

Department of Energy Laboratory Plan –TJNAF

June 6, 2011

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 utilize its unique Continuous Electron-Beam Accelerator Facility (CEBAF) 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 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 technologies for future state-of-the-art light sources. 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 user community of 1,356 researchers whose work has resulted in scientific data from 172 experiments to date, 289 Physics Letters and Physical Review Letters publications and 889 publications in other refereed journals at the end of FY 2010. Collectively, there have been over 30,000 citations for work done at Jefferson Lab.

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 (25 in FY 2010; 419 to date, 204 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, VA

Type: Program-Dedicated Lab

Contract Operator: Jefferson Science Associates, LLC (JSA)

Responsible Site Office: Thomas Jefferson Site Office

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

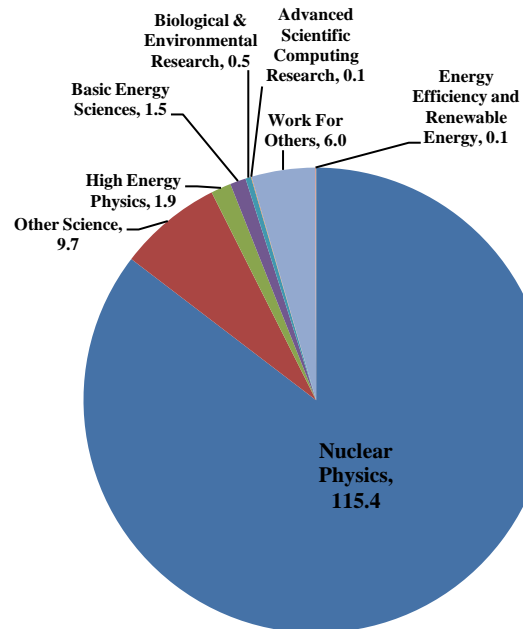
Physical Assets:

- 169 acres and 79 buildings and trailers
- 703,582 GSF in buildings and trailers
- Replacement Plant Value (RPV): \$316.9M
- Deferred Maintenance: \$15.6M
- Asset Condition Index (ACI):
 - Mission Critical 0.96 (Good)
 - Mission Dependent 0.84 (Fair)
 - Asset Utilization Index: 97.4

Human Capital:

- 763 FTEs (at 3/15/11)
- 23 Joint faculty
- 25 Postdoctoral Researchers
- 14 Undergraduate and 30 Graduate students
- 1,356 Facility Users
- 1,188 Visiting Scientists

FY 2010 Funding by Source: (Cost Data in \$M)



FY 2010 Total Lab Operating Costs: \$ 135M

FY 2010 Total DOE Costs: \$ 129M

FY 2010 WFO (Non-DOE/Non-DHS): \$6M

FY 2010 WFO as % Total Lab Operating Costs: 4.4%

FY 2010 DHS Costs: \$ 0

Recovery Act Obligated from DOE Sources in FY 2010: \$0

Recovery Act Costs from DOE Sources in FY 2010: 43.5M

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 unique in the world as a user facility for studies of the quark structure of matter using continuous beams of high-energy, polarized electrons. Its detector and data acquisition capabilities, when coupled with the high-energy electron beams, provide the highest luminosity (10^{39} /eN/cm²/s) capability in the world. TJNAF supports one of the largest nuclear physics user communities in the world. The scientific program aims for excellence and pre-eminence in a number of key areas of nuclear physics. These include:

- a) the structure of hadrons – especially the nucleon's charge and magnetization distributions including the separation in individual quark contributions, the exploration of the degrees-of-freedom governing baryon excitation, the momentum and spin distributions of valence quarks, and the experimental and theoretical tools necessary to carry out a program of nucleon tomography;
- b) the structure of nuclei – including that due to the short-range component of the nucleon-nucleon interaction, the neutron radius of ²⁰⁸Pb, and the underlying quark-gluon structure of the nucleus; and
- c) Tests of fundamental symmetries in nuclear and particle physics, such as the determination of the weak charges of the proton and the electron, tests of the predictions of the Standard Model and the search for its possible extensions.

Theoretical & Computational Nuclear Physics

The 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 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 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. TJNAF's Jozef Dudek (joint appointment with Old Dominion University) received the DOE SC Early Career prize for his research on subatomic particle structure using lattice QCD in May of 2011. 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 contributing to 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, and 35 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))

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 are based on the lab's expertise in three fields, namely, SRF niobium-based accelerating technology, liquid helium refrigeration, and high current, low emittance electron injectors. This expertise, complemented by a talented group of accelerator scientists, supports the five TJNAF Accelerator Science priorities: the 12 GeV CEBAF Upgrade, continued 6 GeV operation, positioning TJNAF for a future beyond 12 GeV, a world-class light source based on a Free Electron Laser (FEL) and Energy Recovering Linac (ERL), and graduate and undergraduate education. Pavel Evtushenko was awarded a DOE SC Early Career prize for his research at TJNAF's FEL to develop high dynamic range diagnostics for linear particle accelerators in May, 2011. The prestigious APS Robert R. Wilson prize for Achievement in the Physics of Particle Accelerators was awarded to TJNAF's accelerator physicist, Yaroslav Derbenev for 2011.

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 continuous wave electron beams with currents of 170 μ A and 89% polarization and unpolarized beams of 9 mA. TJNAF cryogenics staff has received numerous awards for improving the efficiency of cryogenic plants at NASA and at other DOE facilities, notably at Relativistic Heavy Ion Collider of Brookhaven National Laboratory (BNL). Our patented cryogenic operating cycles have been licensed to a commercial vendor for all of their existing and future plants. 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.

All Office of Science projects requiring SRF expertise are currently under discussion 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), and crab cavities funded by the Advanced Photon Source (APS). Office of Nuclear Physics projects for which partnerships are envisioned are FRIB and all versions of an electron ion collider (EIC). Support for other Office of Science projects would include the Spallation Neutron Source (SNS) Power Upgrade Project (PUP), Project X at Fermilab, APS Upgrade at Argonne National Lab (ANL), and International Linear Collider (ILC).

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 >\$4M p.a. from ONR; total investment >\$110M)

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 has now entered a new phase with technology transfer to industry happening as the applications move from the laboratory to the field. TJNAF continues to be involved through Work for Others.

During the last year 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 again in 120 fs pulse 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 has transported the VUV beam and measured its power in the laboratory in preparation for some demonstration experiments planned for summer 2011. Such experiments are intended to demonstrate the usefulness of such a machine and its potential for science relevant to Basic Energy Sciences (BES) programs. Specific activities are directed at temporally resolved studies of combustion dynamics in diesel engines performed by researchers from Sandia National Laboratory, studies of long-lived trace isotopes using atomic trap trace analysis (ATTA) for dating ancient groundwater by PI from ANL and work on angular resolved photoemission studies (ARPES) by a group from Brookhaven National Laboratory.

This program has operated synergistically with the Nuclear Physics activities at TJNAF, benefitting from core capabilities such as SRF accelerators (developing high gradient modules

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 CSR). It also developed a new technology deemed critical for one of the two major branches of next generation light sources for DOE: the ERL. In the ERL, the electron beam is recycled 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. This development is an enabling technology for next generation machines which will produce ultra-short pulses of X-rays for studies into materials as outlined in "Directing Matter and Energy: Five Challenges for Science and the Imagination, a report from the DOE Basic Energy Sciences Advisory Committee". 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.

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

TJNAF is home to and developer of state-of-the-art 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 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.

Radiation Detection and 2D and 3D Imaging in Nuclear, Biomedical and other applications (funded by DOE SC – Biological and Environmental Research)

The Jefferson Lab 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 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. Silicon photomultipliers were explored at Jefferson Lab for nuclear physics detector systems because of their immunity to magnetic fields and have potential for highly compact photosensors for biomedical applications.

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

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

TJNAF is the world's leading user facility for studies of the quark structure of matter using continuous beams of high-energy, polarized electrons. 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 a proposed large-acceptance magnetic spectrometer and possible dedicated apparatus for one-of-a-kind experiments.

Jefferson Lab staff has gained the unique 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 many believe will be needed to advance the field beyond the 12 GeV Upgrade.

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.

Accelerator Science (funded by DOE SC – BES, DOD – ONR)

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. In addition, TJNAF has extensive expertise in high current photoemission sources, especially polarized sources. This broad suite of hardware capabilities is complemented by world-class expertise in accelerator design and modeling. (It should be noted that Jefferson Lab accelerator physicist Yaroslav Derbenev received the 2011 APS Robert R. Wilson prize Achievement in the Physics of Particle Accelerators.) 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 under construction, 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.

In addition, this expertise can be available to other projects within the Office of Science, and also around the world. For example, the extensive experience of TJNAF in the design and construction of high current ERLs, in combination with the world leading capabilities in accelerator science and superconducting radiofrequency techniques, mean that TJNAF is making a major contribution to the design and construction of future large scale user facilities in BES, especially 4th generation light sources.

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. This core competence is dominated by the employment of superconducting radio frequency techniques in multiple pass linear accelerators, energy recovery linear accelerators and free electron lasers. 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 and in photon science where it can directly provide world leading user facilities meeting 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 2013-2015. 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 be opened. Measurements of the weak couplings of elementary particles are accessible through measurements of parity violating asymmetries. Lepton scattering has proven and continues to be a powerful tool in the elucidation of the structure of the world, and a future electron-ion collider with high luminosity could provide the opportunity to explore hadronic structure in a region dominated by the quark-antiquark sea and by gluons.

The existing free electron laser facilities at TJNAF employ a single pass electron linear accelerator followed by combinations of undulator and optical cavities. Energy recovery occurs on a second (out of phase) passage down the linac. The existing facility is set up to operate in the infrared or the ultra-violet regime. A design has been developed to install the capability to accelerate to 300 MeV in one pass and using two passes of acceleration and two passes of deceleration, to generate a continuous wave, coherent, short pulse photon beam with energies up to 100 eV and beyond in the soft X-ray region. There is no comparable facility currently available in the world. This would provide an exciting platform for photon science and would enable the studies of accelerator science needed to underpin the design of a large scale next (4th-generation light source).

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 60 DOE owned buildings (684,832 SF), two state leased buildings (37,643 SF), and 15 real property trailers (18,750 SF) totaling 741,225 (SF), plus roads and utilities. Additionally, the Lab leases office and lab space (44,280 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 72 shipping containers (22,080 SF) used for storage and 19,030 SF of off-site leased storage space. There were no real estate actions in FY 2010 or planned for FY 2011 involving leases of more than 10,000 SF. At the close of FY 2010, ~820 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 currently has a shortage of technical and office space. The Test Lab has the largest amount of deferred maintenance of any Lab building. 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.

A current copy of the [Land Use Plan](#) can be found on the TJNAF Facilities Management website. Table 1 reflects an Asset Condition Index as of 1 October 2010 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 2015. 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 (\$)		\$316,910,947		
Total Deferred Maintenance (\$)		\$15,556,758		
Site-Wide ACI (B, S, T)		0.951		
			# Assets (B, S, T)	GSF (B, T)
Asset Condition Index (B, S, T)	Mission Critical	0.961	54	633,977
	Mission Dependent	0.844	41	69,605
	Not Mission Dependent	0.000	0	0
			# Assets (B, T)	GSF (B, T)
Asset Utilization Index (B, T)	Office	100	19	171,122
	Warehouse	92.06	10	45,315
	Laboratory	100	35	452,079
	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 2015, 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 the support facilities and infrastructure are not mission-ready today, the completion of the TEDF, the Utilities Infrastructure Modernization SLI project and the Research and User Support Facility would enable TJNAF to meet its current modernization goals by 2017.

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 technical and experimental assembly work space. Currently over 18,750 square feet of 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 correct these shortages and eliminate temporary trailers. The Experimental Staging Facility, General Purpose Building Expansion, 4 KW End Station Refrigerator Building, installation of a new 22 MVA substation, and replacement of the Test Lab Cooling Towers completed in 2010 provided some of the needed critical infrastructure. Completion of the 12 GeV and TEDF projects will provide an additional 154,000 SF of technical and experimental space. In addition to space provided by these two projects, the Ten Year Facilities Plan identifies 102,000 SF of additional needed technical, office, or support space.

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 and the Research and User Support Facility currently in the SLI funding profile for 2013. 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, a fourth experimental hall, and upgrades to Halls A, B and C.
- **Technology & Engineering Development Facility (SLI) (CD-3B)** 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 includes construction of a new building and a building addition which will add over 117,000 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 and provide an alternate power feed capable of restarting the Central Helium Liquifier (CHL).
 - 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.

This project initially programmed for FY 2011-13 funding has been delayed. The Lab has requested FY 2013 funding for this critical project.

- **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 LEED Gold standards 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 70% 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. The Lab is in the process of recycling 130 concrete blocks from the Test Lab Building from when it was operated as the NASA Space Radiation Effects Laboratory (1964 to 1984). DOE recently determined that these blocks are not subject to the moratorium on the release of radioactive material. The plan is to recycle these blocks during FY 2011. The Lab has an active metal recycling program with more than 80,000 pounds recycled during the first half of FY 2011.

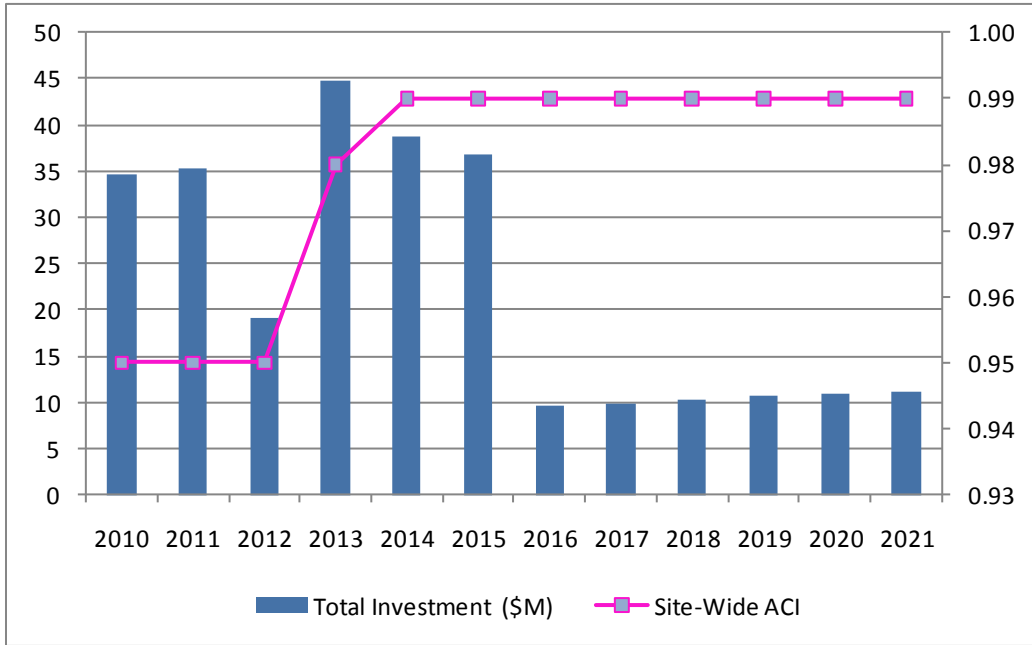
Trends and Metrics

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)

	2010 Actual	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Maintenance	4.9	4.2	4.7	5.2	5.7	6.0	6.6	6.8	7.0	7.3	7.5	7.7
Deferred Maintenance (DM) Reduction												
Excess Facility Disposition (overhead)	-	-	-	-	-	-	-	-	-	-	-	-
IGPP	-	-	-	-	-	-	-	-	-	-	-	-
GPP	2	2.5	2.2	4.6	3.1	3.1	3.1	3.1	3.2	3.3	3.4	3.5
Line Items	27.7	28.5	12.3	35.0	30.0	27.6	0	0	0	0	0	0
Total Investment	34.6	35.2	19.2	44.8	38.8	36.7	9.7	9.9	10.2	10.6	10.9	11.2
Estimated Replacement Plant Value (RPV)	316.6	327.8	339.6	378.6	411.3	433.2	479.1	493.5	512.3	527.7	543.5	559.8
Estimated DM	15.6	16	16.5	8.1	5	5.1	4.5	4.6	4.7	4.9	5	5.2
Site-Wide Asset Condition Index (ACI)	0.95	0.95	0.95	0.98	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99

Figure 1. Facilities and Infrastructure Investments



Enclosure 1: List of DOE/NNSA/DHS Missions

Scientific Discovery and Innovation (SC)

1. Develop mathematical descriptions, models, methods, and algorithms to enable scientists to accurately describe and understand the behavior of the earth's climate, living cells, and other complex systems involving processes that span vastly different time and/or length scales to advance DOE missions in energy and environment
2. Develop the underlying understanding and software to enable scientists to make effective use of computers at extreme scales—many thousands of multi-core processors with complicated interconnections; and to transform extreme scale data from experiments and simulations into scientific insight
3. Advance key areas of computational science and discovery that advance the missions of the Office of Science through partnerships within the Office of Science, R&D integration efforts with the Department's applied programs, and interagency collaborations. For example, ASCR's new applied mathematics research efforts in optimization and risk assessment in complex systems has been identified as important to the research efforts in the Office of Electricity Delivery and Reliability (OE), Office of Nuclear Energy (NE) and other applied energy programs, and critical to cyber security research in other federal agencies
4. Deliver the forefront computational and networking capabilities that enable researchers to extend the frontiers of science
5. Develop networking and collaboration tools and facilities that enable scientists worldwide to work together and share extreme scale scientific resources
6. 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
7. 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
8. 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
9. 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
10. 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 during the studies of the past six years, e.g., in areas such as solar energy conversion, electrical energy storage and transmission, solid state lighting and other aspects of energy efficiency, geological sequestration, catalysis, and materials in extreme energy environments
11. 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
12. 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
13. 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
14. 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
15. Foster integration of research by leveraging DOE computational capabilities across BER programs and promoting coordination of bioenergy, climate and environmental research across DOE's applied technology programs and other agencies such as the Department of Agriculture, the National Aeronautics and Space Administration, and the National Oceanic and Atmospheric Administration
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
17. Advance fundamental low temperature plasma science and high-energy-density plasma science and to coordinate these programs with those of other agencies and the National Nuclear Security Administration

18. Understand the highly non-linear behavior of high-temperature, magnetically confined plasmas and ultimately to learn how to create, confine, and control a burning plasma
19. Develop the fundamental understanding to fabricate materials that can withstand the material-plasma interface and to develop other enabling technologies needed for a sustainable fusion energy source
20. Operate scientific user facilities that maintain world-leading research programs in high-temperature, magnetically confined plasmas, and to participate in the design and construction of ITER, the world's first facility for studying a burning plasma
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
27. Understand how quarks and gluons assemble into the various forms of matter and to search for yet undiscovered forms of matter
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 develop a better understanding of the neutrino, the nearly undetectable fundamental particle produced by the weak interaction that was first indirectly observed in nuclear beta decay
30. Conceive, plan, design, construct, and operate national scientific user facilities to make important discoveries in order to advance the understanding of nuclear matter. 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
33. Increase opportunities for under-represented students and faculty to participate in STEM energy and environment education and careers leveraging the unique opportunities at DOE national laboratories
34. Contribute to the development of STEM K-12 educators through experiential-based programs.
35. Provide mentored research experiences to undergraduate students and faculty through participation in the DOE research enterprise

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	
		N	M	P	C			Laboratory	DOE
								GPP	
<i>Nuclear Physics</i>	Now			X		<ul style="list-style-type: none"> Central Helium Liquefier South Access Bldg North Access Bldg Test Lab Counting House Experimental Equipment Laboratory (EEL) End Station Refrigerator Accelerator Tunnel 	<ul style="list-style-type: none"> Inadequate: Technical & Experimental Assembly Space Inadequate Service Bldgs Deferred Maintenance Building Code Deficiencies 	<ul style="list-style-type: none"> Counting House Sustain. Improvements (FY12) Service Bldg 68 Addition (FY12) Hall B Fire Sprinkler (FY12) Cooling North & South LINAC (FY12) Relocate Shipping & Receiving from EEL (FY15-17) Experimental Equipment Laboratory Rehab (FY 16-19) 	<ul style="list-style-type: none"> 12 GeV Conventional Facilities (LI) FY 08-12 Technology & Eng. Development Facility (SLI) FY 09-12
	In 5 Years				X				
	In 10 Years				X				
<i>Accelerator Science</i>	Now			X		<ul style="list-style-type: none"> Test Lab Cryogenics Test Facility 	<ul style="list-style-type: none"> Inadequate Work Space Aging Facilities Inadequate Utility Capacity 	<ul style="list-style-type: none"> Injector & Cryomodule Test Facility (FY 13) 	<ul style="list-style-type: none"> Technology & Eng. Development Facility (SLI) FY 09-12 Utilities Infrastructure Modernization -Expand CTF (SLI) FY 13-14
	In 5 Years				X				
	In 10 Years				X				
<i>Applied Nuclear Science & Technology</i>	Now			X		<ul style="list-style-type: none"> Free Electron Laser Experimental Equipment Laboratory (EEL) NN Applied Research Center 	<ul style="list-style-type: none"> Inadequate Technical Space Assembly Staging Inadequate South Site LCW 	<ul style="list-style-type: none"> Experimental Equipment Laboratory Rehab (FY 16-19) South Site LCW Plant (FY11) FEL Offices (FY18-21) 	
	In 5 Years				X				
	In 10 Years				X				
<i>Large Scale User Facilities - Advanced Instrumentation</i>	Now			X		<ul style="list-style-type: none"> Experimental Halls Experimental Equipment Laboratory (EEL) CEBAF Center 	<ul style="list-style-type: none"> Inadequate experimental halls for planned program Inadequate experimental support and work space Inadequate work space for scientists & users 		<ul style="list-style-type: none"> 12 GeV Conventional Facilities (LI) FY 08-12 Technology & Eng. Development Facility (SLI) FY09-12 Researcher and User Support Facility (SLI) FY16-18
	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

Real Property Capability		Mission Ready Assumes TYSP Implemented				Facility and Infrastructure Capability Gap	Action Plan	
		N	M	P	C		Laboratory	DOE
						GPP		
Work Environment	Now			X		<ul style="list-style-type: none"> • Insufficient Offices • CEBAF Center Bldg systems at end of service life • No recreational/fitness facilities • Cafeteria undersized 	<ul style="list-style-type: none"> • FEL Offices (FY18-21) • Sustainability Improvements Technical Support Bldgs (FY13-14) 	<ul style="list-style-type: none"> • TEDF (SLI) FY09-12 • Researcher and User Support Facility (SLI) FY16-18
	In 5 Years			X				
	In 10 Years				X			
User Accommodations	Now			X		<ul style="list-style-type: none"> • Minimum User and visitor areas 		<ul style="list-style-type: none"> • Researcher and User Support Facility (SLI) FY16-18
	In 5 Years				X			
	In 10 Years				X			
Site Services	Now			X		<ul style="list-style-type: none"> • Poor location of RADCON Calibration Facility • Limited Computer Center Cooling • Unconsolidated of Facility Storage • Inadequate Site Laydown Area 	<ul style="list-style-type: none"> • RADCON Calibration Facility (FY13) • Cooling for LQCD Data Center FY12) • Relocate Shipping & Receiving (FY15-17) 	<ul style="list-style-type: none"> • UIM(SLI) FY 13-14
	In 5 Years			X				
	In 10 Years				X			
Conference and Collaboration Space	Now			X		<ul style="list-style-type: none"> • Insufficient conference/collaboration space • Auditorium too small 		<ul style="list-style-type: none"> • Researcher and User Support Facility (SLI) FY16-18
	In 5 Years				X			
	In 10 Years				X			
Utilities	Now			X		<ul style="list-style-type: none"> • Aging electrical distribution • Aging Cooling water systems • Complete fire protection loop • Aging/inadequate comms/data • Insufficient cryogenics • Aging Access Control System • Sustainability 	<ul style="list-style-type: none"> • MCC Sustainability Improvements (FY13) • VARC Sustainability Improvements (FY13) • Upgrade Access Control System (Security - FY11) • Fire Prot Loop (FY-14) 	<ul style="list-style-type: none"> • UIM(SLI) FY 13-14 • Water Reuse (TBD) FY14
	In 5 Years				X			
	In 10 Years				X			
Roads & Grounds	Now			X		<ul style="list-style-type: none"> • Inefficient Site Lighting and coverage • Stormwater Mgmt Shortfalls • Roadway surface improvements • Parking Shortage 	<ul style="list-style-type: none"> • Misc Lighting Projects (FY11-15) • Storm water (FY15) • Misc Paving (FY14-15) • Parking Improvements (FY15) 	
	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 3: Site Plan

Lab Site Map – Planned Infrastructure Projects

