Department of Energy Laboratory Plan –TJNAF
June 12, 2012

I. Mission and 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 further 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. At TJNAF, the advancement of SRF technology has enabled the 12 GeV upgrade project to double the energy of CEBAF which is presently underway. In addition, it facilitated the development of TJNAF's Free Electron Laser (FEL) and Energy Recovery Linac (ERL), key future state-of–the–art technologies to support Office of Science projects. TJNAF's present core capabilities are: experimental, theoretical and computational Nuclear Physics; Accelerator Science; Applied Nuclear Science and Technology; and Large Scale User Facilities/Advanced Instrumentation.

The Lab has an international scientific user community of 1,376 researchers whose work has resulted in scientific data from 174 experiments to date, 314 Physics Letters and Physical Review Letters publications and 983 publications in other refereed journals at the end of FY 2011. Collectively, there have been more than 59,000 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 (30 in FY2011; 406 to-date; 180 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)

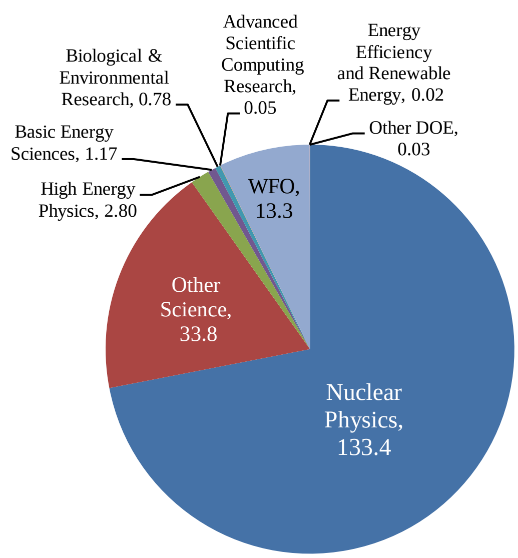
Responsible Site Office: Thomas Jefferson Site Office

Website: http://www.jlab.org

Physical Assets:
- 169 acres in SC buildings and trailers
- 748,888 GSF in 83 SC buildings and trailers
- Replacement Plant Value (RPV): $331M
  - 0 GSF in Excess Facilities
  - 43,645 GSF in Leased Facilities

Human Capital (period ending 9/30/11):
- 769 FTEs
- 22 Joint faculty
- 27 Postdoctoral Researchers
- 14 Undergraduate and 33 Graduate students
- 1,376 Facility Users
- 1,191 Visiting Scientists

FY 2011 Funding by Source: *(Cost Data in $M)*



FY 2011 Total Lab Operating Costs (excl. Recovery Act): $ 185.4M
FY 2011 Total DOE Costs: $ 172M
FY 2011 WFO (Non-DOE/Non-DHS): $13.3M
FY 2011 WFO as % Total Lab Operating Costs: 7.2%
FY 2011 DHS Costs: $ 0
Recovery Act Costed from DOE Sources in FY 2011: $29.1M

III. 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 four major core capabilities meeting these criteria are described below in detail:

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

   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 CEBAF electron beam can be simultaneously delivered to three experimental halls at different energies (currently) up to 6 GeV. 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 over 1,300 users, TJNAF supports one of the largest nuclear physics user communities in the world.

   The experimental nuclear physics program at TJNAF provides unique access to fundamental aspects of hadronic structure, the structure of complex nuclei, hadron formation from colored states, and tests of the standard model of nuclear and particle physics. Thus, the nuclear physics program at TJNAF should be viewed as an integral component of the field of nuclear physics, with important contributions to all major thrusts identified in the 2007 NSAC Long Range Plan, and also the Intensity Frontier of particle physics.

   TJNAF's nearly completed 6 GeV program utilizing the Continuous Electron Beam Accelerator Facility has given the United States leadership in addressing the structure and interactions of nucleons and nuclei in terms of the quarks and gluons of Quantum Chromo Dynamics (QCD). That research program will enable the TJNAF to complete the 8 of 13 OMB/SC milestones for progress in Hadronic Physics. The Nuclear Physics community in the US has acknowledged this leadership and its potential, and indeed the 2007 NSAC Long Range Plan recommends completion of a doubling of the energy reach of CEBAF, the 12 GeV Upgrade, as its highest priority. The science program at 12 GeV represents the realization of major scientific opportunities associated with this priority NSAC recommendation and will enable the completion of 2 of 10 OMB/SC milestones that are part of the initial research program.

   The last decade has seen the development of new theoretical and experimental tools designed to address the nature of confinement and the structure of hadrons comprised of light quarks and gluons in a quantitative way. Together, these will allow both the spectrum and the structure of hadrons to be elucidated in unprecedented detail. New program directions include higher-resolution maps of the nucleon's charge and magnetization distributions and a measurement of the electron's weak charge. 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. Moreover, 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. Going forward, the 12 GeV Upgrade of CEBAF will enable a new experimental program with substantial discovery potential to address these and other important topics in nuclear and hadron physics.

As in all scientific fields, the advancement of experimental nuclear physics requires the development of new experimental tools and techniques. The staff and users of TJNAF have demonstrated exceptional capability to realize scientific progress through new instrumentation and methods. Large acceptance spectrometer systems capable of operation at high luminosity have opened new opportunities to explore the structure of nucleons and test our knowledge of QCD. This program will continue into the future with the upgraded instrumentation associated with the 12 GeV Upgrade project. Another major area of expertise that has been developed is the measurement of small parity-violating asymmetries with high precision. This method has enabled major advances in hadronic structure, the structure of heavy nuclei (through measurement of the neutron radius), and precision tests of the standard model of particle physics. Again, these advances have led to new proposals in all these areas during the upcoming era of 12 GeV operation of CEBAF.

The construction of the 12 GeV CEBAF and associated experimental facilities is currently underway and will be commissioned in 2014-2015. The increased complexity of the accelerator and experimental equipment, including the introduction of a fourth experimental Hall D with its discovery-class program to search for exotic hadronic states of QCD, represent a substantial expansion of the scale of the operations.

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

This program aims to provide comprehensive theoretical effort and leadership across nuclear physics. Support for the experimental program ranges from phenomenological analyses of the nucleon-nucleon interaction, and precise low-energy studies of the Standard Model, to the structure of the nucleon and its excitations, and explorations of the internal landscape of hadrons in terms of momentum, spin and spatial distributions. This internal dynamics is investigated in parallel studies using the methods of both lattice and perturbative QCD, and through phenomenological analyses like that of the EBAC (Excited Baryon Analysis Center) project exploiting the development of appropriate state-of-the-art theoretical tools and technology.

The synthesis of the latest technology with innovative theoretical tools is particularly notable in the area of High Performance Computing in lattice QCD, which focuses on hadronic and nuclear physics. The development and provision of novel software tools (Chroma) and science-optimized hardware (within the national lattice QCD program) have allowed the calculation of observables of direct relevance to the TJNAF experimental program from the spectroscopy of baryons and mesons, including exotics, to form factors and generalized parton distributions. When combined with the power and speed of the dedicated Graphical Processing Unit (GPU) infrastructure, results of unprecedented precision for the hadron spectrum have been produced, as well as the first computations of hadronic scattering amplitudes, with more results to come Half the Theory

Center members are also engaged in phenomenological studies of the physics to be accessed at a future Electron Ion Collider and are finalizing the “white paper” on the physics case. In all aspects, the Theory Center works closely with the experimental community, whether in extracting the properties of nucleon excited states from hadro and photoproduction data, or in studies to constrain generalized parton distribution functions from the full kinematic range of results that TJNAF will produce.

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** (funded by DOE Office of Science – Nuclear Physics, High Energy Physics, Work for Others (NASA, Department of Defense (DOD) – Office of Naval Research (ONR))

SRF R&D

The focus of TJNAF’s Accelerator Science is on superconducting, high current, continuous wave, multi-pass linear accelerators (linacs), including energy recovering linacs. Past achievements and future plans involve the lab’s expertise in three areas, namely, SRF niobium-based accelerating technology, liquid helium refrigeration, and high current, low emittance electron injectors. In particular, TJNAF has extensive expertise in high current photoemission sources, especially polarized sources. This broad suite of capabilities is complemented by world-class expertise in accelerator design and modeling. These strengths support the TJNAF Accelerator Science priorities: the operation and upgrade of the accelerator facilities, the preparation of the future evolution of nuclear physics experimentation at TJNAF, the extension of the accelerator core capabilities and the education of the next generation of accelerator physicists and engineers.

With CEBAF, TJNAF has more integrated operating experience of superconducting linacs (>35%) than any other institution in the world. TJNAF SRF facilities have processed more multi-cell superconducting cavities of multiple types and designs, to consistently higher performance levels than any other facility in the world. TJNAF electron sources and injectors have produced in operations continuous wave electron beams with currents of 180 µA and 89% polarization and unpolarized beams of 9 mA. TJNAF technical infrastructure and staff position us uniquely to design and apply advances in SRF, FEL and injectors, at TJNAF, at other DOE laboratories and at laboratories around the world.

Discussions are presently in progress with all Office of Science projects requiring SRF expertise to determine how TJNAF can support these efforts. The SRF Institute at TJNAF can be a cost-effective R&D partner because of its experience and facilities. Past partnerships include jointly funded R&D and digital RF conductivity with the Facility for Rare Isotope Beams’ (FRIB) predecessor, Rare Isotope Accelerator (RIA), high efficiency cryogenics jointly funded by NASA, high-current cavities funded by ONR, high-voltage electron guns funded by International Linear Collider (ILC), crab cavities funded by the Advanced Photon Source (APS), and R&D on compact light sources funded by BES. Office of Nuclear Physics projects for which partnerships are envisioned are FRIB and for all designs of an electron ion collider (EIC). TJNAF will be processing the half-wave cavities for FRIB and is negotiating the responsibility of assembling the half-wave cryomodules as well. Support for other Office of Science projects would include Project X at Fermilab, the APS Upgrade at Argonne National Lab (ANL), the International Linear

Collider (ILC). Potential for international collaboration exist with the European Spallation Neutron Source (ESS, Sweden) and the MYRRHA Project in Belgium.

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

3. Applied Nuclear Science and Technology

Free Electron Laser (funded by DOD, Office of Naval Research (ONR))

The development of key technologies in accelerator, photon, and detector science at TJNAF established a key skill base enabling the development of other advanced instruments and research tools, namely the Free Electron Laser Facility. Originally commissioned in 1995, it is currently the most powerful Free Electron Laser in the world. Producing up to 14 kW of CW average power in the near infrared regime, the coherent pulses of light have been used for research on such varied topics as the development of a treatment for adult acne, energy loss in semiconductors due to interstitial hydrogen, terahertz imaging for homeland security purposes, and a search for dark matter. The primary funding source for the Infrared (IR) FEL has been the ONR in support of its program to develop a high average power laser for shipboard defense against cruise missiles. That program will continue in an R&D phase for the next several years. TJNAF continues to be involved through Work for Others.

Under separate $12M United States Air Force (AF) funding, a new ultraviolet (UV) FEL system has provided 20 microjoule pulses of 300 nm light at 4.7 MHz repetition rates in 120 fs pulse length trains. The harmonics of that UV FEL at 10 to 13 eV provide fully coherent beams with higher average brightness by a factor of 100 than any 3rd generation storage ring and have the added capability to provide ultra-short pulses to address systems dynamically. The use of narrow-line laser photons in many cases eliminates the requirement for a monochromator giving further advantage over relatively broadband synchrotron sources. The TJNAF UV FEL leads the world in its capability. TJNAF is performing limited work funded by the Commonwealth of Virginia in cooperation with Virginia universities and other national laboratories.

This program has operated synergistically with the Nuclear Physics activities at TJNAF, benefitting from core capabilities such as SRF accelerators (developing high gradient cryomodules partially under BES funding and providing valuable experience in high average current DC injector guns (extending voltage standoff from 320 kV to 500 kV), rf control systems (developing a new digital control system), and beam diagnostics (studying effects which degrade beam brightness such as coherent synchrotron radiation. The advantages of such a high current low energy machine are being studied for possible application to nuclear and high energy physics studies such as the search for massive neutral vector gauge bosons. The FEL effort also developed a new technology deemed critical for one of the two major branches of next generation light sources for DOE: the energy recovery linac (ERL). In the ERL, the electron beam is re-cycled back through the accelerator out of phase with the accelerating field so the beam's energy is extracted back into RF power. This power, which would otherwise be lost, can represent 90% of the input to a high power linear accelerator. TJNAF was the pioneer in developing this technology and its FEL remains the highest power system extant. A number of other laboratories are adopting this technology and NSF is considering the development at Cornell of a very high power system based on such experience. ERL technology is likely to become an important contribution to sustainability initiatives at DOE labs. We are also working with other national laboratories including LBNL to develop accelerator technology and perform beam physics studies relevant to next generation light sources.

<u>Experimental Nuclear Physics (funded by DOE SC – Nuclear Physics)</u>
TJNAF is home to and developer of modern radiation detection, data analysis and imaging techniques, fast electronics and data-acquisition, and data storage capabilities. These capabilities are crucial to the state-of-the-art and to the anticipated experimental nuclear physics program, and underpin the bio-medical applications described below. Scientists and engineers have also developed advanced radiation shielding solutions as part of the Lab's 12 GeV program, including recently-invented and cost-effective hydrogen and boron-enhanced products, particularly well suited for absorbing neutrons.

<u>Radiation Detection and 2D and 3D Imaging in Nuclear, Biomedical and other applications (funded by DOE SC – Nuclear Physics and Biological and Environmental Research)</u>
The TJNAF Radiation Detector and Imaging Group develops, constructs and tests a variety of novel high performance (high resolution and high sensitivity) 2D and 3D single photon, emission computed tomography (SPECT), positron emission tomography (PET), and optical and x-ray computed tomography (CT) imaging systems. These imaging systems are used for a broad variety of applications (beyond nuclear physics research) including: studies of biological function in plants and small animals; motion tracking and imaging, medical preclinical and clinical applications; and the potential for non-destructive evaluation and homeland security applications.

A new compact detector technology called a silicon photomultiplier (SiPM) is a focus at TJNAF. They are planned for nuclear physics detector systems because of their immunity to magnetic fields. Their low profile in terms of compactness and low-voltage requirements give them tremendous potential as photo-sensors for biomedical applications.

TJNAF is using nuclear physics detector technology to develop optimized systems for radioisotope imaging in plants and has developed PhytoPET, a PET imaging methodology for plant research. TJNAF's Radiation Detector and Imaging Group designed and implemented unique imaging tools to aid photosynthesis and sugar transport research in plant biology. The devices are being used to conduct carbohydrate translocation studies in plants under different conditions. This technology has attracted interest from biologists involved in bio-fuel research.

The Applied Nuclear Science and Technology Core Capability serves DOE Scientific Discovery and Innovation mission numbers 9, 14, 26, and 30 from "Enclosure 1: List of DOE/NNSA/DHS Missions."

4. 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. The Continuous Electron Beam Accelerator is housed in a 7/8 mile racetrack and can deliver precise electron beams with energies up to 6 GeV to three experimental End Stations or Halls simultaneously. Hall A houses two high-resolution magnetic spectrometers of some 100 feet length and a plethora of auxiliary detector systems. Hall B is the home of the CEBAF large-acceptance spectrometer with multiple detector systems and some 40,000 readout channels. Hall C boasts an 80 feet long high-momentum magnetic spectrometer and houses 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 Jefferson Lab staff, to facilitate user experiments.

The expertise developed in building and operating CEBAF has led to the design of an upgrade that will double the energy (to 12 GeV) and provide a unique facility for nuclear physics research that will ensure continued world leadership in this field for several decades. This upgrade will add one new experimental facility, Hall D, dedicated to the operation of a hermetic large-acceptance detector for photon-beam experiments. The upgrade will add a new magnetic spectrometer in Hall C, and convert the Hall B apparatus to allow for the higher-energy and higher luminosity operations. Unique opportunities exist in Hall A with the Super BigBite Spectrometer (SBS) and possible, additional dedicated apparatus for one-of-a-kind experiments.

Jefferson Lab 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. In partnership with BNL and scientists and engineers world-wide, TJNAF scientists and engineers are thus leading the conceptual design of a powerful electron-ion collider that has been identified as a major opportunity to advance the field beyond the 12 GeV Upgrade. With the completion of the 12 GeV Upgrade and the foreseen electron-ion collider, TJNAF will continue its role of the world's premier experimental QCD facility. The ability to use the existing FEL 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 FEL and Nuclear Physics.

<u>Accelerator Science (funded by DOE SC – BES, DOD – ONR</u>)

SRF Production
TJNAF has developed state-of-the-art instrumentation for R&D, design, fabrication, chemical processing, and testing of superconducting RF cavities. This complete concept-to-delivery capability is unique in the world. All of these capabilities are essential to the development, deployment, commissioning and operation of the CEBAF 12 GeV Upgrade project. The addition of TJNAF's Technology and Engineering Development Facility (TEDF), currently nearing completion, will provide 100,000 additional square feet that will enhance and collocate all SRF operations elements and will provide additional experimental assembly space. It will also provide configurable space that can be adapted to work on different kinds of SRF cavities as TJNAF's portfolio of projects expands.

Cryogenics
TJNAF's renowned cryogenics staff operates and improves the laboratory's three large 2K cryogenic plants that support CEBAF operations and SRF production. This plant count will soon increase to five plants as the 12 GeV upgrade becomes operational. These plants utilize patented cryogenic cycles developed by TJNAF that increase efficiencies up to 30% more than what was traditionally available from industry. Extensive operations experience has allowed the group to develop controls technologies and techniques that permit year round, unattended operations that drastically decrease staffing needs traditionally required for operations of this magnitude.
These control and cycle technologies have been applied to other DOE facilities, notably to RHIC at Brookhaven and NASA's Johnson Space Center where the technology is being applied to a 12.5kW refrigerator at 20K for a space effects chamber to test the James Webb telescope. Recently, the group was asked to help guide the design, procurement and commissioning of the

refrigerator supporting the FRIB machine at Michigan State University. Nationwide, this group is the 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 Strategy for the Future/Major Initiatives

Science in the 21st Century is making enormous advances on several fronts in physics, chemistry, biology and other subjects through the research capabilities provided by advanced accelerator facilities and their operation as international user facilities. 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. Based on the studies made under the auspices of both the Nuclear Science Advisory Committee (NSAC) and the Basic Energy Sciences Advisory Committee (BESAC), TJNAF has identified areas in nuclear physics photon science, and high energy physics where it can directly provide world leading facilities and expertise to meet the identified needs of the research community. In addition, it has identified collaborative roles that it can play in the provision of facilities elsewhere associated with the Office of Science (Basic Energy Sciences, High Energy Physics and Nuclear Physics) and other agencies.

The nuclear physics program being pursued by more than 1,300 staff and users is currently dominated by a series of key experiments using the Continuous Electron Beam Accelerator Facility operating at energies up to 6 GeV. Among the incisive measurements underway is a measurement of the weak charge of the proton. The motivation and interpretation of these experimental studies is underpinned by theoretical studies using state-of-the-art calculational techniques in QCD both on the lattice and in the continuum, as well as precision photon-Z boson radiative corrections to experiments like Qweak. A major goal of the laboratory is to execute the 12 GeV Upgrade Project. This project, which was identified as the highest priority for the field of Nuclear Physics by the 2007 NSAC Long Range Plan, is currently under construction and will be commissioned in 2014-2015. This will allow a unique 3D map of the valence quarks and extend the earlier studies to comprehensively describe the valence quark momentum and spin distributions in nucleons and nuclei. New opportunities to discover heretofore unobserved hadron states predicted by quantum chromodynamics will become available. Higher precision measurements of the weak couplings of elementary particles will be accessible through measurements of parity violating asymmetries. Lepton scattering has proven to be and continues to be a powerful tool in the elucidation of the structure of the subatomic world, and a future electron-ion collider with high luminosity could provide new opportunities to explore hadronic structure in a region dominated by the quark-antiquark sea and by gluons.

Details on each of the components of TJNAF's scientific strategy and major initiatives follow. Currently structured as a program-dedicated laboratory, a Laboratory Directed Research and Development (LDRD) program does not presently exist but is in preparation.

V. Infrastructure/Mission Readiness

Overview of Site Facilities and Infrastructure

TJNAF is located on a 169 acre federal reservation. North of the DOE-owned land is an eight acre parcel referred to as the Virginia Associated Research Campus (VARC) which is owned by the Commonwealth of Virginia and leased to SURA which, in turn, sub-leases this property for $1 dollar per year to DOE for use in support of the Lab. SURA owns 37 acres, adjacent to the TJNAF site, where it operates a 42-room Residence Facility at no cost to DOE.

TJNAF consists of 66 DOE owned buildings (725,218 SF), two state leased buildings (37,643 SF), and 17 real property trailers (23,670 SF) totaling 786,531 SF, plus roads and utilities. Additionally, the Lab leases office and lab space (44,622 SF) from the City of Newport News located in the Applied Research Center (ARC), which was constructed by the City of Newport News and adjacent to the TJNAF campus. In addition to these facilities, TJNAF has 1 leased trailer (1,415 SF), 74 shipping containers (23,200 SF) used for storage, and 19,030 SF of off-site leased storage space. The Lab will continue efforts to consolidate leased and trailer office space with the elimination of 14,200 SF of leased office space in FY13 and 16,290 SF of trailers in FY15. In addition, the Lab plans to eliminate 7,000 SF of off-site leased warehouse space in FY13 and 20,000 SF of on-site shipping containers used for storage by FY16. These projects are supported by GPP funding. There were no real estate actions in FY 2011 or planned for FY 2012 involving leases of more than 10,000 SF. At the close of FY 2011, ~832 employees were employed and occupying site facilities. Each day, TJNAF hosts on average, ~100 users from the United States and around the world.

The Lab has a shortage of technical, storage and administrative space. The Lab recently moved into the new 74,000 SF Technology and Engineering Development (TED) Building and 47,000 SF Test Lab Addition constructed under the Science Lab Infrastructure (SLI) program. Projects are identified to resolve the remaining space issues. The Test Lab, a 47 year old NASA facility has the largest amount of deferred maintenance of any Lab building, the majority of which will be corrected as part of the Test Lab Rehabilitation (SLI) project currently underway. Accelerator Site electrical distribution and cooling towers have reached the end of their service life. Communications, computing air conditioning and power, and the Cryogenics Test Facility serving the Test Lab have reached their capacity and need to be expanded to meet the Lab's mission. The Utilities Infrastructure Modernization (SLI) project planned for FY13-14 funding will correct these deficiencies. The UIM project was granted CD-1 on October 14, 2010.

A current copy of the Land Use Plan can be can be found on the TJNAF Facilities Management website. Table 1 reflects an Asset Condition Index as of 1 October 2011 that meets the current goal established by DOE SC for Mission Critical Facilities. Mission Dependent Facilities are below the established goal due to aging real property trailers. Through GPP and SLI investments, TJNAF will achieve the SC goal for Mission Dependent Facilities by FY 2013. The site wide Asset Utilization Index is ~ 100% and has been since construction of the Lab. In most areas space is not adequate to accommodate an efficient work environment.

Table 1. SC Infrastructure Data Summary

Total Replacement Plant Value ($)		$ 331,123,966		
Total Deferred Maintenance ($)		$ 15,876,228		
Site-Wide ACI (B, S, T)		0.952		
			# Assets (B, S, T)	GSF (B, T)
Asset Condition Index (B, S, T)	Mission Critical	0.958	57	648,787
	Mission Dependent	0.865	45	100,101
	Not Mission Dependent	0.000	0	0
			# Assets (B, T)	GSF (B, T)
Asset Utilization Index (B, T)	Office	100	22	176,372
	Warehouse	100	19	72,561
	Laboratory	100	42	499,955
	Hospital	0	0	0
	Housing	0	0	0
B = Buildings; S = Structures; T = Trailers				

Facilities and Infrastructure to Support Laboratory Missions

The completion of the 12 GeV Upgrade, scheduled for FY 2016, adds a fourth experimental hall along with upgrades to existing halls and will provide TJNAF users with state-of-the-art facilities necessary to advance science in support of DOE SC goals. Additionally, completion of the Technology and Engineering Development Facility (TEDF), scheduled for FY 2013, will provide a first rate facility for the advancement of research and development in superconducting radio frequency (SRF) technology. While support facilities and infrastructure are not mission-ready today, completion of the Utilities Infrastructure Modernization SLI project in 2015 and the Research and User Support Facility in 2020 will enable TJNAF to meet its current modernization goals.

TJNAF assesses the condition of its facilities on a four year cycle using a software package called "VFA Facility" that is offered by Vanderweil Facility Advisors (VFA). Overall, the condition of the facility infrastructure is good. There are, however, shortages in office and technical work space. Currently over 26,500 square feet of leased and owned temporary trailers are used to provide both office and technical space. GPP and SLI funded projects have been identified in the Lab's Ten Year Facilities Plan to provide 156,000 SF of additional space to correct these shortages and eliminate temporary trailers.

A Mission Readiness Peer Review of TJNAF was held in September 2010 with a very favorable outcome. The review did not report any findings and identified three opportunities for improvement. The Mission Readiness assessment of technical and support facilities and infrastructure is summarized in Enclosure 2. TJNAF is seeking DOE support for two SLI line item projects; the Utilities Infrastructure Modernization Project, currently in the SLI funding profile for a 2013 start and the Research and User Support Facility currently in the SLI funding profile for a 2019 start. Completion of these projects will upgrade critical site support utilities and allow consolidation of staff currently in leased space, provide additional conference space and bring the buildings up to desired sustainability and aesthetic standards.

Strategic Site Investments.

- **12 GeV Conventional Facilities (Line Item)** Conventional facilities required for construction, pre-operation, and some operations of CEBAF at 12 GeV are included as part of the 12 GeV CEBAF Upgrade project. The conventional construction includes 36,400 SF of new space including an extension to the tunnel, and fourth experimental hall.
- **Technology & Engineering Development Facility (SLI) (CD-4A)** The project renovates the current Test Lab (about 95,000 square feet), removes over 10,000 SF of inadequate and obsolete work space in and adjacent to the Test Lab, and removes 12,000 SF of dilapidated trailers that do not meet current commercial standards. The project include**s** construction of a new building and a building addition which will add over 121,000 SF of needed workspace for critical technical support functions, including mechanical and electrical engineering, cryogenics engineering and fabrication, and environment, safety, and health. The project has been submitted as two Leadership in Energy and Environmental Design (LEED) projects (Technology and Engineering Development Building and Test Lab Addition/Rehab) with the design goal of achieving, LEED Gold (second highest designation). Energy savings from the Test Lab Renovation are estimated at 762,570 kWh/yr of electricity and 7,437 therms of natural gas for a total of utility cost savings of $52,000/year.
- **Utilities Infrastructure Modernization Project (SLI) (CD-1)** This project replaces or upgrades the following utility systems:

  - Electrical Distribution: Replace accelerator site primary and secondary electric feeders.
  - Process Cooling: Replace/upgrade 20 to 40 year old site cooling towers serving the Accelerator Site Low Conductivity Water (LCW) systems and provide additional computer center cooling and uninterruptable power.
  - Cryogenics: Upgrade Cryogenics Test Facility adjacent to the Test Lab (TEDF) to fully support SRF and FEL R&D and experimental hall operations.
  - Communications: Replace 20 to 40 year old underground communications and data cabling and equipment.

  The project is programmed for funding in FY13 and FY14.
- **Research and User Support Facility (SLI)**

  This project funds the modernization of, and additions to, the CEBAF Center, which is the hub of the Lab. Construction includes two additional wings (95,000 SF) and the rehabilitation of 67,300 SF of space in the building. The project alleviates overcrowding of personnel, relocates staff and users currently occupying leased space, accommodates planned staff growth needed for the additional 12 GeV experimental hall and reduces leased space in the Applied Research Center and in commercial storage warehouses. The project will be designed and constructed to meet guiding sustainable principles and reduce energy consumption of the existing building by 30%.

- **Maintenance Strategy**

  TJNAF utilizes small business subcontractors to perform the majority of facility maintenance tasks. Maintenance investment will continue at a level to maintain the facilities mission ready. The Lab has developed SLI or GPP projects to significantly reduce deferred maintenance. It is estimated the TEDF and UIM projects will eliminate over 60% of the Lab's deferred maintenance associated primarily with the rehabilitation of the Test Lab and elimination of temporary trailers. The Lab has a trailer disposal plan to replace trailers with permanent building space.

- **Excess Facility/Material/Environmental**

  TJNAF does not have any excess facilities or environmental issues. TJNAF recycled over 1,800 tons of concrete blocks from the Test Lab Building from when it was operated as the NASA Space Radiation Effects Laboratory (1964 to 1984). The Lab has an active metal recycling program with more than 334,876 pounds recycled during FY 2011.

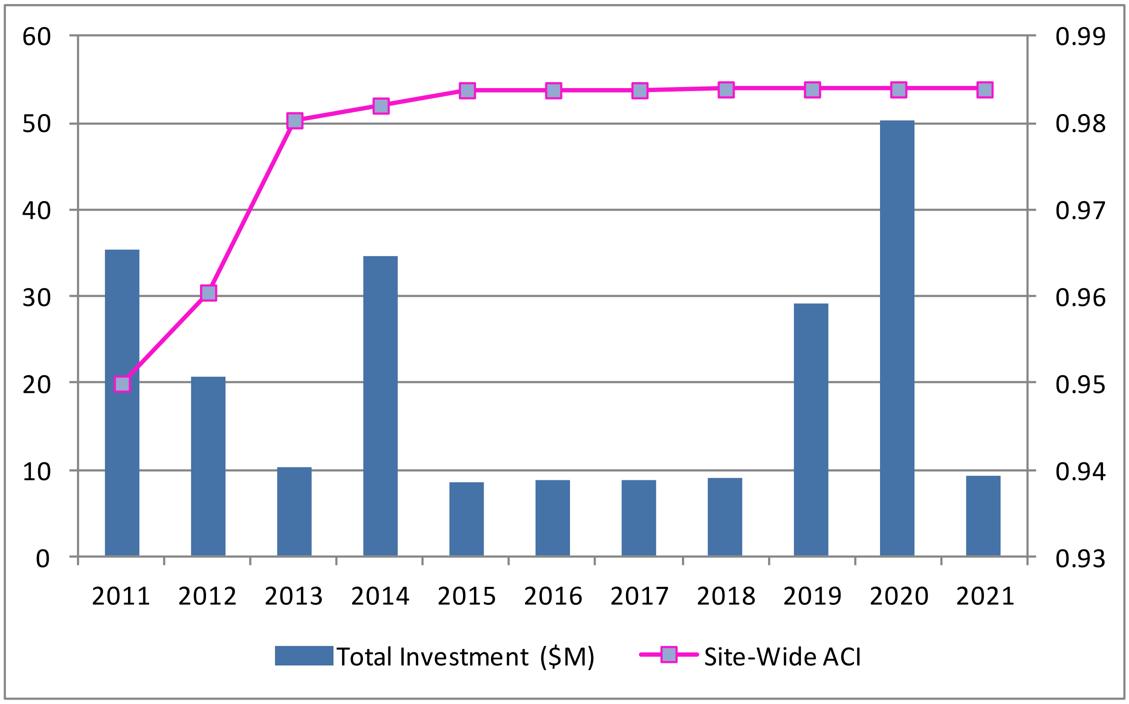
Trends and Metrics

Table 2 shows the Lab's planned infrastructure investment and the positive impact on the Asset Condition Index (ACI) and level of deferred maintenance (DM). Figure 1 depicts site wide ACI and infrastructure investments. Planned projects would allow the Lab to reach and sustain a DOE performance rating of "Excellent" by FY 2013. TJNAF facilities are expected to be mission ready upon completion of the projects identified in the Ten Year Site Plan.

Table 2. Facilities and Infrastructure Investments (BA in $M)

	2011 Actual	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Maintenance ($M)	5.2	5.3	5.4	5.5	5.6	5.7	5.9	6.0	6.1	6.2	6.3	6.5
Deferred Maintenance Reduction	0	0	0	0	0	0	0	0	0	0	0	0
Excess Facility Disposition	0	0	0	0	0	0	0	0	0	0	0	0
IGPP	0	0	0	0	0	0	0	0	0	0	0	0
GPP	1.8	3.2	2.5	2.5	3	3	3	3	3	3	3	3
Line Items	28.4	12.3	2.5	26.7	0	0	0	0	20	41	0	0
Total Investment	35.4	20.8	10.4	34.7	8.6	8.7	8.9	9.0	29.1	50.2	9.3	9.5
Estimated RPV		414	426	439	454	467	481	499	514	529	545	561
Estimated DM		16	8	8	7	8	8	8	8	9	9	9
Site-Wide ACI		0.96	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98

Figure 1. Facilities and Infrastructure Investments



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

Environmental Management (EM)

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

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

Enclosure 2 – Facilities Mission Readiness by Core Capability

Core Capabilities		Mission Ready Assumes TYSP Implemented				Key Buildings	Facility and Infrastructure Capability Gap	Action Plan	
								Laboratory	DOE
		N	M	P	C			GPP	
Nuclear Physics	Now			X		• Central Helium Liquefier • Access Bldgs • Test Lab • Counting House • Experimental Equipment Laboratory (EEL) • End Station Refrigerator • Accelerator Tunnel	• Inadequate: Technical & Experimental Assembly Space • Inadequate Service Bdgs • Deferred Maintenance • Building Code Deficiencies	• Counting House Sustain. Improvements (FY12-14) • Service Bldg 68 Addition (FY12) • Relocate Shipping & Receiving from EEL (FY18-19) • Experimental Equipment Laboratory Rehab (FY 19-21)	• 12 GeV Conventional Facilities (LI) FY 08-13 • Technology & Eng. Development Facility (SLI) FY 09-12
	In 5 Years				X				
	In 10 Years				X				
Accelerator Science	Now			X		• Test Lab • Cryogenics Test Facility	• Inadequate Work Space • Aging Facilities • Inadequate Utility Capacity	• Injector & Cryomodule Test Facility (FY 14)	• Technology & Eng. Development Facility (SLI) FY 09-12 • Utilities Infrastructure Modernization -(SLI) FY 13-14
	In 5 Years				X				
	In 10 Years				X				
Applied Nuclear Science & Technology	Now			X		• Free Electron Laser • Experimental Equipment Laboratory (EEL) • NN Applied Research Center	• Inadequate Technical Space • Assembly • Staging	• Experimental Equipment Laboratory Rehab (FY 19-21) • FEL Offices (FY-21+)	
	In 5 Years				X				
	In 10 Years				X				
Large Scale User Facilities - Advanced Instrumentation	Now			X		• Experimental Halls • Experimental Equipment Laboratory (EEL) • CEBAF Center	• Inadequate experimental halls for program • Inadequate experimental work support and space • Inadequate work space for scientists & users		• 12 GeV Conventional Facilities (LI) FY 08-13 • Technology & Eng. Development Facility (SLI) FY09-12 • Research and User Support Facility **(SLI) FY19-20**
	In 5 Years			X					
	In 10 Years				X				

N = Not, M = Marginal, P = Partial, C = Capable S= Stimulus GPP, LI=Line Item, SLI= Science Lab Infrastructure, UIM=Utilities Infrastructure Modernization

Enclosure 2 – Facilities Mission Readiness by Core Capability

Support Facilities and Infrastructure -- Assumes TYSP Implemented

Real Property Capability	Mission Ready Current				Facility and Infrastructure Capability Gap	Action Plan	
						Laboratory	DOE
	N	M	P	C		(GPP Funding)	
Work Environment			X		• Insufficient Offices • CEBAF Center Bldg systems at end of service life • No recreational/fitness facilities • Cafeteria undersized	• FEL Offices (FY 21+) • Sustainability Improvements Technical Support Bldgs (FY13-16)	• TEDF (SLI) FY09-12 • Research and User Support Facility (SLI) FY19-20
User Accommodations			X		• No visitor center	• Visitor Center (FY21-22)	
Site Services			X		• Poor location of RADCON Calibration Facility • Limited Computer Center Cooling • Unconsolidated of Facility Storage • Inadequate Site Laydown Area	• RADCON Calibration Facility (FY16) • Relocate Shipping & Receiving (FY15-17) • Expand Central Material Storage Area (FY22)	• UIM(SLI) FY 13-14
Conference and Collaboration Space			X		• Insufficient conference/collaboration space • Auditorium too small		• Research and User Support Facility (SLI) FY19-20
Utilities			X		• Aging electrical distribution • Aging Cooling water systems • Complete fire protection loop • Aging/inadequate comms/data • Insufficient cryogenics • Sustainability	• 40 MVA Substation (FY13) • VARC Sustainability Improvements (FY13) • Fire Protection Upgrade (FY 14) • Fire Prot Loop (FY-15)	• UIM(SLI) FY 13-14
Roads & Grounds			X		• Stormwater Mgmt Shortfalls • Parking Shortage	• Storm water (FY15) • Parking Improvements (FY18)	

N = Not, M = Marginal, P = Partial, C = Capable
TEDF = Technology & Engineering Development Facility
CCA&R = CEBAF Center Addition and Renovation
UIM=Utilities Infrastructure Modernization

Enclosure 3: Site Plan

Lab Site Map – Planned Infrastructure Projects