and provide a basis for effective teaming and partnering with other DOE laboratories, universities, and private sector partners in pursuit of the laboratory mission. These distinguishing core capabilities provide a window into the mission focus and unique contributions and strengths of TJNAF and its role within the Office of Science laboratory complex. Descriptions of these facilities can be found at the website noted in the Lab-at-a-Glance section of this Plan.

Each of the laboratory's core capabilities involves a substantial combination of facilities and/or teams of people and/or equipment, has a unique and/or world-leading component, and serves DOE/DHS missions and national needs. Specifically, TJNAF's three major core capabilities meeting these criteria are described below in detail:

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

   Experimental Nuclear Physics
   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}/eN/cm^2/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.

Full operations of the 12-GeV science program are slated for FY18. Accelerator operations have been established to send simultaneous beam to three Halls. The new Hall D has completed its engineering phase and has started its science program. Hall A has successfully completed two experiments already. Hall C has established successful science operations and is ready to start its science program. In Hall B, all detectors are operational but work remains ongoing in FY17 on one superconducting magnet to complete the 12-GeV Upgrade Project.

<u>Theoretical & Computational Nuclear Physics</u>

A comprehensive theoretical effort with leadership across nuclear physics is the mission of the TJNAF Theory Center. The Theory Center has successfully established a unique three-pronged scientific effort, pulling together the state-of-the art theoretical, phenomenological and computational approaches, including the effective field theory techniques, QCD global analyses, and non-perturbative lattice QCD calculations. The research of the Theory Center focuses on *ab initio* calculations of properties and excitations of nucleons and mesons, the properties of light nuclei the properties of the nucleon-nucleon interaction, and the internal landscape of hadrons in terms of the spin, momentum, and spatial distributions of their constituents. The research program at the Theory Center is an essential part of the national and international effort to understand the internal structure of hadronic matter, and to explore the nature of quark and gluon confinement, which are of the highest scientific priorities of US nuclear physics, as articulated in the NSAC 2015 Long-Range Plan, and are critically important for the success of the 12 GeV CEBAF (and future EIC) experimental physics program.

The synthesis of the latest technology with innovative theoretical tools is particularly notable in the area of High Performance Computing. TJNAF deploys cost-optimized 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. An increasingly important part of this lattice effort is the computation of hadronic scattering amplitudes, with emphasis on providing the decay couplings of well-established mesons as a benchmark for extension to hybrid states, where the decay couplings will aid the experimental searches planned for the 12 GeV CEBAF program.

One of the key components in support of the 12 GeV experimental program is the Theory Center's *Joint Physics Analysis Center* (JPAC) working closely with the GlueX and CLAS12 Collaborations. JPAC is developing 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.

Another key aspect of the Theory Center is that almost all of its members work very closely with the experimental community, in particular, in support of the CEBAF program. In addition, about half of the Theory Center members are engaged in the community effort and its phenomenological studies to help develop the strong science case for a future Electron-Ion Collider (EIC). By combining expertise of experimentalists, theorists and computing specialists from around the world, the Theory Center aims to employ advanced computer data processing and state-of-the art theoretical and phenomenological techniques and tools to realize new insights into Quantum Chromodynamics and hadronic and nuclear structure.

The Nuclear Physics Core Capability serves DOE Scientific Discovery and Innovation (SC) mission numbers 2, 4, 22, 24, 26, 27, 28, 30, 33, 34, 35 and 36 from "Enclosure 1: List of DOE/NNSA/DHS Missions."

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 electron and proton linacs 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 90 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 and FRIB.

In addition, TJNAF has pioneered Energy Recovery Linac (ERL) concepts and technologies and currently hold the record for recirculated beam power (1.6 MW), and has been a world leader in high-power free electron lasers.

TJNAF possesses world-leading capabilities in beam dynamics aspects of linear accelerators, energy-recovery linacs, free-electron lasers and colliders.

<u>Advanced Electron Ion Collider (EIC) Design</u>
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 pre-conceptual 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 working towards a pre-Conceptual Design Report (pre-CDR) in 1 to 2 years with a CDR to follow in ~3-4 years. Completing design and R&D towards a conceptual design report consistent with the critical decision timeline for the EIC project and with the requirements for DOE order 413.3.

The Accelerator Science and Technology Core Capability serves DOE Scientific Discovery and Innovation mission numbers 25, 26, and 30 from “Enclosure 1: List of DOE/NNSA/DHS Missions.”

3. **Large Scale User Facilities/Advanced Instrumentation**

<u>Experimental Nuclear Physics (funded by DOE SC – Nuclear Physics)</u>
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 12 GeV Upgrade of the CEBAF large-acceptance spectrometer (CLAS12) with multiple detector systems and some 100,000 readout channels. Hall C boasts two roughly 80-feet 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.

The 12 GeV CEBAF science program will also require construction of additional experimental equipment, such as the MOLLER apparatus to measure the weak charge of the electron and provide a fundamental precision test of the Standard Model. Also foreseen is a general-purpose apparatus such as SoLID, that will allow unprecedented 3D imaging of nucleons in momentum space in the valence quark region, a search to new physics in the 10-20 GeV range complementary to the LHC but unique to a lepto-phobic Z' of 100-200 GeV, and access to the QCD conformal anomaly.

To enable the experimental program, TJNAF staff is a world leader in the development and operation of high-power cryogenic target systems, and highly-polarized gaseous and solid-state target systems, such as polarized ^{3}He, H and D solid-state polarized target systems, and frozen-spin H and HD-Ice targets. Many of these targets have demonstrated world record performance. In addition, to facilitate a modern and efficient data acquisition system, TJNAF staff have designed and developed an ultra-fast fully pipelined electronics system, with components finding their way into other user facilities such as Brookhaven National Laboratory. This development of advanced instrumentation allows for spin-offs such as that described in the bio-medical applications below. TJNAF staff is at present envisioning how with foreseen trends in advanced scientific computing and ultra-fast electronics, we can define the next generation of data readout of large-scale advanced instrumentation, as e.g. relevant for the envisioned SoLID apparatus and a future Electron-Ion Collider.

<u>Nuclear Physics Detector Technology (funded by DOE SC – Nuclear Physics)</u>
Developing and implementing novel detector techniques for the next-generation of nuclear physics experiments supports the main mission of TJNAF. Such techniques allow the development of large-scale particle identification, high-rate tracking and electromagnetic calorimetry systems. Some examples are the Ring-Imaging Cherenkov (RICH) kaon identification detector under construction in collaboration with INFN/Italy, the high-rate Gas Electron Multiplier (GEM)-based tracking systems in collaboration with University of Virginia, and the lead-tungstate ($PbW0_4$) based calorimeter development in collaboration with Orsay/France and Catholic University of America. TJNAF is also instrumental in exploring

scintillator readout utilizing position sensitive detectors such as multi-anode and micro-channel plate photomultiplier tubes as well as silicon photomultipliers (with their first-time ever applicability in a large-scale experiment in GlueX). In collaboration with ANL, TJNAF works on the development of a large-area picosecond photon detector. This expertise has contributed to the technology transfer efforts of TJNAF, as described in Section V, such as commercial breast cancer-imaging systems, the development of a new hand-held camera based on silicon photomultipliers and used as an imaging aid to cancer surgeons during surgical procedures, the advance of a SPECT-CT system that has been used in brain studies on awake, unrestrained mice, and development of PhytoPET, a PET imaging methodology for plant biology research.

<u>CEBAF Operations (funded by DOE SC, Nuclear Physics)</u>
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 has been increased from three to four. The four-laser injector upgrade that is being installed is the last of the capabilities required to execute the simultaneous four-hall operations required of the accelerator. With 418 installed SRF cavities, CEBAF operations represent a significant fraction of the world SRF operating cavity-hour 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 staff has developed a substantial ability to conceive and design large accelerator facilities, building upon 6 GeV CEBAF operations and augmented with the ongoing 12 GeV Upgrade. With the completion of the 12 GeV Upgrade, TJNAF will continue its role of the world's premier experimental QCD facility. The ability to use the TJNAF 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. In addition, the possibility of utilizing LERF in isotope production applications has been evaluated, and a proposal submitted accordingly.

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

Using SRF technology based on CEBAF, TJNAF constructed and operated an advanced Free Electron Laser (FEL). The development of this machine enabled TJNAF to pioneer new Energy Recovery Linac (ERL) technology. In the ERL, the electron beam is re-cycled back through the accelerator out of phase with the accelerating field so the beam energy is returned to the SRF cavities. This power, which would normally be dumped, can represent 90% of the beam power in a high power linear accelerator. A number of other laboratories are adopting this technology, and ERL technology is likely to become an important contribution to sustainability initiatives at DOE labs. TJNAF is developing a new plan for the future use of this valuable asset. The Lab is using the term LERF (Low Energy Recirculator Facility) to refer to this facility to reflect a broad potential. DarkLight is the first experiment to be staged in LERF; construction was partially funded by an NSF MRI grant and the first engineering run took place in August 2016. Other possibilities under discussion include characterization of materials using low energy positrons and R&D on production of medical isotopes using the (gamma, n) reaction. Overall, TJNAF is developing these plans in response to program needs and scientific community interest for future utilization of the facility, to maximize the benefit to the mission of the laboratory and of the nation.

TJNAF is also 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.

SRF Accelerator Construction (funded by DOE SC, Nuclear Physics)
TJNAF has developed and installed state-of-the-art infrastructure for the design, development, fabrication, chemical processing, and testing of superconducting RF cavities. This complete concept-to-delivery capability is among the best in the world. All of these capabilities have been essential to the development, deployment, commissioning and operation of the 12 GeV CEBAF Upgrade and continue to be essential to refurbish cryomodules from CEBAF which is critical to maintaining the gradient needed to support the Physics programs. The completion of TJNAF's Technology and Engineering Development Facility (TEDF) Project, provided about 40,000 additional square feet of space. The SRF Facility will be used to assemble the cryomodules for the LCLS-II project. Construction of the production cryomodules has commenced and will continue into early FY19.

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 an important 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) 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.

TJNAF's cryogenics group's highly-skilled staff operates and improves the laboratory's five operational refrigerators including three large 2K cryogenic plants. The two Central Helium Liquefiers operating at 2K utilize patented cryogenic cycles developed by TJNAF that increase efficiencies by up to 30% as compared to what has traditionally been available from industry. This represents the largest and longest running installation of this type of cold compressors affording the lab the opportunity to gain operational experience that can be applied to similar existing or future installations . Further, this extensive operational experience has allowed the group to develop controls technologies and techniques that permit year round, unattended operations that drastically decrease staffing needs required for operations of this magnitude. Stepwise improvements have been made on the mechanical systems, primarily the warm compressors, which significantly extend their lifetimes between major maintenance cycles and decrease input power needs. The combination of cycle and mechanical improvements has decreased the input power requirements for equivalent refrigeration at 2K by 1.4MW for CHL2 as compared to CHL1.

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.

Nationally, this group is a premier source of cryogenic engineering and design for large helium refrigerators, filling a void in commercially available services. TJNAF's cryogenics group is consulted when project needs for a large helium refrigerator system arise (>2kW @ 4K or equivalent capacity) to ensure effective design results and highly efficient operation.

The Large Scale User Facilities/Advanced Instrumentation Core Capability serves DOE Scientific Discovery and Innovation mission numbers 24, 26 and 30 from Enclosure 1: List of DOE/DHS Missions.

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 imminent completion of its 12 GeV upgrade project, TJNAF is 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 the (lack of?) completeness of the standard model of particle physics. Full exploitation of the upgraded facility will require construction of new experimental equipment, and 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. We continue to develop our 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 will strive to leverage its unique capabilities in high performance computing to address topics in QCD and other areas of computational science. In fact, TJNAF possesses key capabilities and competencies in accelerator science and in the application of the 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 additional such contributions to other Office of Science projects, and also perhaps projects beyond SC, in the future. 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 will continue to build on these developments with the goal of establishing this core capability in the near future.

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 880,269 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 leases 19,030 SF of storage space in two off site storage warehouses within 12 miles of TJNAF.

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 96.8%. Distribution of space by use is summarized below in Table 1.

Table 1: Distribution of Space by Use

Type	Total Square Feet (Owned and Leased)	%
Technical and Lab	263,163	38%
High Bay	151,175	22%
Storage	111,328	16%
Office	112,946	16%
Common	62,018	9%

The condition of TJNAF facilities is generally good (Table 2). Of the 73 DOE owned or leased buildings, 64 are rated adequate, eight substandard, and one inadequate. Of the four trailers, three were rated substandard and one inadequate. Of the 36 other structures and facilities (including OSF

3000 series assets) assessed, 33 were rated adequate and three substandard. A total of 10,495 SF of space is currently rated as underutilized and TJNAF plans to eliminate four trailers by the end of FY18. 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 26 of these containers by the end of FY18.

Table 2: Facility Assessments and Excess Facilities

	Adequate		Substandard		Inadequate	
	Count	**SF**	**Count**	**SF**	**Count**	**SF**
Other Structures and Facilities (OSFs)	33		3		0	
Mission Unique Facilities	32	328,650				
Non-Mission Unique Facilities	32	360,246	11	266,601	2	8,314
	Count	**SF**				
Number and square footage of excess facilities	0	0				
Square footage of underutilized space in non-excess facilities	4	10,495				

TJNAF is entirely dependent on public utility service. JSA sources power from Dominion Virginia Power at an average rate of $0.055/kWh, water from The City of Newport News at an average rate of $5.08/KG, and disposes of waste water through the Hampton Roads Sanitary District at an average rate of $10.85/KG. 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 (Enclosure 3) can be found on the TJNAF Facilities Management website.

Campus Strategy

Infrastructure investments by the DOE and Commonwealth of Virginia added more than 199,000 SF of new or renovated facilities at TJNAF over the past 10 years to accommodate the CEBAF 12 GeV upgrade and large scale SPP projects such as LCLS-II. TJNAF has been a leader in adding high quality office and laboratory space on schedule and at the lowest cost of any DOE site. For example, TJNAF completed the 188,000 SF TEDF for $387/SF and will soon complete the 12,000 SF ESH&Q Building for $345/SF. Once constructed, TJNAF's highly efficient facilities management program maintains these facilities for $11/SF (including utilities but excluding power for the accelerator operation). By comparison, commercial office space adjacent to TJNAF leases for $16-23/SF including utilities.

Despite these investments, critical infrastructure needed to effectively execute the TJNAF S&T mission remains unaddressed. Our campus strategy begins with the S&T mission described in the first four sections of this plan. Working with the CRO and the COO, the facilities planning team reviews the available infrastructure capabilities against the S&T plan and identifies current and projected gaps. We perform an analysis of alternatives (AOA) to identify the set of possible 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 GPP and SLI program funding.

To illustrate the process, Table 3 below shows the correlation between S&T mission requirements, infrastructure need (that is, the gap), and solution that is reflected by our Campus Plan.

Table 3: Infrastructure Need by S&T Mission Objective

TJNAF Core Capabilities					
Nuclear Physics	Accelerator Science and Technology	Large Scale User Facilities and Advanced Instrumentation	S&T Mission Objective	Infrastructure Need	Solution (ID Number Reflects Project Number on Enclosure 3)
X	X	X	Execute the CEBAF 12 GeV science program	Insufficient cryogenics plant capacity or reliability for up to 37 weeks/year of accelerator operation with up to 4 halls and >85% availability	(9) Central Helium Liquefier (CHL) Cold Box Replacement (10) End Station Refrigerator (ESR) 2
				Insufficient space to stage and store large experiment apparatus (targets, detectors, and support equipment) for ~1500 users running up to 37 weeks/year in four experiment halls	(4) New Physics Technical Support Building (5) New Storage Building
X	X	X	Leverage TJNAF expertise in the R&D of SRF, cryogenics, controls, and detector technology for strategic partners	Insufficient cryogenics capacity and reliability to develop and test new SRF technology	(3) Cryogenics Test Facility (CTF) Equipment Recapitalization
				Insufficient work and storage space to build up and test major accelerator system components	(4) New Physics Technical Support Building (5)New Storage Building
X	X	X	Position for major accelerator development projects (e.g. EIC)	Insufficient office space for staff and collaborators	(11) CEBAF Center Wing D (8) Road Improvements
X	X	X	Maximize science productivity by controlling or reducing indirect costs	Eliminate costly leased space	(1) Complete ESH&Q Building (11) CEBAF Center Wing D
				Reduce maintenance expenses	(6) New Shipping and Receiving Building (7) New Facilities Operation Building (12) CEBAF Center Renovation
				Reduce utility expenses	(2) Complete Computer Center Efficiency Upgrade (14) Utilities Energy Savings Contract (UESC)

A brief description of the scope and rationale for each project follows:

Cryogenics Infrastructure

The Lab's highest priority is **Central Helium Liquefier (CHL) 1 Sub-atmospheric Cold Box Replacement (SLI-GPP)** for Cold Box 1 in the Central Helium Liquefier (CHL) plant. In the last 24 months, two cold compressors within the cold box have failed resulting in early termination of the CEBAF science program. Cold compressor replacement parts are no longer available due to age of the equipment and TJNAF has repurposed all available spares. The first failed cold compressor was replaced by a spare from SNS while the original equipment manufacturer assessed the reparability of the original compressor, a task that is still continuing without resolution. The cause of the most recent failure is still undetermined but is similar to the first in that the rotating machinery in the compressor seized during spin down. Various options are being evaluated to restore the CHL to operational status in time for the Fall 2017 accelerator run but there is growing evidence the rotating machinery in CHL 1 is approaching end of life and further cold compressor failures may be expected in the coming year or two. Since the procurement and installation of a modern CHL 1 replacement will take between two and three years, immediate action is needed to maintain the planned accelerator operations schedule.

The **End Station Refrigerator 2 (ESR2) (SLI-GPP)** project is needed to provide additional cryogens to three of the four experimental halls to support the more aggressive 12 GeV experimental schedule and detector demand. The scope is to refurbish and install a 4K refrigerator from the Superconducting Super Collider (SSC) project with the associated distribution system, utilities, and controls. The existing End Station Refrigerator is 40+ years old and has insufficient capacity and reliability due to the lack of critical spare parts that are no longer manufactured or available.

Cryogenics Test Facility (CTF) Equipment Recapitalization (Lab GPP) is needed to continue upgrade of equipment critical to support testing for the cryomodule cavity components produced by the Superconducting Radio Frequency (SRF) Institute for Jefferson Lab, other Labs in the Office of Science complex, as well as SPP. The equipment is past its useful life and has been experiencing a higher fail rate. A new 4K cold box and controls were provided under the UIM project providing additional CTF 4K capacity and improved reliability. Additional investments are needed to increase 2K capacity and overhaul/replace aging equipment related to 2K operations. These investments are planned on a not to interfere basis for delivery of LCLS-II cryomodules in order to support anticipated future SRF projects for the DOE National Lab complex.

Office Space

CEBAF Center Renovation (SLI-GPP/Indirect) – The 1988 built structure has been rated as substandard. The mechanical system in this portion of the building has exceeded its service life and is exhibiting high and increasing failure rate. Replacement of major HVAC equipment is required in the near future. Replacement of the HVAC system will require vacating the portion of the building under renovation and removal and replacement of the ceilings. Lab staff and office equipment is currently overflowing into common areas such as corridors, storage rooms, and utility rooms creating egress issues and safety concerns. Reconfiguration of the affected spaces is needed to alleviate many of these conditions. Renovation will meet high performance building standards. The renovation will be executed one wing per year using GPP funds. The atrium/auditorium will be renovated in the fourth year using facility maintenance funds.

CEBAF Center Wing D (SLI-GPP) – CEBAF Center Wing D will be a 14,000 SF addition to CEBAF Center. The Lab is leasing 6,755 SF of office space in the Applied Research Center for the JSA Center for Advanced Studies of Accelerators (CASA) staff and it is necessary to co-locate CASA with Theory, Physics, and Accelerator Divisions in CEBAF. Further, this move will eliminate lease spaced that costs nearly twice the O&M cost of DOE owned facilities at TJNAF. This new addition will accommodate CASA as well as relieve overcrowding in the existing Wings A–C. Construction will meet high performance building standards and contribute to lower recurring utility cost.

<u>High Bay Space</u>

Physics Technical Support Building (Lab GPP) **–** Currently, technical staff and equipment supporting the operations for all four experimental halls are spread among several buildings on the campus and accelerator site. This new building will provide 14,000-16,000 SF of technical and high bay space for fabrication and will improve continuity and efficiency by consolidating these functions in closer proximity to the experimental halls. Additionally, the project resolves space shortages of Engineering Division technical and high bay fabrication space also currently distributed in multiple buildings. For example, Cryogenics Fabrication currently occupies temporary space in the ESR2 Building which is needed for the new ESR2 helium refrigerator plant.

Experimental Equipment Lab Renovation (SLI) - Renovation of the Experimental Equipment Lab building is needed to increase the functionality and utilization of the high bay space as well as to correct substandard mechanical systems, improve efficiency of the building envelop, and correct code deficiencies. The scope of the work will require vacating large portions of the building during the periods of construction. Functions will be temporarily relocated to the newly constructed on-site warehouse to minimize the impact on operations.

<u>Storage Space</u>

Storage Building (Lab GPP) – The Lab currently leases a 9,755 warehouse about 11.5 miles away from the site to store long term need materials and a 9,275 SF warehouse which is leased for LCLS-II. The Lab also has more than 55 shipping containers (totaling 17,000 SF) inefficiently being used for storage. This project would provide a 15,000 SF onsite storage building to replace the offsite warehouses and the shipping containers. The consolidation process for these materials will include validation of future material needs and elimination of unneeded material.

Shipping and Receiving (Lab GPP) – The existing shipping and receiving function is currently located within the Experimental Equipment Laboratory Building (EEL) among Physics technical areas. Relocation of the shipping and receiving function will make available additional technical and high bay space within the EEL Building to support experimental apparatus assembly and will improve campus continuity.

The storage, shipping and receiving, as well as the Facilities Operations Building will be constructed as one building in phases based on Lab annual GPP funding. The storage element will be the first phase of construction.

Facilities Operations Building (Lab GPP) The facilities maintenance shops are currently located in the Forestry Building (2,904 SF) constructed in 1970 which is leased from the Commonwealth of Virginia and is in substandard condition. Adjacent to this building is an unconditioned DOE owned building which is used to store material. Both buildings need to be replaced. The Facilities Operations Building will be constructed as an additional phase/addition to the Storage and Shipping & Receiving building.

Road Improvement (Lab GPP) Reconfiguration and improvements of Lab entrance roads to improve site coordination with adjacent land development.

Anticipated Future (10 Year) Infrastructure Gaps

Additional office space would be required to support additional staffing and scientific community users associated with major science program construction and operation. Space is available to construct a 70,000 SF wing addition on CEBAF Center for offices and meeting space.

The gaps can be closed using a combination of SLI, SLI-GPP, and NP-GPP funding totaling $90M. A majority of the above mentioned gaps can be closed over the next ten years, although using the prescribed funding profile through 2023 and then using $3M per escalated starting in 2024 only results in $81M in funding. These projects will eliminate more than $3.7M of deferred maintenance. Additional estimated funding of $2.0M is expected through a Utility Energy Services Contract to implement energy conservation measures. A well-funded GPP program for a lab the size of Jefferson Lab would be $3-4M per year.

The Lab's Asset Condition Index is 0.99, a rating of excellent. The Lab has averaged 1.5% for maintenance and repair expenditures over the last 5 years. In spite of modest expenditures for maintenance and repair over the last five years (only 1.5% on average), deferred maintenance has decreased from $15.8M to $4.7M through SLI and GPP capital investments and the elimination of temporary facilities. Over the next few years, however, deferred maintenance is expected to increase due to reduced spending as a result of the budget. Additional indirect funding of maintenance and repair is needed to increase total spending to about1.8% to manage this expected deferred maintenance increase.

Electrical, mechanical, and fire protection preventative maintenance costs have decreased through the conversion from contract to in-house resources. Enclosure 2 is the Integrated Facilities and Infrastructure Crosscut Data Table showing planned Lab maintenance and deferred maintenance projections. FY17 is the last year for repayment of the 2002 Bonneville Power Administration financed energy project making the repayment funds available to allocate for repair and maintenance.

The Campus Land Use Plan is shown as Enclosure 3. Enclosure 2 shows the investments needed to implement this Campus Plan. The plan consists of a mix of SLI, infrastructure crosscut, NP-GPP, and alternative financing. NP-GPP funding levels shown were based on the annual NP budget guidance. It is not anticipated there will be any inadequate facilities at the end of the period.

Site Sustainability Plan Summary

Table 4 shows Sustainability Project funding for planned actions to meet DOE Sustainability goals.

Table 4: Summary of Sustainability Project Funding ($K)

Category	FY16 Actual	FY17 Planned	FY17 Projected	FY18 Projected
Total for "Brick and Mortar" Sustainability Projects (do not list specific projects)	3,574	1,500	0	2,000
Sustainability Activities other than "brick and mortar" projects	0	0	0	0
SPO Funded Projects (if any) (SPO funding portion only)	43.6	26.2	0	26.2
Site Contribution to SPO Funded Projects (if any)	0	0	0	0
ESPC/UESC Contract Payments (if applicable)	0	0	0	400
Renewable Energy Credits (REC) Costs	6.6	10	10	15
Total	3,264.2	1,536.2	10	2,441.2

All but two sustainability targets were met this year. Sustainability objectives expected to be below the FY 2017 interim targets are water intensity (interim FY 2017 target -14% relative to 2007 baseline), and energy intensity (interim FY 2017 target - 5% relative to FY 2015).

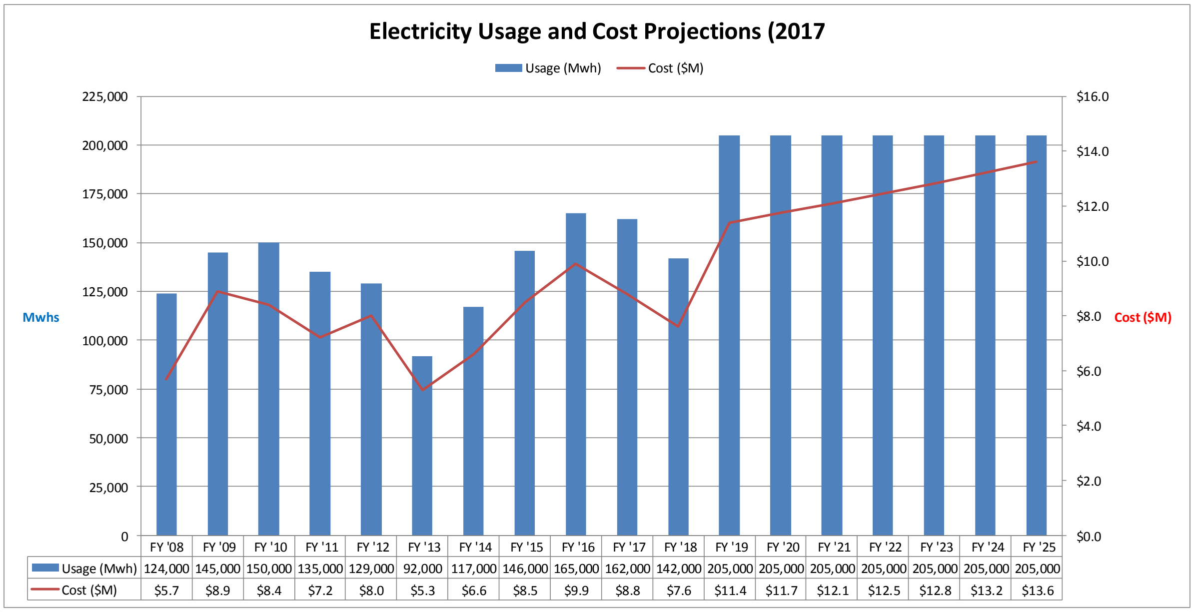
Projects and strategies to achieve future interim targets in both goal categories have been identified, and included in a pending UESC program, and future building renovation plans. Energy intensity (BTU's / GSF) will enjoy significant reduction through high efficiency lighting upgrade focused on goal subject buildings. Reduction of domestic water consumption strategies are included in these same buildings in the UESC and general building renovation plans. The building level energy and water reductions will also contribute to achievement of High Performance Sustainability Building (HBSB) compliance for several additional facilities. To date, the laboratory has exceeded the minimum 15% (by GSF) compliance requirement for HPSB's. Domestic and industrial water reduction projects are included in the UESC set of projects which will contribute to achievement of future interim water intensity targets. Future alternative water strategies are under consideration to achieve a -36% reduction in water intensity (gallons per GSF) by FY 2025.

A previously completed climate change vulnerability assessment identified potential negative site impacts from flooding due to major storm events. Flood protection initiatives have been implemented to protect below grade facilities from potential future flooding.

<u>Electricity Usage and Cost Projections</u>

Figure 1 shows TJNAF's historical electricity usage in (k) Megawatt Hours and costs (Actual year $Million), and future projected electricity usage and costs. Projections based on 12 weeks of accelerator operation using two Central Helium Liquefiers (CHLs) in FY 2018, and 30 weeks in FY 2019 forward per year of operation in subsequent years through FY 2025.

Figure 1: Electricity Usage & Cost Projections



	FY '08	FY '09	FY '10	FY '11	FY '12	FY '13	FY '14	FY '15	FY '16	FY '17	FY '18	FY '19	FY '20	FY '21	FY '22	FY '23	FY '24	FY '25
Usage (Mwh)	124,000	145,000	150,000	135,000	129,000	92,000	117,000	146,000	165,000	162,000	142,000	205,000	205,000	205,000	205,000	205,000	205,000	205,000
Cost ($M)	$5.7	$8.9	$8.4	$7.2	$8.0	$5.3	$6.6	$8.5	$9.9	$8.8	$7.6	$11.4	$11.7	$12.1	$12.5	$12.8	$13.2	$13.6

Enclosure 1: List of DOE/NNSA/DHS Missions

Scientific Discovery and Innovation (SC)

ASCR

1. To develop mathematical descriptions, models, methods, and algorithms to accurately describe and understand the behavior of complex systems involving processes that span vastly different time and/or length scales.

2. To develop the underlying understanding and software to make effective use of computers at extreme scales.

3. To transform extreme scale data from experiments and simulations into scientific insight.

4. To advance key areas of computational science and discovery that further advance the missions of the Office of Science through mutually beneficial partnerships.

5. To deliver the forefront computational and networking capabilities to extend the frontiers of science.

6. To develop networking and collaboration tools and facilities that enable scientists worldwide to work together.

BES

7. Discover and design new materials and molecular assemblies with novel structures, functions, and properties, and to create a new paradigm for the deterministic design of materials through achievement of atom-by-atom and molecule-by-molecule control

8. Conceptualize, calculate, and predict processes underlying physical and chemical transformations, tackling challenging real-world systems – for example, materials with many atomic constituents, with complex architectures, or that contain defects; systems that exhibit correlated emergent behavior; systems that are far from equilibrium; and chemistry in complex heterogeneous environments such as those occurring in combustion or the subsurface

9. Probe, understand, and control the interactions of phonons, photons, electrons, and ions with matter to direct and control energy flow in materials and chemical systems

10. Conceive, plan, design, construct, and operate scientific user facilities to probe the most fundamental electronic and atomic properties of materials at extreme limits of time, space, and energy resolution through x-ray, neutron, and electron beam scattering and through coherent x-ray scattering. Properties of anticipated new x-ray sources include the ability to reach to the frontier of ultrafast timescales of electron motion around an atom, the spatial scale of the atomic bond, and the energy scale of the bond that holds electrons in correlated motion with near neighbors

11. Foster integration of the basic research conducted in the program with research in NNSA and the DOE technology programs, the latter particularly in areas addressed by Basic Research Needs workshops supported by BES in the areas of the hydrogen economy, solar energy utilization, superconductivity, solid-state lighting, advanced nuclear energy systems, combustion of 21st century transportation fuels, electrical-energy storage, geosciences as it relates to the storage of energy wastes (the long-term storage of both nuclear waste and carbon dioxide), materials under extreme environments, and catalysis for energy applications.

BER

12. Obtain new molecular-level insight into the functioning and regulation of plants, microbes, and biological communities to provide the science base for cost-effective production of next generation biofuels as a major secure national energy resource

13. Understand the relationships between climate change and Earth's ecosystems, develop and assess options for carbon sequestration, and provide science to underpin a fully predictive understanding of the complex Earth system and the potential impacts of climate change on ecosystems

14. Understand the molecular behavior of contaminants in subsurface environments, enabling prediction of their fate and transport in support of long term environmental stewardship and development of new, science-based remediation strategies Understanding the role that biogeochemical processes play in controlling the cycling and mobility of materials in the subsurface and across key surface-subsurface interfaces in the environment enabling the prediction of their fate and transport.

15. Make fundamental discoveries at the interface of biology and physics by developing and using new, enabling technologies and resources for DOE's needs in climate, bioenergy, and subsurface science

16. Operate scientific user facilities that provide high-throughput genomic sequencing and analysis; provide experimental and computational resources for the environmental molecular sciences; and resolve critical uncertainties about the role of clouds and aerosols in the prediction of climatic process

FES

17. Advance the fundamental science of magnetically confined plasmas to develop the predictive capability needed for a sustainable fusion energy source
18. Support the development of the scientific understanding required to design and deploy the materials needed to support a burning plasma environment
19. Pursue scientific opportunities and grand challenges in high energy density plasma science to explore the feasibility of the inertial confinement approach as a fusion energy source, to better understand our universe, and to enhance national security and economic competitiveness
20. Increase the fundamental understanding of basic plasma science, including both burning plasma and low temperature plasma science and engineering, to enhance economic competitiveness, and to create opportunities for a broader range of science-based applications

HEP

21. Understand the properties and interactions of the elementary particles and fundamental forces of nature from studies at the highest energies available with particle accelerators
22. Understand the fundamental symmetries that govern the interactions of elementary particles from studies of rare or very subtle processes, requiring high intensity particle beams, and/or high precision, ultra-sensitive detectors.
23. Obtain new insight and new information about elementary particles and fundamental forces from observations of naturally occurring processes -- those which do not require particle accelerators
24. Conceive, plan, design, construct, and operate forefront scientific user facilities to advance the mission of the program and deliver significant results.
25. Steward a national accelerator science program with a strategy that is drawn from an inclusive perspective of the field; involves stakeholders in industry, medicine and other branches of science; aims to maintain core competencies and a trained workforce in this field; and meets the science needs of the SC community
26. Foster integration of the research with the work of other organizations in DOE, in other agencies and in other nations to optimize the use of the resources available in achieving scientific goals

NP

27. To search for yet undiscovered forms of nuclear matter and to understand the existence and properties of nuclear matter under extreme conditions, including that which existed at the beginning of the universe
28. Understand how protons and neutrons combine to form atomic nuclei and how these nuclei have emerged during the 13.7 billion years since the origin of the cosmos.
29. Understand the fundamental properties of the neutron and the neutrino, and how these illuminate the matter-antimatter asymmetry of the universe and physics beyond the Standard Model.
30. Conceive, plan, design, construct, and operate forefront national scientific user facilities for scientific and technical advances which advance the understanding of nuclear matter and result in new competencies and innovation. To develop new detector and accelerator technologies that will advance NP mission priorities
31. Provide stewardship of isotope production and technologies to advance important applications, research and tools for the nation.
32. Foster integration of the research with the work of other organizations in DOE, such as in next generation nuclear reactors and nuclear forensics, and in other agencies and nations to optimize the use of the resources available in achieving scientific goals.

WDTS

33. Increase the pipeline of talent pursuing research important to the Office of Science
34. Leveraging the unique opportunities at DOE national laboratories to provide mentored research experiences to undergraduate students and faculty)
35. Increase participation of under-represented students and faculty in STEM programs
36. Improve methods of evaluation of effectiveness of programs and impact on STEM workforce

Energy Security (ES)

1. Supply - Solar
2. Supply - Nuclear
3. Supply - Hydro
4. Supply - Wind

5. Supply - Geothermal
6. Supply - Natural gas
7. Supply - Coal
8. Supply - Bioenergy/Biofuels
9. Supply - Carbon capture and storage
10. Distribution - Electric Grid
11. Distribution - Hydrogen and Gas Infrastructure
12. Distribution - Liquid Fuels
13. Use - Industrial Technologies (including efficiency and conservation)
14. Use - Advanced Building Systems (including efficiency and conservation)
15. Use - Vehicle Technologies (including efficiency and conservation)
16. Energy Systems Assessment/Optimization

Office of Fossil Energy (FE)

1. Develop cost effective carbon dioxide capture technologies applicable to power generation and industrial sources
2. Develop and demonstrate safe, permanent, cost effective carbon dioxide storage and reuse options.
3. Develop advanced fossil based energy conversion technology, such as oxy-combustion, fuel cells, gasification, supercritical carbon dioxide brayton cycles.
4. Develop crosscutting technologies such as sensors, severe environment material development, and computation modeling tools that support the mission
5. Secure and environmentally sound energy future through responsible production and delivery of our nation's diverse oil and natural gas resources.

Environmental Management (EM)

1. Facility D&D
2. Groundwater and Soil Remediation
3. Waste Processing

Nuclear Energy (NE)

1. Improve the reliability and performance, sustain the safety and security, and extend the life of current reactors by developing advanced technological solutions
2. Meet the Administration's energy security and climate change goals by developing technologies to support the deployment of affordable advanced reactors.
3. Optimize energy generation, waste generation, safety, and nonproliferation attributes by developing sustainable nuclear fuel cycles.
4. Enable future nuclear energy options by developing and maintaining an integrated national RD&D framework.
5. Maintain U. S. leadership at the international level by engaging nations that pursue peaceful uses of nuclear energy

National Security (NNSA)

1. Stockpile Stewardship and Nuclear Weapons Infrastructure
2. Nonproliferation
3. Nuclear Propulsion

Homeland Security (HS)

1. Border Security
2. Cargo Security

3. Chemical/Biological Defense
4. Cyber Security
5. Transportation Security
6. Counter-IED
7. Incident Management
8. Information Sharing
9. Infrastructure Protection
10. Interoperability
11. Maritime Security
12. Human Factors

Office of Technology Transitions (TT)

1. Expand the commercial impact of DOE's research, development, demonstration and deployment portfolio in the short, medium and long-term in order to advance the economic, energy, and national security interests of the country.

2. Increase the commercial impact of DOE investments through the transition of national laboratory-developed technologies into the private sector.

3. Increase the commercial impact of DOE investments through private sector utilization of national laboratory facilities and expertise

Enclosure 2 Laboratory Investments

Thomas Jefferson National Accelerator Facility

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

Planned Capital Investments: (Asterisk denotes infrastructure crosscut proposed project)

(Dollars in Thousands)

Project	Total	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Activity Type	Funding Program	Core Capability
															Select from Drop Down Menu		
Environmental, Safety, Health & Quality (ESH&Q) Building	250		250												GPP	NP	Enabling Infrastructure
Computer Center Efficiency Upgrade	2,250	2,000	250												GPP	NP	Enabling Infrastructure
Cryogenics Test Facility (CTF) Equipment Recapitalization *(a)*	6,867		500	1,012	1,009	1,039	1,070	1,102	1,135						GPP	NP	Accelerator Science & Technology
Physics Technical Support Building	7,748									3,000	3,090	1,658			GPP	NP	Large Scale User Facilities
Storage Building	4,435											1,525	2,910		GPP	NP	Large Scale User Facilities
Shipping & Receiving Building	4,689												368	3,377	GPP	NP	Enabling Infrastructure
Facilities Operations Building	4,900														GPP	NP	Enabling Infrastructure
Road Improvements *(f)*	2,600														GPP	NP	Enabling Infrastructure
Upgrade Cryogenics Infrastructure (CHL 1 Cold Box Replacement)	8,000		8,000												GPP	SLI	Large Scale User Facilities, Accelerator Science & Technology
Upgrade Cryogenics Infrastructure (End Station Refrigerator 2)	8,000				8,000										GPP	SLI	Large Scale User Facilities
CEBAF Center Wing D	6,600					6,600									GPP	SLI	Large Scale User Facilities, Accelerator Science & Technology, Nuclear Physics
CEBAF Center Renovation *(d)*	10,000						10,000								GPP	SLI	Large Scale User Facilities, Accelerator Science & Technology, Nuclear Physics
Experimental Equipment Lab (EEL) Modernization *(e)*	21,000									21,000					LI	SLI	Large Scale User Facilities, Nuclear Physics
Utilities Energy Savings Contract (UESC)	2,000			2,000											AF	--	Enabling Infrastructure

Enclosure 3 – Campus Land Use Plan