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Analysis of Alternatives (AoA) of Open Collaboration and Research Capabilities, Collaboration in Research and Engineering in Advanced Technology and Education (CREATE), and High-Performance Computing Innovation Center (HPCIC) on the Livermore Valley Open Campus (LVOC)

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REVISION SUMMARY

Rev. No.	Date	Change Description	Pages Affected
0	July 2015	Initial Draft Report	
1	July 2015	Updated and added text and tables based on comments received	All
2	August 2015	Section 10 and Table B-1	10-1, B-5
3	September 2015	Additional O&M Sensitivity Analysis; Revise NPV ranges based on math error	ES, Section 7, App E

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CONTENTS

ACRONYMS XI
EXECUTIVE SUMMARY ES-1
1 SCOPE 1-1
1.1 Overall Process 1-1
1.2 GAO Best Practices 1-3
2 INTRODUCTION AND MISSION NEED 2-5
2.1 Introduction 2-5
2.2 Mission Need 2-5
2.2.1 HPCIC 2-6
2.2.2 CREATE 2-7
3 REQUIREMENTS AND ASSUMPTIONS 3-1
3.1 Requirements 3-1
3.1.1 Space Programming Requirements 3-1
3.1.2 Mission and Program Requirements 3-3
3.2 Assumptions and Constraints 3-3
4 ALTERNATIVES IDENTIFIED AND DESCRIBED 4-1
4.1 Alternatives Identified 4-1
4.2 Description of Alternatives 4-1
4.2.1 Existing Facilities (Status Quo) 4-1
4.2.2 Renovate Facilities 4-1
4.2.3 Two New Line-Item Facilities 4-2
4.2.4 Lease Off-site Facility 4-2
4.2.5 Lease Two Commercial On-Site Facilities 4-2
4.2.6 Single New Line-Item Facility 4-3
4.2.7 Lease Single On-Site Facility 4-3
4.2.8 Build Multiple Smaller Facilities 4-3
4.2.9 Develop Only HPCIC 4-4
4.2.10 Develop Only CREATE 4-4
4.2.11 Renovate LLNL Facility/Develop New CREATE Facility 4-4
4.3 Alternative Advantages and Disadvantages 4-4
5 INITIAL SCREENING OF ALTERNATIVES 5-1
6 EVALUATION CRITERIA 6-1
7 COST AND SCHEDULE ESTIMATES 7-1
7.1 Net Present Value (NPV) 7-1
7.2 Acquisition Approach 7-1
7.3 NPV Range 7-2
7.4 Cost Sensitivity Analysis 7-2
8 ALTERNATIVE EVALUATION 8-1

9 CONCLUSIONS 9-1
10 TEAM MEMBERS 10-1

APPENDICES

APPENDIX A GAO AOA BEST PRACTICES EVALUATION A-1
APPENDIX B ALTERNATIVES SKETCHES AND ADVANTAGES/DISADVANTAGES B-1
APPENDIX C INITIAL ALTERNATIVE SCREENING RATIONALE C-1
APPENDIX D EVALUATION CRITERIA D-1
APPENDIX E COST ESTIMATE(S) E-1
APPENDIX F ALTERNATIVE ANALYSES F-1
APPENDIX G REFERENCES G-1

FIGURES

Figure 1-1: Overall AoA Process Diagram 1-2
Figure 1-2: "Develop Alternatives" Process Diagram 1-2
Figure 1-3: "Describe Alternatives" Process Diagram 1-2
Figure 1-4: "Analyze Alternatives" Process Diagram 1-3
Figure B-1: CREATE (Alts. 3, 5, and 11) B-2
Figure B-2: HPCIC (Alts. 3 and 5) B-2
Figure B-3: Single Facility (Alts. 6 and 7) B-3
Figure B-4: HPCIC (B543 Reno – Alt. 11) B-3
Figure E-1: Lease Schedule E-8
Figure E-2: Line Item Schedule E-9

TABLES

Table ES-1: Alternatives for Further Evaluation ES-3
Table ES-2: Alternatives Analysis Results in Rank Order ES-4
Table ES-3: O&M Sensitivity ES-5
Table 3-1: Summary of Space Requirements 3-2
Table 3-2: Mission and Program Requirements 3-3
Table 4-1: Initial Alternatives 4-1
Table 5-1: Initial Screening of Alternatives 5-1
Table 6-1: Desired Criteria 6-1
Table 6-2: Importance Weighting 6-2
Table 6-3: Desired Attribute Relative Importance and Weight 6-3
Table 7-1: NPV Results ($M) 7-1
Table 7-2: TPC Comparisons Based on Acquisition Strategy ($M) 7-1
Table 7-3: Range Analysis Results ($M) 7-2
Table 8-1: Risk Matrix 8-1
Table 8-2: Risk List and Levels for Alternatives 8-2

Table 8-3: Alternative Evaluation Scale 8-3
Table 8-4: Alternative Scoring Results (Un-weighted) 8-3
Table 8-5: Alternatives Results – Weighted Score 8-4
Table 8-6: Sensitivity Cases 8-5
Table 8-7: Sensitivity Analysis for Evaluation Criteria 8-6
Table 8-8: Sensitivity Analysis Results 8-7
Table 9-1: Alternative Rankings 9-1
Table A-1: GAO Best Practices Evaluation A-1
Table B-1: Alternatives Advantages and Disadvantages B-4
Table C-10-1: Mission and Program Requirements C-1
Table C-10-2: Screening Results and Rationale C-1
Table D-1: Desired Attributes D-1
Table D-2: Importance and Weighting Factor D-2
Table D-3: Desired Attribute Relative Importance and Weight D-3
Table D-4: Rationale for Attribute and Importance D-4
Table E-1: Compliance with GAO's 12-Step Guidance E-3
Table E-2: O&M Costs E-9
Table E-3: NPV Results ($M) E-11
Table E-4: Sensitivity Analysis E-12
Table E-5: TPC Comparisons Based on Acquisition Strategy ($M) E-13
Table E-6: Key Parameters Range Analysis E-14
Table E-7: Range Analysis Results ($M) E-14
Table E-8: Estimating Team E-14
Table F-1: Attribute Evaluation Scale F-1
Table F-2: Scoring of Alternatives F-2
Table F-3: Rationale for Alternative Scoring F-3
Table F-4: Alternatives Results – Weighted Score F-10
Table F-5: Ranking of Alternatives F-11
Table F-6: Sensitivity Analyses for Evaluation Criteria F-11
Table F-7: Sensitivity Analysis on Evaluation Weighting F-13
Table F-8: Five Sensitivity Analyses for Elimination of Selected Desired Attributes and Risks F-13

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ACRONYMS

A&E	Architecture and Engineering
AoA	Analysis of Alternatives
ASAP	as soon as possible
BOE	basis of estimate
BOMA	Building Owners and Managers Association
CD	Critical Decision
CDR	Conceptual Design Report
CEPE	Cost Estimating and Program Evaluation
COR	Contracting Officer's Representative
CRADA	Cooperative Research and Development Agreements
CREATE	Collaboration in Research and Engineering for Advanced Technology and Education
CRF	Combustion Research Facility
CSI	Construction Specifications Institute
D&C	design and construction
D&D	dismantlement and decommissioning
DOE	Department of Energy
DOR	Development Options Report
DP	Defense Program
EA	Environmental Assessment
EAC	Estimate at Completion
ECMS	Enterprise Construction Management Services
EIS	Environmental Impact Statement
ENR	*Engineering News-Record*
EOL	end of life
ES	Executive Summary
ES&H	environment, safety, and health
EVM	Earned Value Management
FY	fiscal year
G	Guide
GAA	General Access Area
GAO	Government Accountability Office
GPP	General Plant Project
GSA	General Services Administration
GSF	gross square feet

HPC	High-Performance Computing
HPCIC	High-Performance Computing Innovation Center
ICE	Independent Cost Estimate
ICE/R	Independent Cost Estimate/Review
IGPP	Institutional General Plant Projects
IPR	Independent Project Review
IPT	Integrated Project Team
ISSM	Integrated Safeguards and Security Management
IT	Information Technology
LA	Limited Area
LCC	life-cycle cost
LCCE	life-cycle cost estimate
LEED	Leadership in Energy and Environmental Design
LEP	Life Extension Program
LI	line item
LLNL	Lawrence Livermore National Laboratory
LVOC	Livermore Valley Open Campus
M&O	management and operating
MDNC	Mission Dependent, Not Critical
MNC	Mission Need Concept
MNS	Mission Need Statement
NA-APM	National Nuclear Security Administration, Acquisition and Project Management
NEPA	National Environmental Policy Act
NIF	National Ignition Facility
NMD	Not Mission Dependent
NNSA	National Nuclear Security Administration
NPV	net present value
NRW	Normalized Relative Weighting
NSF	Net square feet
NW	Nuclear Weapons
O	Order
O&M	operations and maintenance
OMB	Office of Management and Budget
PM	Project Management
PME	Project Management Executive

PPA	Property Protection Area
PR	Program Requirement
R&D	Research and Development
ROM	rough order of magnitude
sf	square feet
SME	subject matter expert
SNDA	Subordination Non-disturbance Attornment Agreement
SNL	Sandia National Laboratories
SNL/CA	Sandia National Laboratories - California
ST&E	science, technology and engineering
TPC	total project cost
TSF	Terascale Simulation Facility
US	United States
USACE	US Army Corps of Engineers
USF	usable square feet
WBS	work breakdown structure

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EXECUTIVE SUMMARY

The Livermore Valley Open Campus (LVOC), a joint initiative of the National Nuclear Security Administration (NNSA), Lawrence Livermore National Laboratory (LLNL), and Sandia National Laboratories (SNL), enhances the national security missions of NNSA by promoting greater collaboration between world-class scientists at the national security laboratories, and their partners in industry and academia. Strengthening the science, technology, and engineering (ST&E) base of our nation is one of the NNSA's top goals. By conducting coordinated and collaborative programs, LVOC enhances both the NNSA and the broader national science and technology base, and helps to ensure the health of core capabilities at LLNL and SNL. These capabilities must remain strong to enable the laboratories to execute their primary mission for NNSA.

The LVOC is located on Department of Energy (DOE) federal government property that is managed by SNL and LLNL, with 110 acres of that property designated as a General Access Area (GAA). Two new capabilities to enhance and advance critical national security goals and help the laboratories attract and retain an outstanding workforce are the Collaboration in Research and Engineering for Advanced Technology and Education (CREATE) and the High-Performance Computing Innovation Center (HPCIC). These are key items to expanding existing capabilities and realizing the LVOC vision.

The NNSA Administrator and the Under Secretary for Science authorized the creation of LVOC by approving the Mission Need Concept (MNC) on July 20, 2009 [Ref. 1]. The need for CREATE and HPCIC, the first new major acquisition projects for LVOC, was documented in the Critical Decision-0 (CD-0) *Mission Need Statement: Open Collaboration and Research Capabilities in the Livermore Open Campus* [Ref. 2]. The NNSA Administrator approved the CD-0 for LVOC development on April 22, 2013, and requested submission of CD-1 for CREATE and HPCIC. In accordance with DOE Order (O) 413.3B, *Department of Energy Program and Project Management for the Acquisition of Capital Assets* [Ref. 3], systems engineering principles and processes were used to evaluate the alternatives to meet the Mission Need. This report provides the analysis of alternatives (AoA) to evaluate the alternatives to meet the Mission Need.

A team of subject matter experts (SMEs) from the Enterprise Construction Management Services (ECMS) contractor, including project management, risk, and estimating personnel, was assembled to perform the AoA. The team was independent of the contractors benefitting from the outcome of the AoA, and had sufficient federal oversight. The composition of the team is included in Section 10. The analysis was conducted consistent with the Government Accountability Office (GAO) best practices, GAO report GAO-15-37, *DOE and NNSA Project Management: Analysis of Alternatives Could be Improved by Incorporating Best Practices*, dated December 11, 2014 [Ref. 4]. The evaluation of how the team addressed the 24 Best Practices is in Appendix A.

To evaluate the alternatives to achieve the capabilities of CREATE and HPCIC for the LVOC, the team used the following process:

- Identify high-level functional requirements to meet the Mission Need.
- Establish the criteria to be used to screen and evaluate the alternatives.
- Identify the weighting factors for each evaluation criterion based on their relative importance.
- Conduct brainstorming sessions to identify a list of potential alternatives.
- Develop pre-conceptual alternative descriptions, facility sketches, advantages/disadvantages (pros/cons), and relative risks for each alternative.
- Review and screen out alternatives that do not meet the mission and program requirements.
- Develop net present value (NPV) and life-cycle costs (LCCs) for each remaining alternative, including design and construction, operations and maintenance (O&M), and decommissioning.
- Using multi-attribute decision analysis, rate each alternative according to its ability to meet evaluation criteria.
- Perform sensitivity analyses, document the results, and identify the ranking of the alternatives.
- Present the AoA to management.

Authorized in 2009, the LVOC facilitates strategic partnering for the broader national security mission by:

1. Mission Delivery: LVOC provides an optimum environment to engage external knowledge and capabilities in support of NNSA missions. Leveraging talent and resources compounds value of NNSA investments.

2. Science, Technology & Engineering (ST&E): LVOC facilitates national and international collaborations to maintain second-to-none ST&E supporting the breadth of the national security mission.

3. Workforce: LVOC addresses the intellectual challenges facing the NNSA through stimulating work that helps retain the current workforce, as well as attract the next generation of talent to the NNSA laboratories.

LLNL is leading the effort on the HPCIC. The HPCIC is currently operating on the open campus in rented trailers and focusing on developing industry and academic programs in areas of nuclear security, advanced manufacturing, energy, cybersecurity, biosecurity, and big data. The goals of the HPCIC include the following:

1. Advances needed in next generation supercomputing systems intensifies urgency to expand beneficial external collaborations
2. High-performance computing (HPC) solutions applied to stockpile stewardship, advanced manufacturing (e.g. additive), cybersecurity, biosecurity, big data analytics, and complex energy systems.

SNL is leading the effort on CREATE at its California campus. The goals of CREATE include the following:

1. Hydrogen science and technology for energy applications, cybersecurity, advance engineering and manufacturing and translational biomedicine.
2. Growing NNSA Mission Needs in the Nuclear Weapons (NW) program (directed stockpile work and life extension programs) drive the need to reconfigure the site to bring additional buildings into the Limited Area by moving appropriate functions to the LVOC.

The team identified 11 alternatives to address the required capabilities of CREATE and HPCIC. After initial screening against the mission and program requirements, Alternatives 1, 2, 4, 9, and 10 were screened out from further evaluation, and six alternatives remained for further analysis. The remaining alternatives and their descriptions are shown in Table ES-1.

Table ES-1: Alternatives for Further Evaluation

Alt. #	Alt. Name	Alt. Description
3	Two New Line-Item Facilities (2LI)	Two separate facilities (CREATE and HPCIC) in different locations.
5	Lease Two Commercial On-Site Facilities (2LS)	Two separate facilities (CREATE and HPCIC) in different locations.
6	Single New Line-Item Facility (1LI)	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).
7	Lease Single On-Site Facility (1LS)	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).
8	Build Multiple Smaller Facilities (Mult)	Build approximately 10 separate, distinct 16,000-square-foot (sf) to 20,000-sf “standard” design facilities in LVOC north (LLNL) and south (SNL) portions, as needed (currently pursuing this strategy for some facilities).
11	Renovate LLNL Facility / Develop New CREATE Facility (Reno/New)	SNL has no existing facilities in the LVOC or its proximity; therefore, must build a new facility for CREATE. LLNL has a facility that could be renovated, to include an addition.

After completing detailed alternative descriptions, the ECMS team developed rough order of magnitude (ROM) cost estimates for the design and construction (D&C) costs of a 98,000-square-foot (sf) HPCIC, a 86,000-sf CREATE building, and a single facility of 175,000 sf, as well as the LCCs for each alternative. These estimates are Class 5 estimates, as described in DOE Guide 413.3-21 [Ref. 5]. The Class 5 estimates are based on the degree of project definition (0 to 2 percent). The LCC estimates were used as the basis to compare alternatives on an NPV basis.

In addition, the team evaluated the advantages and disadvantages of each alternative and performed a comparative qualitative risk analysis. Those activities supported the quantitative scoring of the alternatives against the desired attributes and features, or "selection criteria." The team developed 20 evaluation criteria, or attributes, that were rated in importance and then weighted. The team then rated each alternative against how well it met each desired attribute, allowing the alternatives to be compared to each other.

The AoA report provides details of the analysis process, as well as the descriptions for each alternative and the results of the final scoring and ranking process.

Table ES-2 shows the results of the weighted scoring for each alternative in rank order.

Table ES-2: Alternatives Analysis Results in Rank Order

Rank	Alternative No.	Weighted Score	NPV ($M)	Risk Rank
1	5 (lease 2 new facilities)	94.4	131.0	M
2	7 (lease 1 combined facility)	77.1	135.9	M
3	3 (build 2 new line items)	75.6	165.2	M
4	6 (build 1 combined line item)	64.9	164.4	M
5	8 (build multiple smaller facilities)	55.1	225.2	M
6	11 (renovate 1 facility and build 1 new facility)	42.5	181.1	M

In summary, Alternative 5 (2 leased facilities) was ranked the highest by the team and Alternative 7 (1 combined leased facility) was ranked second. Overall, the leased facilities ranked higher in the evaluation than the line item (LI) alternatives. In general, leased facilities have a more favorable NPV and are expected to be ready for use sooner than the LI construction.

A single facility, procured by either lease or LI, will have additional risks or concerns that will need to be addressed if either of the single facility alternatives is chosen to move forward. The concerns include the following:

- National Environmental Policy Act (NEPA): A single building combining the capabilities of CREATE and HPCIC, may put the DOE's and the laboratories' environmental approval postures at risk. Each laboratory has identified its separate facilities in the appropriate site Environmental Assessment (EA) or Environmental Impact Statement (EIS). A single facility combining the capabilities of CREATE and HPCIC may lead to a reanalysis and additional NEPA documentation. Possible delay could be 6 to 18 months.
- State Regulatory Agencies: DOE and SNL – California (SNL/CA) or LLNL may be at risk of being identified as a single owner/manager of the single facility. State regulators currently consider the two laboratories as separate facilities because they are managed and operated separately.

- Air Permitting/Emissions: Permitting and negotiations with the local air district would belong to the laboratory that operates and manages the land on which the single facility is located. Impact costs have been roughly estimated as ranging from $300,000 to $660,000.
- Governance: The LVOC is managed and operated as two separate areas. A single facility located on either LLNL or SNL/CA would require a revision to the current governance agreements with each Management and Operating (M&O) contractor. Also, as stated above, the State regulators may view the laboratories as one facility for regulatory actions if both laboratories occupy a single facility.

Addendum: Following the submission of the initial report, additional cost sensitivity analysis was performed. The NPV for the alternatives was found to be highly sensitive to the O&M rates applied on a per square-foot basis. For the base case used in the analysis, actual O&M rates at LLNL and SNL/CA are approximately three times higher than O&M rates assumed for alternative financing (based on industry-standard regional rates published by the Building Owners and Managers Association [BOMA]).

The difference of the O&M values used in the LCCEs ($5.63/sf for a lease versus $16.73/sf and $15.94/sf for line item alternatives) is the major factor in the rankings of the alternatives by NPV. Through sensitivity analysis, the O&M rates were set as being equal for the alternatives which caused a change in the order of NPVs, with the line item alternatives being roughly $20M less than the lease alternatives. If the line item O&M rate is set at 1.5 times the lease O&M rate (instead of 3 times in the base case), the NPV of all alternatives are very comparable; with the line item alternatives being slightly less than the lease alternatives.

Table ES-3: O&M Sensitivity

	NPV ($M)		
Alternatives	Baseline O&M Rates (Actuals)	Lease O&M= LI O&M	LI O&M= 1.5 x Lease O&M
3 (2 LI)	165.2 (Rank 4)	165.2 (Rank 2)	127.6 (Rank 1)
5 (2 LS)	131.0 (Rank 1)	183.4 (Rank 3)	131.0 (Rank 3)
6 (1 LI)	164.4 (Rank 3)	164.4 (Rank 1)	130.5 (Rank 2)
7 (1 LS)	135.9 (Rank 2)	183.8 (Rank 4)	135.9 (Rank 4)

Moving forward, in the approval process, the project team must be aware of this sensitivity. The assumed O&M rates will have an effect on the NPV range. As shown in Section 8, Table 8-8, and Appendix F, Table F-4, the NPV alternatives order does not affect the AoA rankings of the alternatives.

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1 SCOPE

The National Nuclear Security Administration (NNSA) tasked the Enterprise Construction Management Services (ECMS) team to develop an independent Analysis of Alternatives (AoA) for the Open Collaboration and Research Capabilities of Collaboration in Research and Engineering for Advanced Technology and Education (CREATE) and High-Performance Computing Innovation Center (HPCIC) on the Livermore Valley Open Campus (LVOC). Following the process described in Department of Energy (DOE) Order (O) 413.3B, the project team worked closely with the NNSA Office of Acquisition and Project Management (NA-APM) and the Management and Operating (M&O) contractors. A team of subject matter experts (SMEs) was assembled to develop and evaluate the potential alternatives. The ECMS team conducting the AoA was independent of the M&O contractors. Federal oversight was provided by NNSA, NA-APM, and Cost Estimating and Program Execution (CEPE). The collaborative team is listed in Section 10 and includes federal, ECMS, and M&O members. The M&O members provided SMEs to support the ECMS team with information on the laboratories facilities, LVOC and for the CREATE and HPCIC mission need. This report identifies and analyzes preliminary conceptual design alternatives for the capabilities needed for CREATE and HPCIC; it suggests pursuing an alternative concept for the basis of the conceptual design. This report provides the high-level functions/requirements, alternative descriptions, selection criteria, and results of the alternatives evaluation, which could serve as the basis for the selection of the alternative to be developed during the conceptual design of CREATE and HPCIC for the LVOC.

The ECMS team was requested to complete the independent AoA after considerable progress had been made by the M&O teams. A significant amount of documentation had been completed to include the *Livermore Valley Open Campus Master Plan, Final Report, Version 1.2, Flad Architects,* dated November 4, 2010 [Ref. 6] (referred to as the Flad study), a draft Conceptual Design Report (CDR), and Critical Decision-1 (CD-1) documents [Ref. 7] and appendices. An independent project review (IPR) had also been completed on the CD-1 documentation, and numerous cost estimates were previously completed. This information was provided; however, to complete an independent analysis of alternatives, much of the information was used for comparison purposes only.

1.1 Overall Process

The approach for the AoA was to identify the requirements, develop evaluation criteria (attributes), identify possible alternatives, perform an initial screening of the alternatives, and then perform a more complete evaluation of the viable alternatives to determine which alternative best satisfies the selection criteria. These evaluations included preconceptual-level life-cycle costs estimates (LCCEs), project schedule, execution risk, and other criteria established in advance by the alternatives team and the Program Office. At the conclusion of the alternatives evaluation, it is anticipated that the Project Management Executive (PME) or another appropriate decision maker will select a preferred alternative based on the team's results.

Figure 1-1 shows the overall process. The process starts with the Mission Need Statement (MNS) and functions and requirements. Steps 1 and 2 are part of the CD-0, Approve Mission Need, as specified in DOE O 413.3B. The AoA team reviews this information and ensures that the functions and requirements are clearly stated. If needed, the team clarifies the requirements so that they can be used for initial screening of alternatives. The team then develops the evaluation criteria and assigns an importance level (1–4) to each criterion (3 on the process diagram).

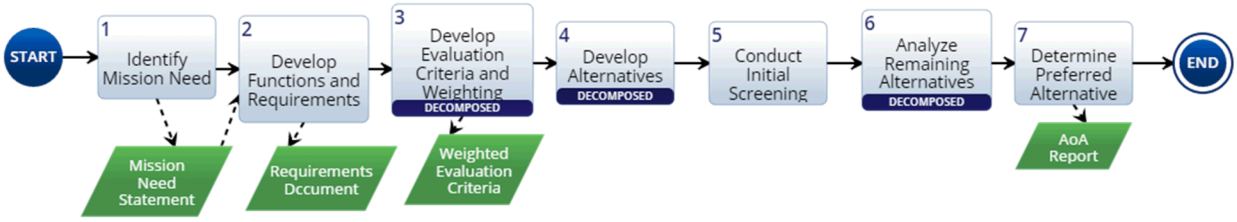

Figure 1-1: Overall AoA Process Diagram

The next step (4) is to develop the alternatives. Figure 1-2 shows this process in additional detail. This activity starts with a team brainstorming session to identify the possible alternatives.

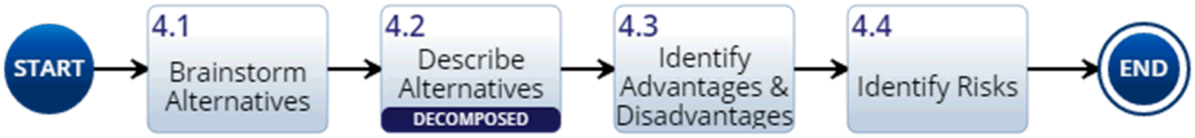

Figure 1-2: "Develop Alternatives" Process Diagram

After the alternatives are identified, they are then depicted in both words and conceptual sketches. Figure 1-3 shows this process, which begins with the preparation of the draft alternative descriptions, followed by alternative sketches and further definition of the alternative attributes and features. This material is reviewed and updated.

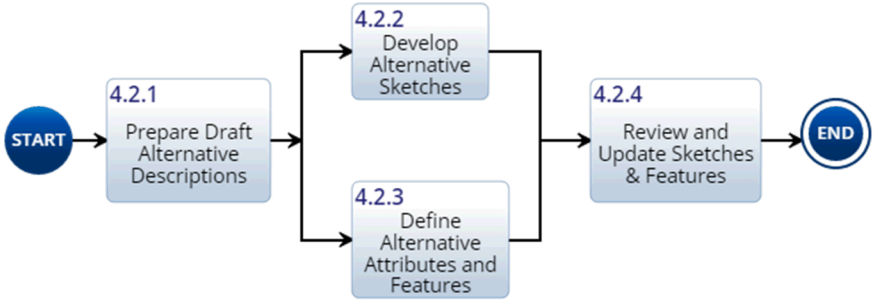

Figure 1-3: "Describe Alternatives" Process Diagram

After the alternatives are defined, an initial screening of the alternatives is performed using the mission and program requirements identified in Step 2. If an alternative cannot meet the requirements, it is screened out from further consideration. In this case, the team does not develop life-cycle costs (LCCs) and conducts no further analysis of the screened-out alternative. The team documents the rationale for the screening decisions. After screening, the team analyzes the remaining alternatives (Step 6). Figure 1-4 shows this process.

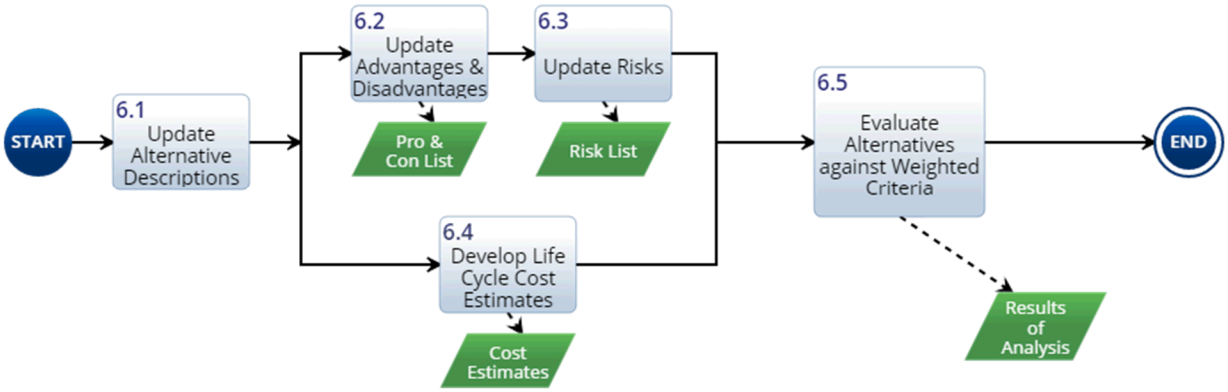

Figure 1-4: "Analyze Alternatives" Process Diagram

After the alternative descriptions, including the conceptual sketches, are reviewed and updated, the LCCE and Advantages/Disadvantages and Alternative Risks activities proceed in parallel. Once this material is available the team meets to evaluate the alternatives against the weighted criteria. The team identifies and performs sensitivity analyses to determine the robustness of the ranked scores and documents the rationale for the scoring.

The ECMS team developed a Microsoft Excel workbook to perform these calculations and report the results.

The analysis results in a ranking of the alternatives. Once the analysis is complete, the team develops a briefing for management and report to document the analysis (this document). The final step (7), determine the preferred alternative, is performed by senior management after briefings and review of the AoA report.

1.2 GAO Best Practices

To ensure that the recommended alternative is selected correctly, the Government Accountability Office (GAO)'s 24 Best Practices for the AoA was followed to the extent possible; each is documented in Appendix A. The use of a rigorous alternatives analysis process assists in the selection of an alternative based on the criteria reviewed and approved by major stakeholders, so that a proper selection can be made.

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2 INTRODUCTION AND MISSION NEED

2.1 Introduction

The NNSA Administrator and the Under Secretary for Science approved the Mission Need Concept (MNC) for the LVOC on July 20, 2009. The LVOC project will include, in part, the design and construction of the CREATE and the HPCIC capabilities. The LVOC is a joint initiative of the NNSA, the LLNL, and the SNL/CA to enhance the national security missions of NNSA by promoting greater collaboration between the world-class scientists at the national security laboratories and their partners in industry and academia. The LVOC, which creates a shared space between the two adjacent laboratories, is in accordance with NNSA's vision for increased scientific interaction and collaboration across the nuclear security enterprise.

2.2 Mission Need

The MNC for LVOC was approved in 2009, and the LVOC Development Options Report (DOR) [Ref. 8] was received and endorsed in 2010. These documents established a mission need and the framework for developing LVOC. The Mission Need and Program Requirements Document for the Livermore Valley Open Campus was approved on April 22, 2013. This approval was for the Open Collaboration and Research Facilities in the Livermore Valley Open Campus; HPCIC and CREATE.

The LVOC leverages and facilitates ready access to the expertise and capital investments already made by NNSA and the DOE Office of Science while providing a dynamic and exciting work environment for scientists and engineers. As stated earlier, this joint initiative is a campus of more than 100 acres dedicated to enhancing the national security mission by strengthening the science, technology, and engineering (ST&E) base of our nation, one of the NNSA's top goals in its 2011 Strategic Plan. Currently encompassing more than a dozen buildings and over 200 employees working in areas such as combustion, biofuels, advanced computing, and cybersecurity, this new campus is specifically designed as an unclassified open environment to encourage and build collaboration with external partners in academia and industry. LVOC expands on the nuclear weapons (NW)-focused partnership initiated between LLNL and SNL in the 1950s into a channeled alliance that is prepared to meet a broad range of 21st century challenges. Capitalizing on the expertise and opportunities of a thriving and innovative community, LVOC draws on new intellect and problem-solving skills to address our nation's most pressing security challenges.

The LVOC will address many capability gaps related to LLNL and SNL/CA efforts to enhance their national security Research and Development (R&D) programs, develop a new pipeline for the workforce of the future, and stay at the forefront of ST&E capabilities through increased collaboration with academic and industry partners. The approval of the MNS on April 22, 2013, provided authorization to proceed with the development of LVOC and preparation of CD-1 for the HPCIC and CREATE to target one or more specific capability gaps.

2.2.1 HPCIC

The effort being led by LLNL focuses on the HPCIC. The HPCIC benefits NNSA by (1) advancing high-performance computing (HPC) tools; (2) attracting, retaining, and training the workforce; and (3) establishing strategic partnerships with the industry in open research fields that are aligned with the broader DOE and NNSA missions. Initial efforts of the HPCIC continue to focus on developing industry and academic programs in the areas of manufacturing, energy, cybersecurity, biosecurity, and big data. HPCIC programmatic activities have grown in scale and complexity and now require a transition from temporary incubators into modern, higher capacity facilities that better meet the program needs for approximately 400 staff, partners/collaborators and interns.

High-end computing is a core strategic capability of the NNSA laboratories, particularly at LLNL since its founding in 1952. The nuclear security mission space is the original and is still a critically important driver for maintaining this strategic capability. Under the Advanced Simulation and Computing Program, the NNSA laboratories have developed and are continuing to develop sophisticated methodologies and techniques that are necessary to accurately model physical systems. This involves an enormous and comprehensive effort to fund, coordinate, and manage multiple disciplines, including computer acquisition and services, siting and support, integrated code development, underlying science, verification and validation, and quantification of uncertainty. Despite the classified nature of NNSA's primary mission, many of the underlying science and engineering activities are unclassified and involve universities, industry, and civilian agencies. Specific actions by the NNSA are being initiated to further facilitate such collaborations. The endorsement and support of the LVOC and HPCIC are two such examples.

The HPCIC was launched to foster LLNL and industry collaborations, and is dedicated to partnering with American industry to develop, prove, and deploy HPC solutions in areas including (but not limited to) manufacturing, complex energy and infrastructure systems, cybersecurity, biosecurity, and big data analytics – all areas in which NNSA and DOE mutually share the need for cutting-edge research. Attraction and retention of a world-class workforce are important facets to maintaining a US technological advantage in HPC. These broadened collaborations with industry will allow the workforce to enhance and apply their skills to a diverse set of new and intellectually challenging projects. More broadly, the objectives of the HPCIC program align with NNSA's mission to strengthen US competitiveness.

The historical body of effort and investment by DOE in simulation provides a collective capability that is unique in the world and can be leveraged to create jobs and strengthen US competitiveness in the 21st Century's global economy, consistent with the FY 2011 National Defense Authorization Act, which strongly encourages the support of industrial interactions through Cooperative Research and Development Agreements (CRADAs). The HPCIC brings government, national laboratories, research institutes, industry, and academia together in an

ecosystem in which partners leverage the strengths and talent of entities across the globe with new partnering constructs.

Due to the location, ease of access (in particular for foreign nationals), and the collaborative design environment, the HPCIC facility has hosted more than 30,000 visitors and 3,000 events since its opening in June 2011. The incubator currently houses industry and academic collaborators, as well as a small contingent of LLNL personnel who are necessary to operate and manage the facility. Due to space limitations, the HPCIC workforce pipeline programs continue to be dispersed throughout the General Access (open) and Property Protection (closed) Areas (PPAs).

2.2.2 CREATE

At its California campus, SNL has growing unclassified, collaborative programs in hydrogen science and technology, cybersecurity, and engineering environments for the future. At the same time, growth in the NW program requires additional space in the limited area to execute this core mission. An opportunity exists to simultaneously meet these programmatic needs while also enhancing the security profile of the SNL/CA site through a more efficient configuration. Sandia has proposed that the CREATE facility support these customer-driven national security mission requirements while demonstrating a fiscally responsible approach to cost control.

The CREATE facility on the LVOC is needed to support customer-driven national security mission requirements and is a key enabler to meeting the need for classified program growth on the site while demonstrating a fiscally responsible approach to cost control. Specific requirements for the CREATE facility are driven by the efficiencies of combining several unclassified administrative functions into one location in the LVOC GAA along with space for R&D programs that enhance NW and other national security work in hydrogen science, cybersecurity, and diverse engineering collaborations. Completion of this facility in the GAA will allow the relocation of about 150 staff members who are engaged in unclassified administrative functions and research programs, freeing up office space in the Limited Areas (LAs) for NW and other classified activities.

The proposed CREATE facility will make space available on the LVOC GAA for office, light laboratory, and meeting areas in a state-of-the-art facility that is safer, more functional, and more energy efficient than many existing buildings on the site. This space will enable collaboration with academic and industrial partners that build or maintain expertise in unclassified aspects of programs that are normally housed in the LA. Collaborations with universities in the CREATE facility will also provide increased recruiting opportunities for prospective employees, enticing talent to explore careers within the NW and related programs.

The increase in classified work on the SNL/CA site requires additional office and light laboratory space in the LA, forcing other programs and administrative functions to relocate to appropriate lower security zones. To ensure uninterrupted operations, reduce long-term operational costs,

reduce energy inefficiency, increase productivity, and enhance capabilities while allowing for growth in critical national security programs housed in the LA, SNL/CA has an urgent need to develop its GAA space on the LVOC.

3 REQUIREMENTS AND ASSUMPTIONS

3.1 Requirements

3.1.1 Space Programming Requirements

The team received information on the space planning for CREATE and HPCIC that had been used in the development of the CD-1 documentation, revision 3, dated February 2015. The Space Requirement Planning Worksheets were reviewed with the known requirements to determine if the 86,000-sf CREATE facility and the 98,000-sf HPCIC are appropriately sized. The team developed independent estimates of net square footage (NSF) using circulation factors of workstations and support facilities based on typical industry standards and experience. A comparison was then made, shown in Table 3-1, between the provided numbers (column A), and the numbers developed by the team (column B).

Table 3-1 shows the breakdown of the space requirements, which were reviewed in meetings with the alternatives team and in interviews. The comparison of A and B resulted in an approximate 12 percent increase in the HPCIC. The difference in area is due to standardizing the circulation factor and the building common area factor. The circulation factor is the interior space of a structure that is required for internal movement between offices and support areas and is not included in the NSF. The building common area factor allows for restrooms, stairs, elevators, mechanical/electrical rooms, janitor closets, etc. The 98,000 sf, as identified by the HPCIC team, is achievable through compromise on the sizes of the support area and collaborative spaces.

In an effort to evaluate the space requirements of a single facility alternative, the requirements provided by CREATE and HPCIC were combined to achieve efficiencies in space utilization. Under column C, in Table 3-1, the facility would consist of a centralized “hub” for training/conference, a cafeteria, badge requirements, a learning center, and a fitness center. Separate wings for CREATE and HPCIC would connect to the hub. Combining the requirements into the single facility resulted in an approximate overall reduction of 5 percent from the total of space requirements that LLNL and SNL/CA identified for their facilities. It represents an approximate 10 percent reduction of the size identified using typical commercial sizing and building factors (column B versus column C).

Table 3-1: Summary of Space Requirements

Program Comparison Summary			
CREATE	**A**	**B**	**C**
Engineering	23,624	20,142	0
Mission Support	14,581	11,960	0
Campus Amenities	23,527	23,171	0
Shared Support	6,756	6,227	0
Subtotal USF	**68,488**	**61,500**	**0**
Building Common Area Factor	17,122	21,525	0
Total GSF	**85,610**	**83,025**	
HPCIC	**A**	**B**	**C**
Group A	25,618	18,314	0
Group B	25,618	16,533	0
Group C	11,220	9,916	0
Group D	14,295	12,951	0
Learning Center	Included below	5,413	0
Badging/Reception/Outreach Multimedia	Included below	14,918	0
Support Areas	20,729	3,478	0
Subtotal USF	**97,480**	**81,523**	**0**
Building Common Area Factor	Included above	28,533	0
Total GSF	**97,480**	**110,056**	**0**
One Facility	**A**	**B**	**C**
CREATE Staff	0	0	28,508
HPCIC Staff	0	0	46,895
Training/Conference Center	0	0	13,897
Badging/Reception/Outreach Multimedia	0	0	3,393
Technical Library	0	0	4,940
Public Spaces	0	0	4,030
Fitness Center	0	0	7,155
Café/Coffee Shop	0	0	6,526
Learning Center	0	0	5,413
Common Functions on Each Floor	0	0	9,087
Subtotal USF			**129,844**
Total USF			**129,844**
Building Common Area Factor			45,445
Total GSF	**183,090**	**193,081**	**175,289**
GSF = gross square feet USF = usable square feet	A = Programmed area provided B = Parsons' revisions to program C = Proposed program for one shared facility		

3.1.2 Mission and Program Requirements

Thirteen high-level requirements were identified as Mission Requirements and Program Requirements; they are listed in Table 3-2. The team reviewed the program assumptions from the documentation provided and added assumptions, as appropriate, for the project and the analysis.

The criteria identified as "Requirements" were used in the prescreening process. Alternatives were judged to either meet the requirements "minimally" or "fully." If an alternative did not meet one of the criteria, it was judged as noncompliant and screened out. The criteria identified as "Desired Features/Attributes" were used to perform the detailed evaluation of the down-selected alternatives from the prescreening process. Section 5 discusses this evaluation process.

Table 3-2: Mission and Program Requirements

Requirements		
Number	Description	Source
Mission Requirements		
PR-1	Provide additional unclassified office/laboratory/collaboration space for LLNL, SNL/CA, and outside collaborators in the LVOC.	MNS – page 3, 4
PR-2	Provide a work environment that is modern, dynamic, and flexible.	MNS – page 3, 4
PR-3	Obtain operational effectiveness and efficiencies.	MNS – page 4
PR-4	Develop workforce pipeline for attraction, recruitment, development, and retention of world-class staff in a competitive regional market.	MNS – page 1
Program Requirements		
PR-5	Provide approximately 160,000 to 200,000 total gross square feet (gsf) (combined requirement for CREATE and HPCIC).	MNS – page 4
PR-6	Provide flexible space of about 4,400 gsf (CREATE) and 1,000 net sf (HPCIC) for light laboratory.	MNS and PRD (CD-1 space reqmts)
PR-7	Support increased demands for LA space.	MNS – page 4, PRD
PR-8	Consolidate educational outreach programs and facilities.	MNS and PRD
PR-9	Provide additional space in proximity to synergistic programs.	MNS and PRD
PR-10	Provide additional space as soon as possible.	NW LEP schedule Exoscale Roadmap
PR-11	Mission need is for 15 years (currently identified), with expected life of facility of 35 years.	Strategic Planning Documents / Mission timeframes
PR-12	Provide capability to meet Leadership in Energy and Environmental Design (LEED) Gold.	PRD and DOE reqmt
PR-13	Provide appropriate security flexibility for different program requirements.	MNS – page 2

3.2 Assumptions and Constraints

Key assumptions and constraints factor into the scope and content of the program requirements for the CREATE and HPCIC capabilities within the existing LVOC. In addition, the interface of both existing and proposed infrastructure systems, facilities, and projects with CREATE and HPCIC must be coordinated.

Replacement of support systems, utilities, and facilities must be fully integrated with the overall site modernization, consolidation, and disposition effort. CREATE and HPCIC capabilities will be integrated with projects supporting the strategic framework and transformational activities for LVOC.

Other key assumptions are as follows:

1. Budget and resources will be available, as necessary, to optimize the CREATE and HPCIC implementation.
2. The facility(ies) will be located on or adjacent to the existing Open Campus, on federal government owned property.
3. The LVOC will provide typical infrastructure support: office and support facilities, roads, and utility systems (e.g., electrical, natural gas, fire protection, water, sewer, and information and security communications).
4. The acquisition strategy for CREATE and HPCIC will be determined in accordance with the DOE O 413.3B process and as part of the outcome of CD-1. The AoA will evaluate a diverse set of options to determine those that best meet the mission needs established at CD-0.

Site initiatives to implement the NNSA vision are constrained by the following:

1. Near-term line item (LI) budget limitations for Mission Dependent, Not Critical (MDNC) and Not Mission Dependent (NMD) construction.
2. There is no space on SNL/CA to renovate near the LVOC. Space is not available and no building exists that could meet the requirements of CREATE.

- **Operational Limitations:**
  - The project(s) has no unmanageable operational limitations in effectiveness, capacity, technology, organizations, or other special considerations. Existing facilities will continue to be used and maintained during the acquisition of any alternative.
- **Geographic, Organizational, and Environmental Location:**
  - No unmanageable geographic, organizational, or environmental limitations are expected with this project.
  - Internal organizational interfaces exist to support functional requirements development, program management concurrence, and environmental, safety, and health requirements; to include National Environmental Policy Act (NEPA) requirements.
  - The LVOC is governed by two separate institutions: North Campus – LLNL and South Campus – SNL/CA.

- **Standardization and Standards Requirements:**
  - If acquired through the traditional LI process, the requirements of DOE O 413.3B will be applied to the entire project life cycle, including design, construction, startup, and turnover. Design, construction, and execution of the project will comply with all applicable national codes and standards.
  - If acquired through alternative financing process, the requirements for operating leases under Office of Management and Budget (OMB) A-11 criteria will be met.
- **Environment, Safety, and Health (ES&H):**
  - All proposed alternatives must comply with applicable federal, state, and local policies, regulations, and orders related to the protection of the environment and the safety and health of workers and the public.
- **Safeguards and Security:**
  - LLNL and SNL/CA are committed to implementing Integrated Safeguards and Security Management (ISSM). All project documentation will be reviewed for classification before it is issued.
- **Interfaces with Existing and Planned Acquisitions:**
  - All preliminary planning related to satisfying the mission need have not identified any existing or planned acquisition consequence.
- **Affordability Limits on Investment:**
  - The objective is to meet the requirements of the mission need at the optimum life-cycle cost, while protecting the health, safety, security, and welfare of employees and the public.
- **Legal and Regulatory Constraints or Requirements:**
  - The project will be conducted in full compliance with all applicable federal, state, and local requirements.
- **Stakeholder Considerations:**
  - Significant stakeholder involvement is anticipated. Primary stakeholders include DOE/NNSA Headquarters Program Offices, various LLNL and SNL/CA government and contractor organizations, potential facility developer(s), and land owners near the site. Other external stakeholders may comment or provide input to the initial project planning.
- **Limitations Associated with Program Structure, Competition and Contracting, Streamlining, and Use of Development Prototypes or Demonstrations:**

- An Integrated Project Team (IPT) was formed, consisting of government and contractor personnel. The IPT functional areas included project management, program management, operations, budget and finance, contracting, safety, environment, and quality.

- **Additional Assumptions:**
  - All alternatives that pass the initial screening will at least minimally meet the Mission and Program Requirements. If not feasible, the alternative will be screened out from further consideration.
  - Cost analysis will be completed using parametric estimates and resources, such as RSMeans and existing DOE/NNSA projects.
  - Cost estimating will be reported at a Level 2/3 work breakdown structure (WBS).
  - The LI cost estimates will use a Federal Direct approach for the design and construction. This approach will include the design and construction efforts being directly contracted by the NNSA or through an entity such as the US Army Corps of Engineers (USACE). The facility(ies) are of low risk, with standard office and light laboratory space.
  - Construction will be outside the LA/PPA, or in areas that are transitioning to become outside the LA/PPA.
  - Additional estimating assumptions are documented in the basis of estimate (BOE) provided in Appendix E.

4 ALTERNATIVES IDENTIFIED AND DESCRIBED

4.1 Alternatives Identified

The team developed the initial set of alternatives in meetings during the site visit in May 2015. The team used these alternative concepts to identify 11 distinct alternatives. These alternatives were evaluated as potential solutions for the needed capabilities of HPCIC and CREATE for the LVOC, to include the identification of the potential preferred alternative that would be further developed during the conceptual design process.

The group of initial alternatives is included in Table 4-1.

Table 4-1: Initial Alternatives

Alt. #	Alt. Name	Alt. Description
1	Existing Facilities	No action, other than normal maintenance (Status Quo).
2	Renovate Facilities	Renovate facilities at both laboratories.
3	Two New Line-Item Facilities	Two separate facilities (CREATE and HPCIC) in different locations.
4	Lease Off-Site Facility	Consider GSA lease or separate commercial lease.
5	Lease Two Commercial On-site Facilities	Two separate facilities (CREATE and HPCIC) in different locations.
6	Single New Line-Item Facility	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenues).
7	Lease Single On-site Facility	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).
8	Build Multiple Smaller Facilities	Build approximately 10 separate, distinct 16,000-sf to 20,000-sf "standard" design facilities located in LVOC in north (LLNL) or south (SNL) portions, as needed (currently pursuing this strategy for some facilities)
9	Develop Only HPCIC	Build or lease a single facility meeting HPCIC needs only.
10	Develop Only CREATE	Build or lease a single facility meeting CREATE (SNL) needs only.
11	Renovate LLNL Facility/ Develop New CREATE Facility	SNL has no existing facilities in the LVOC or its proximity; therefore, build a new facility. LLNL has a facility that could be renovated, to include additions.

4.2 Description of Alternatives

4.2.1 Existing Facilities (Status Quo)

Use existing facilities as is and perform no special actions other than normal maintenance.

This alternative would not generate or make available any new facility; therefore, it would continue operations and maintenance (O&M) of substandard, inefficient offices and trailers that are beyond their useful life.

4.2.2 Renovate Facilities

Renovate facilities at both laboratories, including additions. The alternative includes repurposing and/or renovating (which could include minor modifications, general plant project [GPP]

improvements, and/or LI-funded modifications) one or more existing on-site facilities as a means to satisfy the mission specifications and facility requirements. SNL does not have any buildings suitable for renovation in or adjacent to LVOC that will meet the functional requirements of CREATE.

For HPCIC, renovating any of three existing LLNL building complexes (B543, B551E/W, and B571/671) is possible. These buildings are currently functioning as standard office buildings with LLNL occupants. In each case, significant modifications would be required to meet HPCIC project performance parameters. All three buildings pose issues with locality, seismic suitability, and disruption to the traffic and roadways, and they are currently occupied. Two were previously considered unworkable by the project team due to these issues.

Based on building size, location, and compatibility of building layout for offices, as well as the need for meeting, training, visualization, education, and other collaboration space, B543 provided the closest fit to the criteria.

4.2.3 Two New Line-Item Facilities

Two separate facilities (CREATE and HPCIC) may be constructed in different locations. The CREATE facility would be a 3-story building comprising 86,000 gsf; HPCIC would be a 3-story building comprising 98,000 gsf.

This alternative would meet the mission need by acquiring the capital asset through the DOE LI process, as outlined in DOE O 413.3B. Under this approach, site selection and facility specification and design can specifically meet the mission need.

4.2.4 Lease Off-Site Facility

Consider a General Services Administration (GSA) lease or a separate commercial lease.

Lease an off-site facility, either by occupying an existing facility or by pursuing a new construction lease approach. Commercial options are at least 2 miles from SNL, and existing office facilities are 3 miles from SNL. Note that a GSA lease would be direct to NNSA and not through SNL or LLNL.

4.2.5 Lease Two Commercial On-Site Facilities

Two separate facilities (CREATE and HPCIC) in different locations on-site.

This third-party leasing approach offers the potential for a private developer to address the functional and technical requirements through a commercial opportunity on Sandia's and Livermore's campuses. Because Sandia and Livermore would be the key anchor tenants in the developments, the mission and functional requirements could be met. The co-location studies indicate that close proximity is an enabler of the national security mission imperative outlined for CREATE, HPCIC and LVOC development. DOE would provide a 35-year ground lease to the owner/developer, and the M&O contractors would lease the facilities for 15 years.

4.2.6 Single New Line-Item Facility

Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).

The new facility would combine the CREATE and HPCIC functions into a single, co-located complex of buildings with a central common area consisting of a training center, a cafeteria, other stand-alone functions, and two wings—one for CREATE and one for HPCIC. The new facility is assumed to be on the portion of the LVOC managed and operated by SNL/CA, on the west side of the current Greenville Road fence near the guard gate. The new facility will reduce space requirements over the two separate buildings (Alt. 3) by approximately 5 percent by sharing common spaces. The acquisition strategy would be a design-build, LI project. SNL would manage the new facility and LLNL would rent (lease) space for its activities.

4.2.7 Lease Single On-Site Facility

Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).

The new facility would combine the CREATE and HPCIC functions into a single, co-located complex of buildings with a central common area consisting of a training center, cafeteria, other stand-alone functions, and two wings—one for CREATE and one for HPCIC. The new facility is assumed to be on SNL property on the west side of the current Greenville Road fence near the guard gate. The new facility will reduce space requirements over the two separate buildings (Alt. 5) by approximately 5 percent by sharing common spaces. The acquisition strategy would be an on-site lease project. DOE would provide a 35-year ground lease to the owner/developer and M&O contractors would lease the facility for 15 years.

4.2.8 Build Multiple Smaller Facilities

Build approximately 10 each of 16,000-sf to 20,000-sf "standard" design facilities in the north and south portions of the LVOC, as needed (currently pursuing this strategy for some facilities). A similar facility is currently being built on SNL.

Each laboratory would develop approximately five facilities using the campus approach, as defined in the Flad study, creating a North Village and a South Village. The acquisition strategy would be operations-funded facilities, constructing one building per year for each laboratory in a 5-year period (assumed to match the LI timeline).

Each facility will have separate, distinct functions (departments, groups, etc.) so that each facility can be considered as a stand-alone, complete facility. Each laboratory would develop an annual work plan to perform multiple new construction (single function) projects in strategically located facilities around the plant over several years.

4.2.9 Develop Only HPCIC

Build or lease a single facility meeting the needs of HPCIC only.

This would be the same facility as defined in alternatives 3 or 5, but only the HPCIC (LLNL) facility.

4.2.10 Develop Only CREATE

Build or lease a single facility meeting the needs of CREATE only.

This would be the same facility as defined in Alternatives 3 or 5, but only the CREATE (SNL) facility.

4.2.11 Renovate LLNL Facility / Develop New CREATE Facility

This option provides a new CREATE facility in the LVOC (using cost information from Alts. 3 and 10), since SNL has no existing facilities in the proximity of the LVOC that can be renovated. LLNL has a facility (Building 543) that could be renovated and/or expanded to meet HPCIC needs. (See discussion in Alt. 2.)

4.3 Alternative Advantages and Disadvantages

As an initial step in the alternatives evaluation, the alternatives team identified advantages (pros) and disadvantages (cons) for each alternative. Appendix B, Table B-1 provides a more detailed list and comparison of the advantages and disadvantages among the alternatives. The advantages and disadvantages of each alternative were developed and are used to assist the team with informing the risk evaluation and how well each alternative addresses the evaluation criteria.

5 INITIAL SCREENING OF ALTERNATIVES

The team performed an initial screening of the alternatives against the 13 mission and program requirements. The screening resulted in either a "2" score (meaning that the alternative fully met the requirement), "0" score (meaning that the alternative did not meet the requirement), or a "1" score (meaning that the alternative partially met the requirement). Table 5-1 shows the results of the screening. If an alternative has a single "0" score, the summary shows a "No." The requirements are described in Section 3. The scoring is only intended to determine the viability of an alternative and is only used to perform an initial screening of those alternatives not being able to meet, or partially meet, the requirements. Appendix C describes the screening performed and the rationale for scoring.

Table 5-1: Initial Screening of Alternatives

Req. #	Requirement	Alternative										
		1	2	3	4	5	6	7	8	9	10	11
PR-1	Provide additional unclassified office/ laboratory/collaboration space for LLNL, SNL, and outside collaborators in the LVOC.	0	0	2	0	2	2	2	2	0	0	2
PR-2	Provide a work environment that is modern, dynamic, and flexible.	0	0	2	2	2	2	2	1	2	2	1
PR-3	Obtain operational effectiveness and efficiencies.	0	0	2	0	2	1	1	1	1	1	1
PR-4	Mission: Develop workforce pipeline for attraction, recruitment, development, and retention of world-class staff in a competitive regional market.	0	0	2	1	2	2	2	2	1	1	2
PR-5	Provide approximately 160,000 to 200,000 total gsf (combined requirement for CREATE and HPCIC).	0	0	2	2	2	2	2	2	0	0	2
PR-6	Provide flexible space for light laboratory of about 4,400 gsf (CREATE) and 1,000 net sf (HPCIC).	0	0	2	2	2	2	2	2	0	0	2
PR-7	Support increased demands for LA space.	0	0	2	2	2	2	2	2	1	1	1
PR-8	Consolidate educational outreach programs and facilities.	0	0	2	2	2	2	2	2	1	1	1
PR-9	Provide additional space in proximity to synergistic programs.	0	0	2	0	2	1	1	2	1	1	2
PR-10	Provide additional space as soon as possible.	0	0	1	2	2	1	2	1	2	2	1
PR-11	Mission need is for 15 years (currently identified), with expected life of facility of 35 years.	1	0	2	2	2	2	2	2	1	1	2
PR-12	Provide approximately 160,000 to 200,000 total gsf (combined requirement for CREATE and HPCIC).	0	0	2	2	2	2	2	2	2	2	2
PR-13	Provide flexible space for light laboratory of about 4,400 gsf (CREATE) and 1,000 net sf (HPCIC).	1	0	2	2	2	2	2	2	2	2	1
Summary Conclusion		No	No	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes
1 = Marginal 0 = No 2 = Yes												

Alternatives 1, 2, 4, 9, and 10 were screened out by the team and, therefore, removed from further consideration. The alternatives removed did not meet one or more of the minimum requirements listed in Table 5-1. Therefore, the team did not consider that these alternatives should be evaluated further. Table C-2, Appendix C, provides the specific rationale for each screening evaluation of the requirements by alternative.

6 EVALUATION CRITERIA

The team developed criteria to evaluate the alternatives. Materials previously developed for this project, including the identified requirements, were used. Additional desired elements were identified based on discussions with potential users and the team's experience with NNSA and other projects. Table 6-1 shows these criteria, or attributes, and the source of the criteria.

Table 6-1: Desired Criteria

D#	Desired Attribute	Additional Description and Notes	Source of Criteria
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	Flad Architecture and Engineering (A&E) 11-4-10 Master Plan (pp.4-26–4-29) identified the village concept for synergistic grouping for walking and bicycling between areas, as well as adjacency to "anchor" facilities; National Ignition Facility (NIF) and Terascale Simulation Facility (TSF) for LLNL; and Combustion Research Facility (CRF) for SNL.	PR-9
2	Operations within 3 to 5 years is of highest importance.	HPCIC timeframe is consistent with Sierra procurement (precursor to Exascale technology, CORAL partnership). CREATE: timing is important to meet upcoming NW Life Extension Program (LEP) and ALT schedules	PR-3, PR-10
3	Moving out of old and/or temporary space is highly desirable.	HPCIC trailer lease renewal uncertain after May 2017; CREATE replaces aged mobile facilities.	PR-1, PR-2, PR-5
4	Reduced deferred maintenance is highly desirable.	Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).	PR-3, PR-5
5	Co-locating related functions is critical to improving site operations.	CREATE allows consolidation of key externally-focused mission programs with currently distributed support functions and creates efficiency for both researchers and administration; reduced redundancy in badging personnel and processing systems (CREATE); and overall mission improvements with co-locating R&D functions in modern space. HPCIC allows for the co-location of key externally focused mission programs in HPC and applied HPC, and allows multidisciplinary research staff to increase efficiency and form high-functioning IPTs for complex projects. Workforce development programs are streamlined through co-location and resource sharing.	PR-1, PR-5, PR-8, PR-9
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	CA NNSA facilities compete with Fortune 100 Silicon Valley and San Francisco/Mission Bay companies (e.g., new Googleplex, Apple, Autodesk facilities).	PR-2, PR-3, PR-4, PR-12
7	Create a gateway for industrial partnerships.	Industry partners bring resources and new talent to problems of interest to NNSA. Industry partners are drawn to laboratories for their intellectual property and highly educated and specialized workforce. Creating a physical space that attracts partners and potential new hires requires modern facilities and adequate space to enable and sustain collaborations and networking events.	PR-1, PR-5, PR-13
8	Lower DOE risks.	Use qualitative risk analysis results from the risk analysis.	PR-5, PR-7, PR-11
9	Lower LCC (NPV).	35-year evaluation; all DOE costs, including capital, O&M, end of life (EOL) dismantlement and decommissioning (D&D), and lease (if applicable).	PR-3, budget
10	Near-term cash flow—lower is better.	Evaluate the first 5 years of cash flow.	PR-3, budget
11	Ease of making facility modifications in the future.	Ability to make changes in the future.	PR-2, PR-6, PR-13

D#	Desired Attribute	Additional Description and Notes	Source of Criteria
12	Ease of meeting Freeze the Footprint initiative.	Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).	PR-3, PR-8 / OMB Directive
13	Ease of transition and relocation.	Transition and relocation may require double moves; very desirable to eliminate double moves.	PR-3, PR-4, PR-5, PR-10
14	Increased energy efficiency and sustainability.	Very important in meeting Department goals.	PR-3, PR-5, PR-12
15	Ease of providing space for visitors or part-time staff (flexible space).	Flexible space allows reconfiguration to meet needs, usually accomplished with open floor plan offices.	PR-1, PR-2, PR-4, PR-5, PR-6
16	Ease of standing up different laboratory functional areas in flex space.	Laboratories (light or educational) are used for various purposes; flexible space allows for reconfiguration, as needed.	PR-6
17	Expedient funding availability.	Funding options include LI, GPP, IGPP, and alternative finance.	PR-10, PR-11
18	Assuring and overseeing safety.	Assuring and overseeing construction and operations safety.	PR-2, PR-3
19	Assuring and overseeing security.	Assuring and overseeing security during construction and operations.	PR-7, PR-13
20	Ease of constructing within the existing NEPA envelope.	Staying within the current environmental framework for the open campus (LLNL and SNL/CA).	PR-3

For the detailed alternatives evaluation, the team assigned weighting factors to each desired feature. The team used a scale to evaluate the relative compliance of the alternative for each feature. Table 6-2 shows the weighting factors used for the evaluation. The weighting factors are not sequential: the most important criterion is weighted 5; the next most important criterion is weighted 3. This adds emphasis to the highest criterion importance.

Table 6-2: Importance Weighting

Criteria Importance	Weighting Factor	Importance Rationale
1	5	Highest importance; borders on a requirement.
2	3	Very important; highly desirable.
3	2	Medium; desirable.
4	1	Lowest importance.

Appendix D provides further discussion of the evaluation criteria and the rationale for the rating of importance. The importance of each attribute is a reflection of the AoA team's interpretation of the requirements on the attributes/evaluation criteria. As can be seen in Table 6-3, the team has determined that the most important criteria to meet include the need to minimize distance between synergistic activities, achieve operations within 3 to 5 years, obtain Class A office space, establish collaborative space for industrial partners, minimize risk, and maintain DOE safety, security, and environmental objectives.

During the alternative evaluation a series of sensitivity analyses were performed on the ratings of importance. Those results are shown in Section 8.

Table 6-3: Desired Attribute Relative Importance and Weight

D#	Desired Attributes	Importance	Attribute Weight
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	5
2	Operations completion within 3 to 5 years is of highest importance.	1	5
3	Moving out of old and/or temporary space is highly desirable.	2	3
4	Reduced deferred maintenance is highly desirable.	2	3
5	Co-locating related functions is critical to improving site operations.	1	5
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	5
7	Create a gateway for industrial partnerships.	1	5
8	Minimize DOE risks.	1	5
9	Lower LCC (NPV).	2	3
10	Near-term cash flow; lower is better.	2	3
11	Ease of making facility modifications in future.	4	1
12	Ease of meeting Freeze the Footprint initiative.	2	3
13	Ease of transition and relocation.	2	3
14	Increased energy efficiency and sustainability.	2	3
15	Ease of providing space for visitors or part-time staff (flexible space).	1	5
16	Ease of standing up different laboratory functional areas in flex space.	4	1
17	Expedient funding availability.	1	5
18	Assuring and overseeing safety.	1	5
19	Assuring and overseeing security.	3	2
20	Ease of constructing within the existing NEPA envelope.	1	5

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7 COST AND SCHEDULE ESTIMATES

LCCEs were developed for each viable alternative identified for the project. These estimates are only intended to be used to support the AoA. A subset of the LCCE for the preferred alternative can also be used to confirm or revise the total project cost (TPC) range and expected funding profile for the project at the time of CD-1 approval if no further estimates are developed as part of a conceptual design process.

The bases and assumptions used for the LCCEs and the calculations of NPV for each alternative are fully described in Appendix E. Appendix E also discusses how these estimates were developed in accordance with the best practices for developing and managing the capital program costs found in the *Government Accountability Office (GAO) Cost Estimating and Assessment Guide* [Ref. 9].

7.1 Net Present Value (NPV)

Table 7-1 presents the results of the NPV analyses for each alternative considered. All costs are time-phased using a summary-level schedule developed for the proposed overall facility life of 35 years. The time-phased costs are appropriately escalated and a NPV is calculated in accordance with OMB Circular A-94 using the January 2015 nominal discount rate presented therein for a 30-year life (maximum provided). The discount factor used was 3.4 percent.

Table 7-1: NPV Results ($M)

Alternative	NPV	Ranking by NPV
3 – Build New Facilities (Line Item)	165.2	4
5 – Build New Facilities (Lease Financing)	131.0	1
6 – Single New Facility (Line Item)	164.4	3
7 – Single New Facility (Lease)	135.9	2
8 – Multiple Small Constructed Facilities	225.2	6
11 – Renovate LLNL Facility/Develop New CREATE Facility	181.1	5

7.2 Acquisition Approach

Table 7-2 compares the TPCs for the various acquisition strategies.

Table 7-2: TPC Comparisons Based on Acquisition Strategy ($M)

Facility	Alternative Financing (Lease)	Line Item (Federal Direct)	M&O Procurement
HPCIC	31.2	39.0	47.5
CREATE	30.2	37.8	46.0
Single Building	65.9	82.3	100.2

The Alternative Financing option presumes that a third-party developer designs and constructs the new building using the specifications and standards provided, and then leases the new building following construction.

The LI option (Federal Direct) assumes no M&O markups. The M&O contractor does not issue the subcontracts for design or construction, and is not responsible for Title III or any of the Quality/Safety requirements. NNSA either does the contracting or, alternatively, USACE or some other entity performs the contracting and management of the design and construction. M&O staff is involved at a limited level—limited design reviews, interfaces for installation support, etc. The premium over the alternative financing base case is estimated at 15 percent.

The M&O procurement option is the typical DOE paradigm with the M&O contractor(s) issuing the design and construction through subcontracts. The M&O contractor includes all markups and is responsible for everything (design reviews, quality, safety, etc.). We assume a higher premium for this strategy due to the markups and the greater involvement required of the M&O staff. The premium over the alternative financing base case is estimated at 40 percent. This acquisition approach for line-item construction was not used for the LCCEs.

The single facility, even with less area than the two facilities, is estimated to have a higher cost. This is due to the location, longer utility runs, and other additional cost factors; to include: contingency and environmental costs. Appendix E contains additional details, as well as the Cost Sensitivity Analysis in Section 7.4.

7.3 NPV Range

Many assumptions and key parameters used for this analysis are highly uncertain, and an analysis was completed to assess the extent of that uncertainty. The details of the analyses are shown in Appendix E. The summary results are presented in Table 7-3, which shows the range of NPVs for each alternative.

Table 7-3: Range Analysis Results ($M)

Alternative	NPV Based on Uncertainty		
	Base	Low	High
3 – Build New Facilities (Line Item)	165.20	131.3	267.1
5 – Build New Facilities (Lease Financing)	131.00	93.2	227.2
6 – Single New Facility (Line Item)	164.40	126.8	268.7
7 – Single New Facility (Lease)	135.90	94.9	231.4
8 – Multiple Small Constructed Facilities	225.20	153.2	366.4
11 – Renovate LLNL Facility/Develop New CREATE Facility	181.10	154.1	261.7

The NPV range is developed by assessing the realistic range of various key parameters that underpin the NPV point estimates. These key parameters include the basic cost estimating uncertainty, escalation rates, lease financing rates, contingency percentages, cost of small building construction, and the DOE premium for line item work. Calculating the LCCEs using

both minimum and maximum values for these parameters generated the data necessary to calculate the low and high NPVs for each alternative and establish the range. See Appendix E - Table E-6, Section E9.

Figure 7-1 graphically presents the ranges of NPV for each of the viable alternatives. For each alternative, the triangle represents the "Base" NPV from Table 7-3.

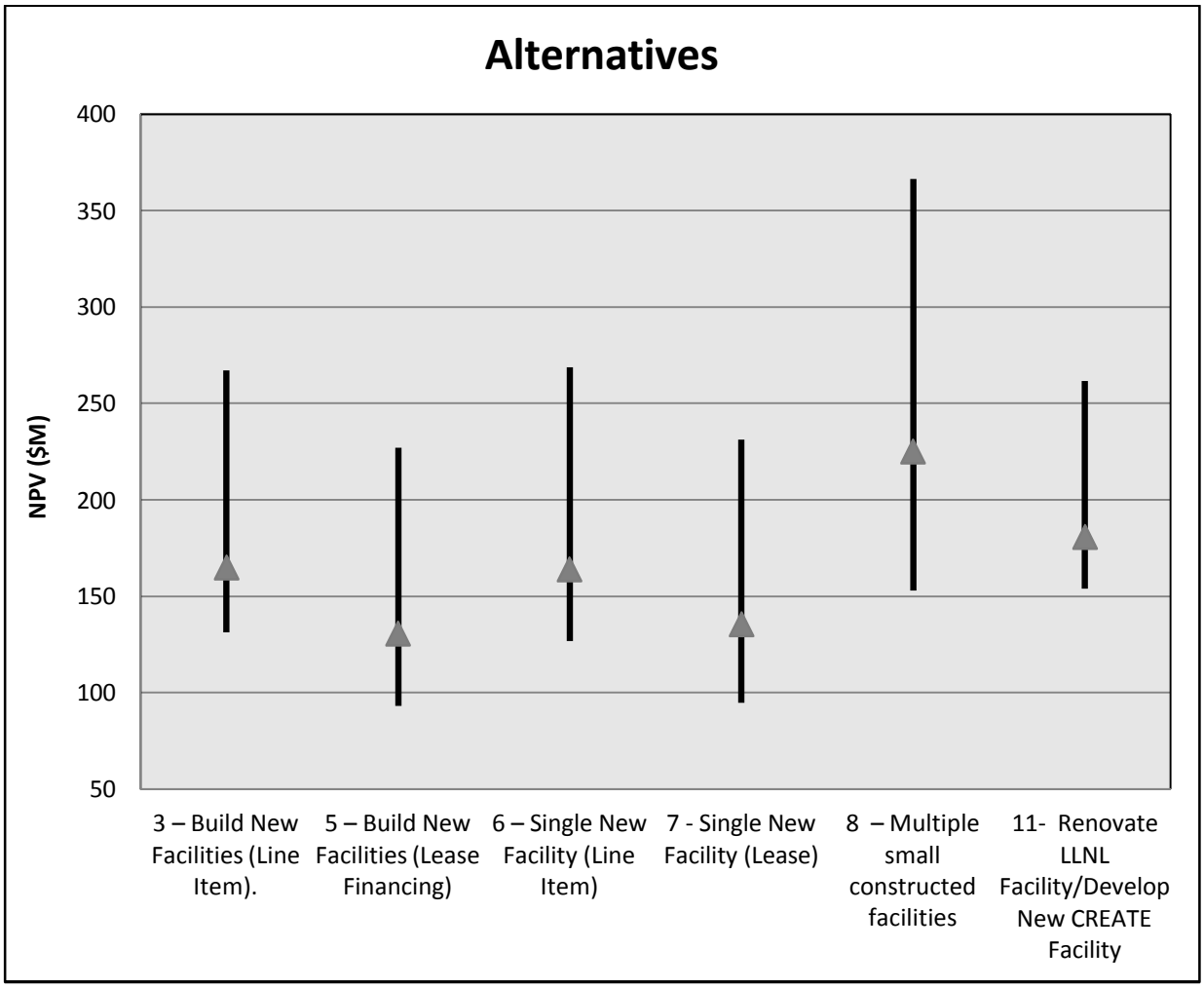

Figure 7-1: NPV Ranges

7.4 Cost Sensitivity Analysis

A cost sensitivity analysis was conducted by varying 10 key parameters as described in Appendix E. The sensitivity analysis concludes that the results are generally insensitive such that very few variations in key parameters alter the ranking of the alternatives relative to the NPV of LCCs. Changes to just a few parameters have a minor impact on that ranking. These are summarized as follows:

- Decreasing the assumed O&M escalation from 2 percent to 1 percent reverses the rankings of Alternatives 3 and 6.

- Using the same contingency percentage for the single-building concept as for the separate buildings makes Alternative 7 slightly more favorable than Alternative 5. For the base case, contingency rates for the single building alternatives were 5 percent higher than the other alternatives based on the increased level of risk identified with a single building alternative.

The only exception is the O&M rate. For the base case, actual O&M rates at LLNL and SNL/CA are approximately three times higher than O&M rates assumed for alternative financing (based on industry-standard regional rates published by the Building Owners and Managers Association). Sensitivity analysis shows that the line item scenarios (Alt. 3 and 6) become slightly more favorable from a life cycle cost perspective when the commercial rate gets within 20% of the current actual rates.

8 ALTERNATIVE EVALUATION

Detailed descriptions of the alternatives to be evaluated are included in Section 5 and in Appendix B, which includes sketches of the possible new facilities.

When comparing cost and schedule data and the overall AoA evaluation scores, the project execution risks should also be considered because these risks vary between alternatives and can influence the decision on the preferred alternative. Although quantitative risk and contingency analyses were not performed as part of the AoA process, the team has identified some of the project risks that should be considered together with the overall AoA evaluation scores.

The team identified potential risks, both threats and opportunities, and rated those risks in a qualitative analysis using the process identified in DOE Guide (G) 413.3-7A, Risk Guide [Ref. 10]. The Qualitative Risk Analysis Matrix of the Risk Guide (Figure 3, Page 18), was used to identify the risk as "Low," "Moderate," or "High." The resulting risk level is the potential impact (consequence) and occurrence probability. Table 8-1: Risk Matrix from the Risk Guide is provided.

The team evaluated each alternative for applicable risks. Table 8-2 shows the identified risks and risk levels. The risk shows as a threat or opportunity. The table also shows the risk level for each alternative, as applicable.

Table 8-1: Risk Matrix

		Consequence of Occurrence (C_R)				
		Negligible	Marginal	Significant	Critical	Crisis
	Cost	Minimal or no consequence. No impact to Project cost.	Small increase in meeting objectives. Marginally increases costs.	Significant degradation in meeting objectives significantly increases cost; fee is at risk.	Goals and objectives are not achievable. Additional funding may be required; loss of fee and/or fines and penalties imposed.	Project stopped. Funding withdrawal; withdrawal of scope, or severe contractor cost performance issues.
	Schedule	Minimal or no consequence. No impact to Project schedule.	Small increase in meeting objectives. Marginally impacts schedule.	Significant degradation in meeting objectives, significantly impacts schedule.	Goals and objectives are not achievable. Additional time may need to be allocated. Missed incentivized and/or regulatory milestones.	Project stopped. Withdrawal of scope or severe contractor schedule performance issues.
Likelihood of Occurrence (L)	Very Likely >90%	Low	Moderate	High	High	High
	Likely 75% to 90%	Low	Moderate	Moderate	High	High
	Unlikely 26% to 74%	Low	Low	Moderate	Moderate	High
	Very Unlikely 10% to 25%	Low	Low	Low	Low	High
	Non-Credible <10%	Not Considered a Project Risk				

Table 8-2: Risk List and Levels for Alternatives

No.	Risk Description (Threat Unless Noted)	Alternatives – INPUT VALUES					
		2LI	2LS	1LI	1LS	Mult	Reno/New
		3	5	6	7	8	11
	Threats						
1	Design does not provide for all desired functions, requiring additional investment	l	m	l	m	m	m
2	Limited vendor/contractor availability and/or interest because of external market conditions	m	l	m	l	m	m
3	Significant safety, security, or environmental issues emerge during development of a facility on federal land, impacting project success	m	l	m	l	m	m
4	Costs much higher than expected or accounted for in uncertainty to due inflation, labor issues, or competition for CA labor/materials	m	l	m	l	m	m
5	Inability to get contracts approved, (e.g., construction, ground lease signed or facility lease agreement signed)	l	m	l	m	l	l
6	Unidentified subsurface conditions (e.g., utility, environmental hazard, or cultural/historic resource) delays project and increases costs	l	l	m	m	m	l
7	Inadequate government staffing to deliver project causes delays and increases costs	m	l	m	l	l	m
8	Turnover of government personnel causes approval delay or reauthorization	l	m	l	m	l	l
9	Lack of clarity of roles, responsibilities, and authorities for DOE/NNSA, delaying the project	l	m	l	m	l	l
10	Claims and changes during construction process increase costs	m	l	m	l	m	m
11	Availability of construction materials delays project and increases costs	m	l	m	l	m	m
12	Project invokes additional NEPA/CEQA lab-prepared environmental documentation, causing project delays and increasing costs	l	l	m	m	l	l
13	Increased probability that NEPA/CEQA regulators move to consider LLNL/SNL joint site regardless of project outcome and/or potentially impacting laboratories' future operations	l	l	h	h	l	l
14	Delays in the required governmental actions or approvals delay the project	m	h	m	H	l	m
15	Funding is unavailable, reduced, and/or delayed, impacting the project	h	l	h	l	m	h
	Opportunity						
16	Provides capital investment while minimizing demand for limited DOE funds (LI)	(l)	(h)	(l)	(h)	(m)	(l)
17	Cost and schedule improvements due to transfer of government risk to nongovernment entity	(m)	(h)	(m)	(h)	(m)	(m)
18	Construction costs realized much lower than expected or planned	(m)	(l)	(m)	(l)	(m)	(m)
19	Building size is optimized, reducing construction costs	(m)	(l)	(h)	(m)	(l)	(l)
20	Ability to accommodate changes in future mission needs reduces operational costs	(l)	(h)	(l)	(h)	(m)	(l)
	Overall Risk Summary (All Risks)	m	m	m	m	m	m
	Sum/#	1.80	1.50	1.95	1.65	1.70	1.90
	Rank:	4	1	6	2	3	5
	Threats Only Summary	m	l	m	m	m	m
	Sum/#	1.6	1.4	1.87	1.67	1.53	1.67
	Rank:	3	1	6	4	2	4
	Opportunities Only Summary	(m)	(m)	(m)	(m)	(m)	(l)
	Sum/#	2.40	1.80	2.20	1.60	2.20	2.60
	Rank:	5	2	3	1	3	6

Note: Score calculated: H or (L) = 3; M or (M) = 2; L or (H) = 1.

To perform the alternative evaluation, the team used the weighted analysis matrix described in Section 6 and rated how completely each alternative met the desirable criteria. Table 8-3 shows the scoring system used. As with the importance scoring, the attribute scoring is nonlinear and provides more weight to the "fully meets criteria" than to the other lesser scores.

Table 8-3: Alternative Evaluation Scale

Attribute Evaluation	Score
Fully meets the criteria	1
Generally meets the criteria	0.5
Somewhat meets the criteria	0.3
Barely meets the criteria	0.1
Does not meet the criteria at all	0

The team used the risk analysis, the advantages/disadvantages of each alternative (Section 5 and Appendix B), subject matter expertise, and the LCCEs to inform the alternative scoring.

The team completed the scoring as summarized in Table 8-4 with a maximum score of 20.

Table 8-4: Alternative Scoring Results (Un-weighted)

Alternative	Un-weighted Score	Rank (On Un-weighted Score)
3 (build 2 new line items)	15.1	3
5 (lease 2 new facilities)	18.3	1
6 (build 1 combined line item)	13.5	4
7 (lease 1 combined facility)	15.7	2
8 (build multiple smaller facilities)	10.7	5
11 (renovate 1 facility and build 1 new facility)	8.4	6

The detailed scoring is shown in Table F-2, Appendix F. The rationale for the scoring is listed in Table F-3, Appendix F. To provide a consistent basis from which all alternative scores could be compared, the weighted scores were converted according to a 0-to-100 grading scale, with 0 being the lowest possible score and 100 being the highest possible score. The weighted results are shown in Table 8-5.

Table 8-5: Alternatives Results – Weighted Score

D#	Desired Attributes	Importance	Normalized Weighting (NW)	3 2LI	5 2LS	6 1LI	7 1LS	8 Mult	11 Reno/ New
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	6.7	6.7	6.7	0.7	0.7	6.7	6.7
2	Operations within 3 to 5 years is of highest importance.	1	6.7	6.7	6.7	6.7	6.7	3.3	2.0
3	Moving out of old and/or temporary space is highly desirable.	2	4.0	4.0	4.0	4.0	4.0	4.0	2.0
4	Reduced deferred maintenance is highly desirable.	2	4.0	4.0	4.0	4.0	4.0	2.0	2.0
5	Co-locating related functions is critical to improving site operations.	1	6.7	6.7	6.7	6.7	6.7	2.0	2.0
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	6.7	6.7	6.7	6.7	6.7	3.3	2.0
7	Create a gateway for industrial partnerships.	1	6.7	3.3	6.7	2.0	3.3	3.3	3.3
8	Lower DOE risks.	1	6.7	2.0	6.7	2.0	3.3	3.3	2.0
9	Lower LCC (NPV).	2	4.0	2.0	4.0	2.0	4.0	0.4	1.2
10	Near-term cash flow—lower is better.	2	4.0	1.2	4.0	1.2	4.0	0.4	0.4
11	Ease of making facility modifications in the future.	4	1.3	0.7	0.4	0.7	0.4	0.7	0.7
12	Ease of meeting Freeze the Footprint initiative.	2	4.0	0.4	4.0	0.4	4.0	1.2	1.2
13	Ease of transition and relocation.	2	4.0	4.0	4.0	4.0	4.0	2.0	1.2
14	Increased energy efficiency and sustainability.	2	4.0	4.0	4.0	4.0	4.0	2.0	1.2
15	Ease of providing space for visitors or part-time staff (flexible space).	1	6.7	6.7	6.7	6.7	6.7	2.0	3.3
16	Ease of standing up different laboratory functional areas in flex space.	4	1.3	1.3	1.3	1.3	1.3	0.4	0.7
17	Expedient funding availability.	1	6.7	0.7	6.7	0.7	6.7	3.3	0.7
18	Assuring and overseeing safety	1	6.7	6.7	3.3	6.7	3.3	6.7	3.3
19	Assuring and overseeing security	3	2.7	2.7	1.3	2.7	1.3	2.7	1.3
20	Ease of constructing within the existing NEPA envelope.	1	6.7	6.7	6.7	2.0	2.0	6.7	6.7
	Score		100.0	76.9	94.4	64.9	77.1	56.4	43.9

As a check on these results and to determine the impacts of both the weighting and some input scores, the evaluation team performed a series of sensitivity analyses. Table 8-6 lists the Sensitivity Cases that modified the evaluation weighting factors (Cases S-1 through S-4). The table also lists additional sensitivity analyses performed on the impact of various evaluation criteria and risk analysis in the scoring (Cases S-5 through S-9).

- Sensitivities 1 through 4 were completed to ensure there was no biasing of the results in favor of one category (Cost, Mission, Infrastructure, or Schedule) over others in the evaluation of the alternatives against the criteria.
- Sensitivity 5 (Remove Attribute #8 from the evaluation criteria) was completed to validate that there was no inadvertent effect of bias of over counting in the risk analysis.
- Sensitivities 6 and 7 were added to ensure that there was no inadvertent biasing of alternative financing alternatives due to low near-term cash flow and NPV.
- Sensitivity 8 removes the attributes for risk, near-term cash flow and NPV from the evaluation criteria – a combination of sensitivities 5, 6 and 7.
- Sensitivity 9 was done to revise the risk matrix to remove possible risks that could be considered a duplicate to the desired attributes.

Table 8-6: Sensitivity Cases

Sensitivity Case	Change
S-1: Cost Highest Importance (Desired Attributes D#9 and D#10)	Cost Importance =1; Others = –2
S-2: Mission Highest Importance (Desired Attributes D#1, D#2, D#5, D#7, and D#15)	Mission Importance = 1; Others = –2
S-3: Infrastructure Sustainment Highest Importance (Desired Attributes D#4, D#5, D#6, D#12, D#14, and D#16)	Infrastructure Sustainment Importance=1; Others = –2
S-4: Schedule Highest Importance (Desired Attributes D#2, D#10, and D#17).	Schedule Importance = 1; Others = –2
S-5: Delete Desired Attribute for Risk	Delete Attribute #8
S-6: Delete Desired Attribute for Near-Term Cash Flow	Delete Attribute #9
S-7: Delete Desired Attribute for NPV	Delete Attribute #10
S-8: Combined Changes S-5, S-6, and S-7	Delete Attributes #8, #9, #10
S-9: Revise Risk Matrix to Remove Risks Possibly Duplicative of Desired Attributes	Delete Risks #12,#13, #15, #16, and #17

Key: Others –2 = Reduce baseline Importance values by 2, or to the minimum value (4)

For sensitivity runs 1 through 4, the revisions to the importance rankings are shown in Table 8-7.

Table 8-7: Sensitivity Analysis for Evaluation Criteria

D#	Criteria	Baseline	S-1 Cost	S-2 Mission	S-3 Infrastructure Sustainment	S-4 Schedule
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	3	1	3	3
2	Operations completion within 3 to 5 years is of highest importance.	1	3	1	3	1
3	Moving out of old and/or temporary space is highly desirable.	2	4	4	1	4
4	Reduced deferred maintenance is highly desirable.	2	4	4	1	4
5	Co-locating related functions is critical to improving site operations.	1	3	1	3	3
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	3	3	1	3
7	Create a gateway for industrial partnerships.	1	3	1	3	3
8	Lower DOE project success risks.	1	3	3	3	3
9	Lower LCC (NPV).	2	1	4	4	4
10	Near-term cash flow; lower is better.	2	1	4	4	1
11	Ease of making facility modifications in future.	4	4	4	1	4
12	Ease of meeting Freeze the Footprint initiative.	2	4	4	1	4
13	Ease of transition and relocation.	2	4	4	4	4
14	Increased energy efficiency and sustainability.	2	4	4	1	4
15	Ease of providing space for visitors or part-time staff (flexible space).	1	3	1	3	3
16	Ease of standing up different laboratory functional areas in flex space.	4	4	4	1	4
17	Expedient funding availability.	1	3	3	3	1
18	Assuring and overseeing safety	1	3	3	3	3
19	Assuring and overseeing security	3	4	4	4	4
20	Ease of constructing within the existing NEPA envelope.	1	3	3	3	3

Table 8-8 provides the normalized weighted results for the top four alternatives. Alternative 5 scored the highest of all the cases. For sensitivity cases 2, 7, 8, and 9, Alternative 3 becomes the second highest rated, instead of Alternative 7. Appendix F provides the complete sensitivity results.

Table 8-8: Sensitivity Analysis Results

Sensitivity Analysis	Alternatives & Normalized Weighted Results			
	3	5	6	7
Baseline Analysis	75.6	94.4	64.9	77.1
S-1: Cost Highest Importance (Desired Attributes D# 9 and D#10)	68.4	94.2	60.0	80.5
S-2: Mission Highest Importance (Desired Attributes D#1, D#2, D#5, D#7, and D#15)	79.3	95.1	66.2	74.2
S-3: Infrastructure Sustainment Highest Importance (Desired Attributes D#4, D#5, D#6, D#12, D#14, and D#16)	77.5	91.2	71.9	82.1
S-4: Schedule Highest Importance (Desired Attributes D#2, D#10, and D#17)	68.3	94.5	60.3	81.5
S-5: Delete Desired Attribute for Risk	78.9	94.0	67.4	79.0
S-6: Delete Desired Attribute for Near-term Cash Flow	76.7	94.2	65.6	76.1
S-7: Delete Desired Attribute for NPV	77.5	94.2	66.4	76.1
S-8: Combined Changes S-5, S-6, and S-7	82.5	93.4	70.0	77.0
S-9: Revise Risk Matrix to Remove Risks Possibly Duplicative of Desired Attributes	76.9	94.4	66.3	80.4

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9 CONCLUSIONS

The results of the scoring of the alternatives are listed in Table 9-1.

Table 9-1: Alternative Rankings

Rank	Alternative	Score
1	5 (lease 2 new facilities)	94.4
2	7 (lease 1 combined facility)	77.1
3	3 (build 2 new line items)	75.6
4	6 (build 1 combined line item)	64.9
5	8 (build multiple smaller facilities)	55.1
6	11 (renovate 1 and build 1 new facility)	42.5

Alternative 5 (2LS: HPCIC and CREATE) was identified as the highest ranking alternative. Alternative 7 (1LS) and Alternative 3 (2LI: HPCIC and CREATE) were scored very similarly and ranked second and third, respectively. In the nine sensitivity analyses completed (see Table 8-8), these were the only two alternatives that changed positions. In sensitivity cases 3, 7, 8, and 9 (described in Section 8 and Appendix F), the rankings for these two were reversed; Alternative 3 was ranked second and Alternative 7 was ranked third.

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10 TEAM MEMBERS

The Alternatives Analysis team consisted of the following personnel:

NNSA Participants	Area of Expertise/Role
Sam Brinker	NNSA – Livermore Field Office – Contracting Officer's Representative
Lois Marik	NNSA – Sandia Field Office
Tony Trujillo	NNSA – NA-APM 23 – Project Integrator
Ward Sigmund	NA-113 (Contractor) – Programs
Paul Ross	NA-113 – Programs
Bill McNavage	NA-1.3 CEPE (Advised Team and Reviewed Process)
ECMS Participants	
Mark Lane	ECMS Team Lead
Matt Champagney	ECMS Team Task Manager
Scott Dam	ECMS Team Risks / Alternatives Analysis
Doug Gray	ECMS Team Life-cycle costs
Terri Callins	ECMS Team Space Planner
Lawrence Livermore National Laboratory	
Buck Koonce	LLNL – Senior Management
Camille Bibeau	LLNL – LVOC Lead
Jeff Brunetti	LLNL – LVOC Project Management (Risks, Security, and ES&H)
Al Moser	LLNL – Business Directorate (Cost Analysis)
Jeff Brenner	LLNL – LVOC Planning Manager
Hank Glauser	LLNL – Facilities
Dean Yoshida	LLNL – Project Management Engineering & Construction
John Post	LLNL – Management
Sandia National Laboratories/California	
Denise Koker	SNL – Director California Site Operations
Andrew McIlroy	SNL – Deputy Chief Technology Officer
John Garcia	SNL – Physical Operations
Doug Vrieling	SNL – Project Management Engineering & Construction
Devon Powers	SNL – LVOC Project Management
Dave Hopman	SNL – Cost Analysis
Howard Royer	SNL – Planning & Studies

The AoA execution process was reviewed and advised on by the following:

- NNSA Cost Estimating and Program Evaluation (CEPE) – William McNavage (NA-1.3)

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APPENDIX A GAO AOA BEST PRACTICES EVALUATION

Table A-1: GAO Best Practices Evaluation

24 Best Practices: GAO-15-37			
General Principles		**Yes/No**	**Discussion**
1	The customer defines the mission need and functional requirements without a predetermined solution.	Yes	Mission Need Statement – CD-0 Documentation provided
2	The customer defines functional requirements based on mission need.	Yes	Developed with Development Options Report (DOR)/CD-0 and other documents
3	The customer provides the team conducting the AoA with enough time to complete the AoA process and ensure a robust and complete analysis.	Yes	Timeframe for this work is from end of April 2015 to June 2015. Evaluations of Alternatives took place June 15-16, 2015, with the final Alternatives Analysis report to be completed in June 2015.
4	The team includes members with diverse areas of expertise including, at a minimum, subject matter, project management, cost estimating, and risk management expertise.	Yes	Team members of the IPT have been identified. The Team List is included in the report. A sub-team was identified to complete the Evaluation of the Alternatives.
5	The team creates a plan, including methodologies, for identifying, analyzing, and selecting alternatives, before beginning the AoA process.	Yes	Initial Work Plan was provided and captured in the Kick-off Meeting Trip Report. The plan will be revised and updated as progress is made.
6	The team documents all steps taken to identify, analyze, and select alternatives in a single document.	Yes	Documentation is included in the AoA Report.
7	The team documents and justifies all assumptions and constraints used in the analysis.	Yes	A listing of assumptions and constraints has been completed and reviewed by the team. This is included in the Report.
8	The team conducts the analysis without a predetermined solution.	Yes	The team conducted the analysis without a pre-determined solution. Due to the timing of the analysis, considerable documentation was already developed. The team used these as reference, but did not have a pre-determined solution.
Identifying Alternatives			
9	The team identifies and considers a diverse range of alternatives to meet the mission need.	Yes	On May 6, 2015, a suite of Alternatives was identified and screened against the Program Requirements.
10	The team describes alternatives in sufficient detail to allow for robust analysis.	Yes	Alternative descriptions were developed on May 6, 2015 and were reviewed and confirmed by the team in meetings on June 15, 2015.
11	The team includes one alternative representing the status quo to provide a basis of comparison among the alternatives.	Yes	Alternative 1 – Existing Buildings was kept as the "status quo" alternative.
12	The team screens the list of alternatives before proceeding, eliminates those that are not viable, and documents the reasons for eliminating the alternatives.	Yes	Each alternative was screened against the Program Requirements. Alternatives 1, 2, 4, 9, and 10 were determined not to be viable.

24 Best Practices: GAO-15-37			
Analyzing the Alternatives			
13	The team develops a LCCE for each alternative, including all costs from inception of the project through design, development, deployment, operation, maintenance, and retirement.	Yes	LCCEs for each viable alternative were developed using the estimate plan that was originally drafted in May 2015 and was updated throughout the process.
14	The team presents the LCCE for each alternative as a range, or with a confidence interval, and not solely as a point estimate.	Yes	NPV of LCC was presented and provided as a range. This is described in the report.
15	The team expresses the LCCE in present value terms and explains why it chose the specific discount rate used.	Yes	The LCCEs were presented in the NPV. The Estimate Plan includes escalation and the discount rate used.
16	The team uses a standard process to quantify the benefits/effectiveness of each alternative and documents this process.	Yes	The team quantified the benefits/effectiveness of each alternative and documented them in the report.
17	The team quantifies the benefits/effectiveness resulting from each alternative over that alternative's full life cycle, if possible	Yes	An NPV was prepared for each of the viable alternatives.
18	The team explains how each measure of benefit/effectiveness supports the mission need.	Yes	The rationale of how each of the Alternatives is included in the report.
19	The team identifies and documents the significant risks and mitigation strategies for each alternative.		Risks were documented and identified by the team. Both threats and opportunities are included.
20	The team tests and documents the sensitivity of both the cost and benefit/effectiveness estimates for each alternative to risks and changes in key assumptions.	Yes	Sensitivity Analyses were completed on the LCCE and on the attributes (changing in Importance).
Selecting a Preferred Alternative			
21	The team or decision maker defines the selection criteria based on mission need.	Yes	The team identified a list of "Desired Attributes" and rated their importance relative to each other, from 1 (most important) to 4 (least important). This list was developed on May 5, 2015. Attributes and importance were confirmed in meetings held June 15-16, 2015.
22	The team or decision maker weights the selection criteria to reflect the relative importance of each criterion.	Yes	The team decided the relative importance of each attribute and the weight. Importance of 1 = weight of 5; Importance of 2 = weight of 3, Importance of 3 = 2, and Importance of 4 = 1.
23	The team or the decision maker compares alternatives' NPV, if possible.	Yes	The NPVs of the LCCs were presented and provided as a range. This is described in the report.
24	An entity independent of the AoA process reviews the extent to which best practices have been followed (for certain projects, additional independent reviews may be necessary at earlier stages of the process, such as reviewing the study plan or for reviewing the identification of viable alternatives).	Yes	Cost Estimating and Program Evaluation (CEPE) reviewed the evaluation process and acted as a process advisor throughout the analysis.

APPENDIX B ALTERNATIVES SKETCHES AND ADVANTAGES/DISADVANTAGES

Alt. #	Alt. Name	Alt. Description
1	Existing Facilities	No actions other than normal maintenance (Status Quo).
2	Renovate Facilities	Renovate facilities at both laboratories.
3	Two New Line-Item Facilities	Two separate facilities (CREATE and HPCIC) in different locations.
4	Lease Off-Site Facility	Consider GSA lease or separate commercial lease.
5	Lease Two Commercial On-Site Facilities	Two separate facilities (CREATE and HPCIC) in different locations.
6	Single New Line-Item Facility	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).
7	Lease Single On-Site Facility	Combine CREATE and HPCIC into a single facility (assume southwest corner of Greenville Road and East Avenue).
8	Build Multiple Smaller Facilities	Build approximately 10 separate, distinct 16,000-sf to 20,000-sf "standard" design facilities in LVOC north or south portions, as needed (currently pursuing this strategy for some facilities).
9	Develop Only HPCIC	Build or lease a single facility meeting HPCIC needs only.
10	Develop Only CREATE	Build or lease a single facility meeting CREATE needs only.
11	Renovate LLNL Facility/Develop New CREATE Facility	SNL has no existing facility in the LVOC or its proximity; therefore, build a new facility. LLNL has facility that could be renovated, to include additions.

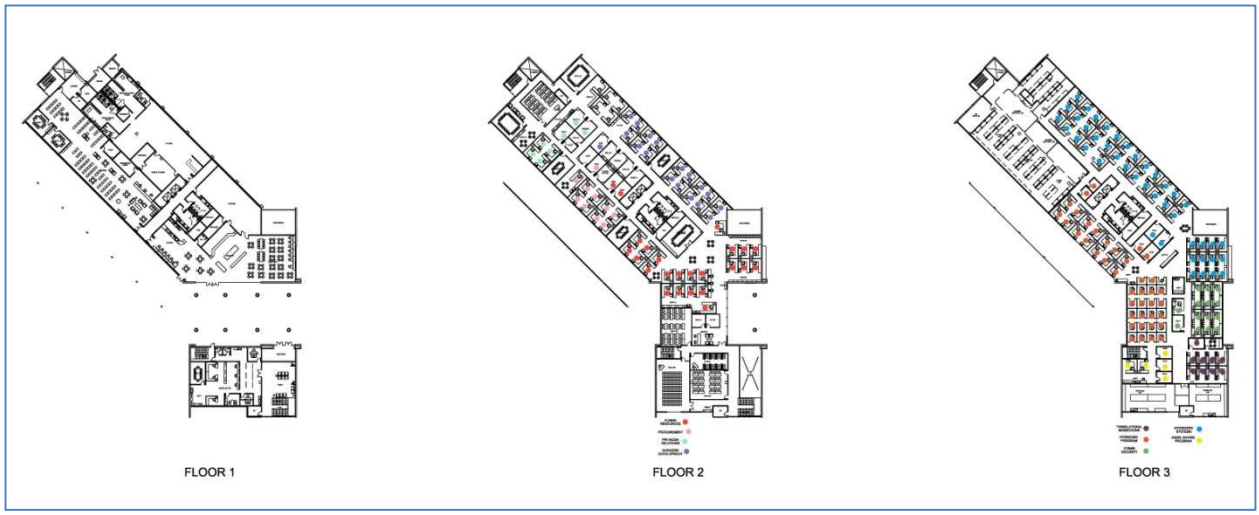

Figure B-1: CREATE (Alts. 3, 5, and 11)

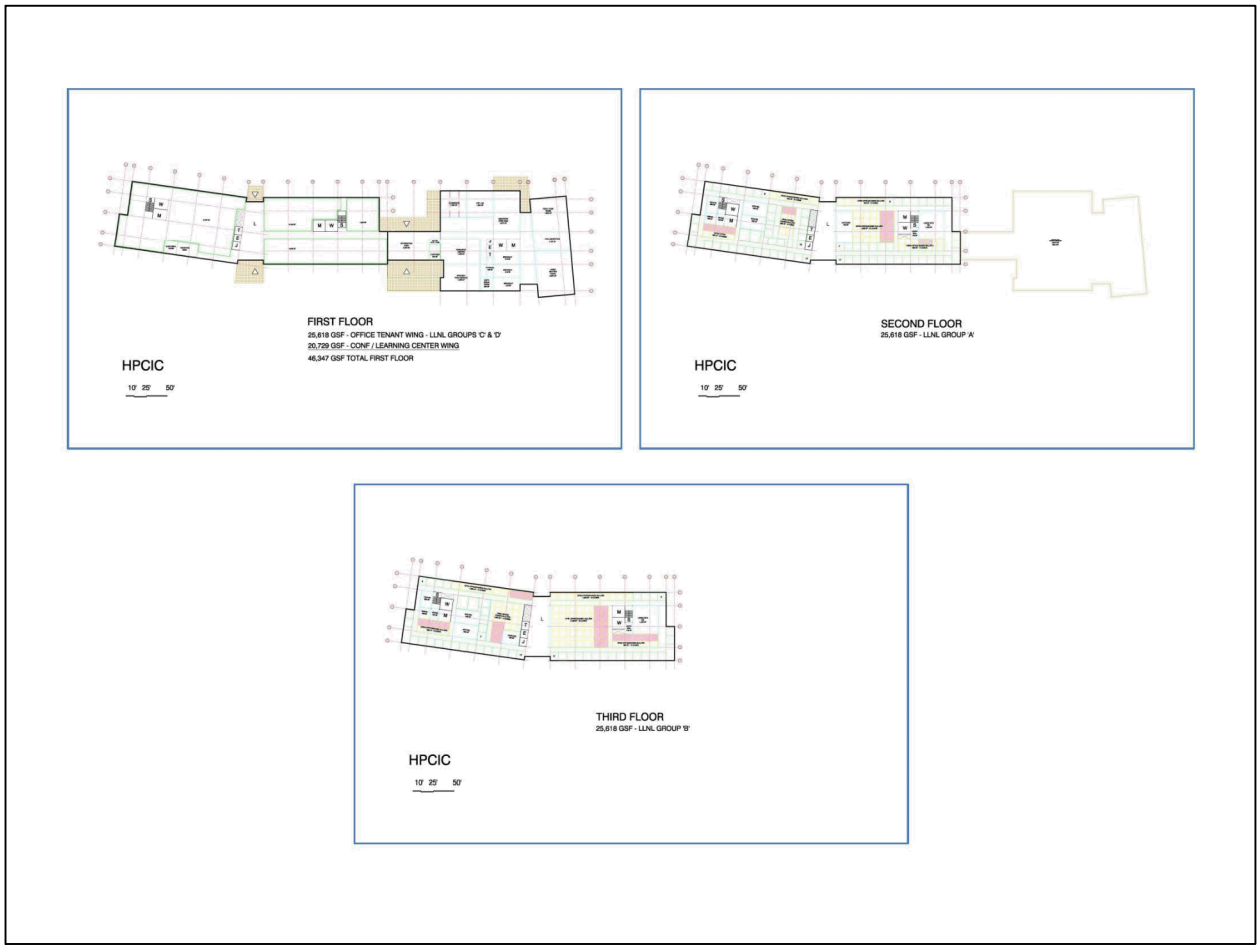

Figure B-2: HPCIC (Alts. 3 and 5)

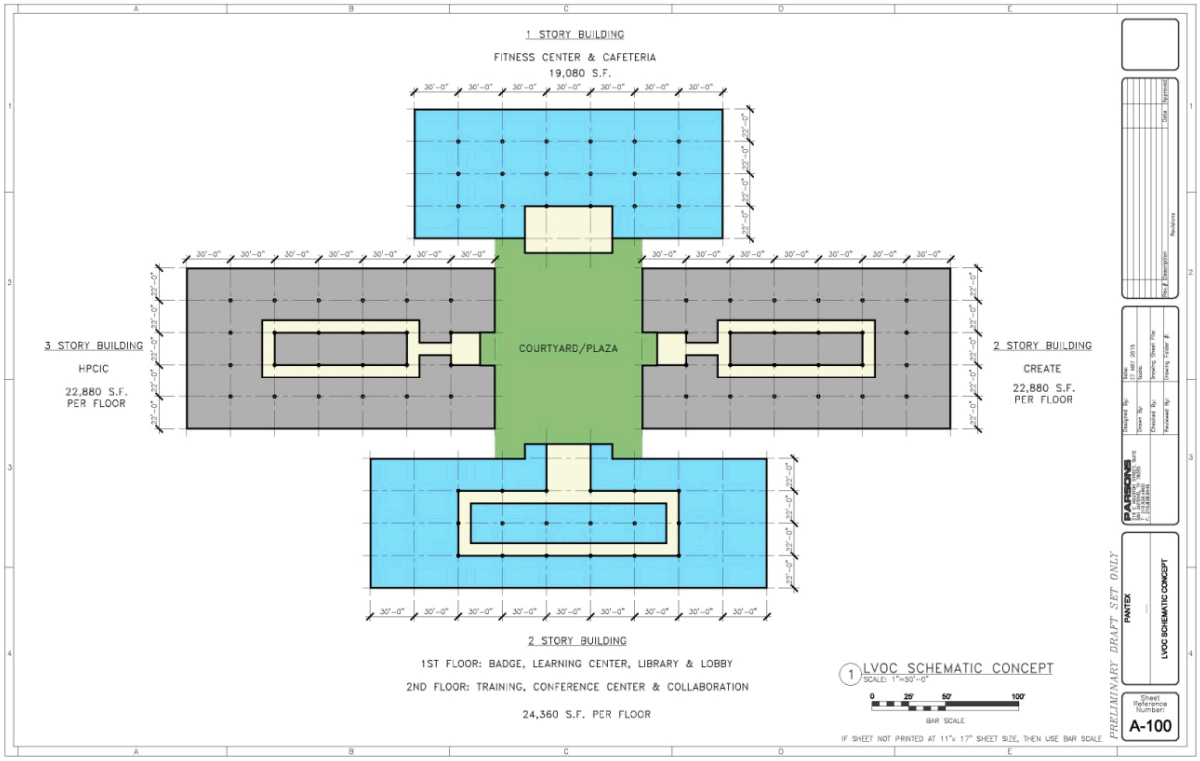

Figure B-3: Single Facility (Alts. 6 and 7)

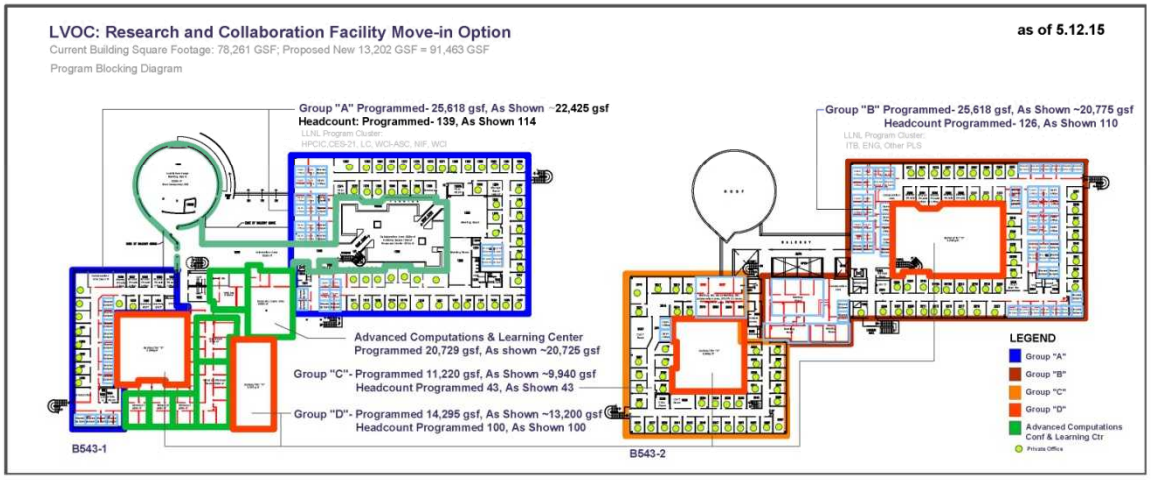

Figure B-4: HPCIC (B543 Reno – Alt. 11)

Table B-1: Alternatives Advantages and Disadvantages

Advantages (Pros)	2LI 3	2LS 5	1LI 6	1LS 7	Mult 8	Reno/New 11
Meets mission needs (mission and program requirements).	X	X	X	X	X	X
Eliminates deferred maintenance (as a result of the facilities being turned cold and dark).	X	X	X	X	X	X
Known process within DOE to get approval.	X		X		X	X
Maintains greater control of the facility (direct involvement in design and operations).	X		X		X	X
Easier construction/schedule advantages using standard commercial construction.		X		X		
Requires fewer federal and M&O resources (e.g., construction management and safety oversight).		X		X		
Less O&M support under lease; owner responsible for major items.		X		X		
Likely an earlier move-in date.		X		X		
Timeline of funding availability is quicker by using indirect (laboratory overhead) budgets to fund leases and no requirement to compete for funding (external to laboratory).		X		X		
Lower upfront cash flow requirement, since not funding design/construction.		X		X		
Ease of collaboration with outside commercial activities, since commercial entities would have no (or fewer) restrictions on outside work.		X		X		
Captures numerous partnering and funding opportunities aligned with Exascale and advanced manufacturing activities (assuming ability to complete on schedule).		X		X		
Provides a single anchor facility for the LVOC.			X	X		
Enhancement in the collaboration between laboratories.			X	X		
One building construction would be simpler to control; design through operations, negotiations, and approval.			X	X		
Only a single set of tie-ins needed; fewer service disruptions to make tie-ins.			X	X		
Fits into existing governance structure of each laboratory controlling its own facilities.	X	X			X	X
Independently controlled and managed by each laboratory.	X	X			X	X
Fits within existing state and federal regulatory framework of the LLNL and SNL as separate sites and separate NEPA envelopes.	X	X			X	X
Location more convenient (utilities and distance from core facilities, for both laboratories).	X	X			X	X
Likely quicker to get to the first facility.					X	
More flexibility in future use.					X	
CREATE (SNL) would get a new building.						X
Repurposing the existing facility is desirable; does not increase the footprint.						X
Brings existing facility (B543) up to current earthquake standards; life safety.						X

Table B-1: Alternatives Advantages and Disadvantages (Cont'd.)

Disadvantages (Cons)	2LI 3	2LS 5	1LI 6	1LS 7	Mult 8	Reno/New 11
LI process is complex and time consuming.	X		X			X
Competes with numerous higher budgetary priorities across the complex.	X		X			X
Timeline to obtain funding is extended (versus lease).	X		X			X
Higher upfront cash flow required to fund design and construction.	X		X			X
More difficult to accommodate strategic industry partners (and their ability to do commercial work), thus limiting collaboration.	X		X		X	X
Likely misses numerous partnering and funding opportunities that are aligned with Exascale and advanced manufacturing activities (HPCIC need date is timed with the Exascale roadmap).	X		X		X	X
More cumbersome approval process involving Office of Management and Budget (OMB).		X		X		
More complex legal interfaces required (ground lease, SNDA, facility lease, third-party structure, financing structure, etc.).		X		X		
Decision whether to renew facility and ground leases required at end of each lease term.		X		X		
Less control over design and construction.		X		X		
Less control over modifications and improvements.		X		X		
Must work through third-party (owner) for maintenance and other tenant issues.		X		X		
Requires some level of priority changes for indirect budgets possibly delaying other activities.		X		X		
Doesn't fit in existing governance model.			X	X		
Location not as convenient (utilities and distance from core facilities for both laboratories).			X	X		
Certain NEPA and regulatory/state regulatory issues with one facility.			X	X		
Possible impact to regulators viewing the laboratories as one site for emission purposes.			X	X		
Requires managing two simultaneous design and construction efforts.	X	X				X
Requires OMB approval for two leased facilities.		X				
If there is a change in mission, less flexibility in getting out of the lease.				X		
Each laboratory may need (want) to lease its portion of the facility.				X		
Slower process to get to the total required area (mission need).					X	
Not as efficient to build or operate.					X	
Not as efficient from a land-use perspective.					X	
Lack of collaboration, since groups are located in different buildings.					X	
Uncertainty of funding availability due to increased need for using internal (indirect) budgets.					X	
Requires greater Federal and M&O resources to develop and manage design through operations; potential impacts on staff.					X	
Possibly more disruption to site operations.					X	
Segmentation may be an issue (each building must be unique and support a separate function/use—stand-alone).					X	
May impact overhead rates to construct facilities, since using indirect budgets (higher cost impact to indirect rate).					X	

Disadvantages (Cons)	2LI 3	2LS 5	1LI 6	1LS 7	Mult 8	Reno/New 11
Renovate B543 – Building would have to be expanded and renovated (assume LI funding).						X
Need to construct new roadways.						X
Fencing relocation to capture B543 into the open campus.						X
Current occupants of B543 would need to be relocated into a currently unknown location (see below).						X
Undermines the millions of dollars that are already invested into bringing three major groups together (e.g., Chief Financial Officer, Human Resources) and shutting down old high-maintenance facilities that were vacated.						X
Requires millions of dollars to bring shutdown facilities back up to code if the occupants of B543 are moved out and core groups are kept together.						X
For-profit partners; lack of use (LLNL only).						X

APPENDIX C INITIAL ALTERNATIVE SCREENING RATIONALE

Table C-1 provides the rationale for the initial screening of alternatives included in Section 5. The 13 Mission and Program Requirements, detailed in Table 4-2 (reproduced below as Table C-1 for easy reference), were evaluated for each alternative and the rationale. Table C-2 provides the rating and rationale.

Table C-10-1: Mission and Program Requirements

Requirements	
Number	**Description**
Mission Requirements	
PR-1	Provide additional unclassified office/laboratory/collaboration space for LLNL, SNL/CA, and outside collaborators in the LVOC.
PR-2	Provide a work environment that is modern, dynamic, and flexible.
PR-3	Obtain operational effectiveness and efficiencies.
PR-4	Develop workforce pipeline for attraction, recruitment, development, and retention of world-class staff in a competitive regional market.
Program Requirements	
PR-5	Provide approximately 160,000 to 200,000 total gsf (combined requirement for CREATE and HPCIC)
PR-6	Provide flexible space for light laboratory of about 4,400 gsf (CREATE) and 1,000 net sf (HPCIC)
PR-7	Support increased demands for Limited Area Space
PR-8	Consolidate educational outreach programs and facilities
PR-9	Provide additional space in proximity to synergistic programs
PR-10	Provide additional space as soon as possible
PR-11	Mission need is for 15 years (currently identified) with expected life of facility 35 years
PR-12	Provide capability to meet LEED Gold
PR-13	Provide appropriate security flexibility for different program requirements

Table C-2 provides the rating and rationale for the alternatives with respect to the requirements.

Table C-10-2: Screening Results and Rationale

Alt #	Brief Title	Req. #	Score	Rationale for Screening Results
1	Existing Facilities	Sum	0	Does not meet mission or program requirements.
		PR-1 to PR-10	0	Existing facilities don't provide additional modern space to meet mission requirements in either laboratory, near the LVOC areas.
		PR-11	1	Existing facilities with maintenance should last 15 years.
		PR-12	0	Existing facilities do not meet LEED Gold.
		PR-13	1	Existing facilities provide security flexibility.
2	Renovate Facilities	Sum	0	Does not meet mission or program requirements.
		PR-1 to PR-13	0	LLNL can renovate one building, but SNL cannot renovate any buildings in the LVOC vicinity; insufficient space to meet future needs.

Alt #	Brief Title	Req. #	Score	Rationale for Screening Results
3	Two New Line-Item Facilities	Sum	1.92	Meets all requirements
		PR-1 to PR-2	2	New facilities can be designed to meet project requirements.
		PR-3 to PR -6	2	New facilities located near other laboratory areas can foster operational effectiveness and efficiencies
		PR-7	2	Moving staff from Limited Area (LA) space into new facilities can free up space in the LA
		PR-8	2	New facilities can allow space for educational programs allowing consolidation
		PR-9	2	New facilities can be located near other laboratory operations
		PR-10	1	Capital (line item) projects will generally take longer to accomplish due to time to obtain funding and DOE management processes
		PR-11	2	New facilities can be designed for a minimum of 35 year life.
		PR-12	2	New facilities can be designed to meet LEED Gold
		PR-13	2	New facilities can meet security flexibility needs.
4	Lease Off-site Facility	Sum	0	Does not meet requirements.
		PR-1	0	Search of potential off-site facilities showed no existing facilities that met space requirements; GSA not interested in developing new facility for this purpose
		PR-2	2	Off-site facility may meet work environment requirements
		PR-3	0	Off-site facilities cannot provide operational effectiveness and efficiencies due to distance from current site staffing
		PR-4	1	Off-site facilities would barely meet requirements for workforce pipeline due to location away from laboratories.
		PR-5	2	Off-site facilities can provide space needed but would most likely require new construction
		PR-6	2	Off-site facilities can provide space needed but would most likely require new construction
		PR-7	2	Moving staff from Limited Area (LA) space into new facilities can free up space in the LA
		PR-8	2	New facilities can allow space for educational programs allowing consolidation
		PR-9	0	Off-site facilities are not expected to be in proximity to synergistic programs
		PR-10	2	Off-site facilities are assumed to be available ASAP
		PR-11	2	Off-site facilities are assumed to be available for a 15 year period
		PR-12	2	A facility lease is assumed to include provisions for LEED Gold
		PR-13	2	New facilities can meet security flexibility needs
5	Lease Two Commercial On-Site Facilities	Sum	2	Meets all requirements.
		PR-1 to PR-2	2	New facilities can be designed to meet project requirements.
		PR-3	2	New facilities located near other laboratory areas can foster operational effectiveness and efficiencies.

Alt #	Brief Title	Req. #	Score	Rationale for Screening Results
		PR-4 to PR-6	2	New facilities can be designed to meet project requirements.
		PR-7	2	Moving staff from Limited Area (LA) space into new facilities can free up space in the LA.
		PR-8	2	New facilities can allow space for educational programs allowing consolidation.
		PR-9	2	New facilities can be located near other laboratory operations.
		PR-10	2	A leased facility is assumed to be available sooner compared to a line-item project.
		PR-11	2	New facilities can be designed for a minimum 35-year life.
		PR-12	2	New facilities can be designed to meet LEED Gold standards.
		PR-13	2	New facilities can meet security flexibility needs.
6	Single New Line-Item Facility	Sum	1.77	Meets all requirements.
		PR-1	2	New facility can be designed to meet project requirements.
		PR-2	2	New single facility will be further away from at least one of the operational areas.
		PR-3	1	New facility can be designed to meet project requirements.
		PR-4	2	Moving staff from LA space into new facilities can free up space in the LA.
		PR-5	2	New facility can allot space for educational programs, allowing consolidation.
		PR-6	2	New single facility will be further away from at least one of the laboratories.
		PR-7	2	Capital (line item) projects will generally take longer to accomplish due to time to obtain funding and DOE management processes.
		PR-8	2	New facility can be designed for a minimum life of 35 years.
		PR-9	1	New single facility will be further away from at least one of the laboratories.
		PR-10	1	New facility can meet security flexibility needs.
		PR-11	2	New facility can be designed for a minimum life of 35 years.
		PR-12	2	New facility can be designed to meet LEED Gold.
		PR-13	2	New facility can meet security flexibility needs.
7	Lease Single On-Site Facility	Sum	1.85	Meets all requirements.
		PR-1 to PR-2	2	New facility can be designed to meet project requirements.
		PR-3	1	New single facility will be further away from at least one of the operational areas.
		PR-4 to PR-6	2	New facility can be designed to meet project requirements.
		PR-7	2	Moving staff from LA space into new facilities can free up space in the LA.
		PR-8	2	New facility can allot space for educational programs, allowing consolidation.
		PR-9	1	New single facility will be further away from at least one of the laboratories.
		PR-10	2	A leased facility is assumed to be available sooner compared to an LI project.
		PR-11	2	New facilities can be designed for a minimum life of 35 years.
		PR-12	2	New facilities can be designed to meet LEED Gold standards.

Alt #	Brief Title	Req. #	Score	Rationale for Screening Results
		PR-13	2	New facilities can meet security flexibility needs.
8	Build Multiple Smaller Facilities	Sum	1.77	Can meet all mission and program requirements.
		PR-1 to PR-2	2	New facilities can be designed to meet project requirements.
		PR-3	1	Numerous small facilities are not as efficient or effective due to need to move between buildings.
		PR-4 to PR-6	2	New facility can be designed to meet project requirements.
		PR-7	2	New facilities will provide sufficient space to allow freeing LA space.
		PR-8	2	New facilities can allot space for educational programs, allowing consolidation.
		PR-9	1	Multiple facilities can be located near other laboratory operations.
		PR-10	2	Multiple projects will take longer to accomplish due to having to phase the work due to annual funding limitations.
		PR-11	2	New facilities can be designed for a minimum life of 35 years.
		PR-12	2	New facilities can be designed to meet LEED Gold standards.
		PR-13	2	New facilities can meet security flexibility needs.
9	Develop Only HPCIC	Sum	0	Does not meet mission need because SNL does not participate in this alternative; screened out.
		PR-1	0	Does not meet mission need since SNL does not participate in this alternative.
		PR-2	2	A new facility can provide a modern, flexible work environment.
		PR-3	1	A new facility can provide operational effectiveness; however, because it is only for one laboratory, it will minimally meet effectiveness needs.
		PR-4	1	A new facility can provide a competitive pipeline, but for only one laboratory.
		PR-5	0	Single-purpose facility does not provide sufficient space for other laboratory activities.
		PR-6	0	Single-purpose facility does not provide sufficient space for other laboratory activities.
		PR-7 to PR-9	1	Single-purpose facility does not provide sufficient space for other laboratory activities and therefore is rated as “partially meets.”
		PR-10	2	Assume single smaller facility could be provided faster than larger facility or two facilities.
		PR-11	1	Single-purpose facility is assumed to be available for at least 15 years (design life of 35 years), but it only meets one laboratory’s need.
		PR-12	2	A new facility can be designed to meet LEED Gold standards.
		PR-13	2	A new facility can meet security flexibility needs.
10	Develop Only CREATE	Sum	0	Does not meet mission need since LLNL does not participate in this alternative; screened out.
		PR-1	0	Does not meet mission need since LLNL does not participate in this alternative.
		PR-2	2	A new facility can provide a modern, flexible work environment.
		PR-3	1	A new facility can provide operational effectiveness for only one laboratory, thus minimally meeting effectiveness needs.

Alt #	Brief Title	Req. #	Score	Rationale for Screening Results
		PR-4	1	A new facility can provide a competitive pipeline, but for only one laboratory.
		PR-5 to PR-6	0	Single-purpose facility does not provide sufficient space for other lab activities.
		PR-7 to PR-9	1	Single-purpose facility does not provide sufficient space for other laboratory activities and is therefore rated as “partially meets.”
		PR-10	2	Assume single smaller facility could be provided faster than a larger facility or two facilities.
		PR-11	1	Single-purpose facility is assumed to be available for at least 15 years (design life of 35 years), but it only meets one laboratory’s need.
		PR-12	2	New facility can be designed to meet LEED Gold standards.
		PR-13	2	New facility can meet security flexibility needs.
11	Renovate LLNL Facility/ Develop New CREATE Facility	Sum	1.54	Can meet all mission and program needs.
		PR-1	2	New facility can be designed to meet project requirement; renovated facilities can be improved or expanded to meet needs.
		PR-2	1	One new facility can provide a modern, flexible facility, but the refurbished facility is challenged to meet this need; rated "partial."
		PR-3	1	One new facility can provide operational effectiveness, but the refurbished facility is challenged to meet this need; rated "partial."
		PR-4	2	The new and refurbished facilities can provide competitive facilities for the workforce.
		PR-5	2	A new facility can be designed to meet project space requirements; renovated facilities can be improved or expanded to meet needs.
		PR-6	2	New facilities can be designed to meet project space requirements; renovated facilities can be improved or expanded to meet needs.
		PR-7	1	New facilities can be designed to meet project space requirements; renovated facilities can be improved or expanded to meet needs, but not as well as all new facilities can.
		PR-8	1	New facilities can be designed to meet project space requirements; renovated facilities can be improved or expanded to meet needs, but not as well as all new facilities can.
		PR-9	2	New and refurbished facilities can be located in proximity to synergistic programs.
		PR-10	1	Refurbished facilities may take longer that other alternatives.
		PR-11	2	New or refurbished facilities can meet the 35-year lifetime requirement.
		PR-12	2	New and refurbished facilities can meet LEED Gold standards.
		PR-13	1	Security flexibility may be more difficult for a refurbished LLNL facility, since it requires relocation of security fencing separating LVOC and the PPA.

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APPENDIX D EVALUATION CRITERIA

The AoA is an activity-driven process. Appendix D lists the first five activities in the process. Appendix E continues the process by detailing the LCCE, and Appendix F continues the evaluation activities through the sensitivity analyses.

Activity 1: Determine the required and desirable attributes for the project. List the attributes for the project. Table D-1 lists the desired attributes established by the alternative team and additional descriptions for the attribute, as well as its source.

Table D-1: Desired Attributes

D#	Desired Attribute	Additional Description and notes.	Source of Criteria
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	Flad A&E 11-4-10 Master Plan (pp.4-26--4-29) identified the village concept for synergistic grouping for walking and bicycling between areas, as well as adjacency to "anchor" facilities; National Ignition Facility (NIF) and Terascale Simulation Facility (TSF) for LLNL and Combustion Research Facility (CRF) for SNL.	PR-9
2	Operations completion within 3 to 5 years is of highest importance.	HPCIC timeframe consistent with Sierra procurement (precursor to Exascale technology, CORAL partnership); CREATE: timing important to meet upcoming NW LEP and ALT schedules.	PR-3, PR-10
3	Moving out of old and/or temporary space is highly desirable.	HPCIC trailer lease renewal uncertain after May 2017; CREATE replaces aged mobile facilities.	PR-1, PR-2, PR-5
4	Reduced deferred maintenance is highly desirable.	Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).	PR-3, PR-5
5	Co-locating related functions is critical to improving site operations.	CREATE allows consolidation of key externally-focused mission programs with currently distributed support functions and creates efficiency for both researchers and administration; reduced redundancy in badging personnel and processing systems (CREATE); and overall mission improvements with co-locating R&D functions in modern space. HPCIC allows for the co-location of key externally-focused mission programs in HPC and applied HPC, and allows multidisciplinary research staff to increase efficiency and form high functioning integrated project teams (IPTs) for complex projects. Workforce development programs are streamlined through co-location and resource sharing.	PR-1, PR-5, PR-8, PR-9
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	CA NNSA facilities compete with Fortune 100 Silicon Valley and San Francisco/Mission Bay companies (e.g., new Googleplex, Apple, Autodesk facilities).	PR-2, PR-3, PR-4, PR-12
7	Create a gateway for industrial partnerships.	Industry partners bring resources and new talent to problems of interest to NNSA. Industry partners are drawn to laboratories for their intellectual property and highly educated and specialized workforce. Creating a physical space that attracts partners and potential new hires requires modern facilities and adequate space to enable and sustain collaborations and networking events.	PR-1, PR-5, PR-13
8	Minimize DOE risks.	Use qualitative risk analysis results from the Risk Tab.	PR-5, PR-7, PR-11
9	Lower LCC (NPV).	35-year evaluation; all DOE costs, including capital, O&M, end-of-life D&D, and lease (if applicable).	PR-3, budget

D#	Desired Attribute	Additional Description and notes.	Source of Criteria
10	Near-term cash flow; lower is better.	Evaluate first 5 years of cash flow.	PR-3, budget
11	Ease of making facility modifications in future.	Ability to make changes in future.	PR-2, PR-6, PR-13
12	Ease of meeting Freeze the Footprint initiative.	Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).	PR-3, PR-8 / OMB Directive
13	Ease of transition and relocation.	Transition and relocation may require double moves; very desirable to eliminate double moves.	PR-3, PR-4, PR-5, PR-10
14	Increased energy efficiency and sustainability.	Very important in meeting Department goals.	PR-3, 5, 12
15	Ease of providing space for visitors or part-time staff (flexible space).	Flexible space allows reconfiguration to meet needs, usually accomplished with open floor plan offices.	PR-1, PR-2, PR-4, PR-5, PR-6
16	Ease of standing up different laboratory functional areas in flex space.	Laboratories (light and educational) are used for various purposes; flexible space allows for reconfiguration, as needed.	PR-6
17	Expedient funding availability.	Funding options include LI, GPP, IGPP, and alternative finance.	PR-10, PR-11
18	Assuring and overseeing safety.	Assuring and overseeing construction and operations safety.	PR-2, PR-3
19	Assuring and overseeing security.	Assuring and overseeing security during construction and operations.	PR-7, PR-13
20	Ease of constructing within the existing NEPA envelope.	Staying within the current environmental framework for the open campus (LLNL and SNL/CA).	PR-3

Activity 2: Determine how the attributes will be ranked by importance. Assign a number to each (1-4).

Activity 3: Assign a weighting factor for each criteria importance. The weighting factor will be associated with each attribute. The most important criterion is given a weighting of 5; the least important, a rating of 1.

Table D-2: Importance and Weighting Factor

Attribute Importance	Weighting Factor	Importance Rationale
1	5	Highest importance; borders on a requirement.
2	3	Very important; highly desirable.
3	2	Medium; desirable.
4	1	Lowest importance.

Activity 4: Assign an importance factor to each attribute and document rational for selection.

Activity 5: Correlate the weight factor with the importance. Table D-3 shows the importance and weight for each attribute. Table D-4 describes the rationale used for identifying the importance of the attribute.

Table D-3: Desired Attribute Relative Importance and Weight

D#	Desired Attributes	Importance	Attribute Weight
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	5
2	Operations completion within 3 to 5 years is of highest importance.	1	5
3	Moving out of old and/or temporary space is highly desirable.	2	3
4	Reduced deferred maintenance is highly desirable.	2	3
5	Co-locating related functions is critical to improving site operations.	1	5
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	5
7	Create a gateway for industrial partnerships.	1	5
8	Minimize DOE risks.	1	5
9	Lower LCC (NPV).	2	3
10	Near-term cash flow; lower is better.	2	3
11	Ease of making facility modifications in future.	4	1
12	Ease of meeting Freeze the Footprint initiative.	2	3
13	Ease of transition and relocation.	2	3
14	Increased energy efficiency and sustainability.	2	3
15	Ease of providing space for visitors or part-time staff (flexible space).	1	5
16	Ease of standing up different laboratory functional areas in flex space.	4	1
17	Expedient funding availability.	1	5
18	Assuring and overseeing safety.	1	5
19	Assuring and overseeing security.	3	2
20	Ease of constructing within the existing NEPA envelope.	1	5

Table D-4: Rationale for Attribute and Importance

No.	Desired Attribute	Importance	Rationale for Criteria and Importance
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	Borders on a mission requirement.
2	Operations completion within 3 to 5 years is of highest importance.	1	Borders on a mission requirement.
3	Moving out of old and/or temporary space is highly desirable.	2	Temporary space has limited functionality and life; need as soon as possible (ASAP).
4	Reduced deferred maintenance is highly desirable.	2	SNL dealing with accelerated deferred maintenance.
5	Co-locating related functions is critical to improving site operations.	1	Critical to SNL/LLNL mission, currently hindering programmatic growth and pipeline.
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	Borders on a mission requirement.
7	Create a gateway for industrial partnerships.	1	Critical to SNL/LLNL mission, currently hindering programmatic growth and pipeline.
8	Lower DOE project success risks.	1	Lower risks are critical; of highest importance.
9	Lower LCC (NPV).	2	Consider cost sensitivity analysis with 1 rating.
10	Near-term cash flow; lower is better.	2	Consider cost sensitivity analysis with 1 rating.
11	Ease of making facility modifications in future.	4	Of lowest importance compared to other criteria.
12	Ease of meeting Freeze the Footprint initiative.	2	Important, but not high compared to other criteria.
13	Ease of transition and relocation.	2	Minimizing double moves very desirable.
14	Increased energy efficiency and sustainability.	2	Very important in meeting Department goals.
15	Ease of providing space for visitors or part-time staff (flexible space).	1	Borders on a requirement.
16	Ease of standing up different laboratory functional areas in flex space.	4	Ability to convert spaces for different laboratory uses is minimally important.
17	Expedient funding availability.	1	Ability to obtain funding is critical to project success.
18	Assuring and overseeing safety.	1	Safety is always an important goal.
19	Assuring and overseeing security.	3	Security risk is lower in the general access area.
20	Ease of constructing within the existing NEPA envelope.	1	Any exceedance of the current NEPA and regulatory permits could have significant project (cost and time), and broader institutional impacts if additional environmental permitting is required.

APPENDIX E COST ESTIMATE(S)

E1 Purpose of Estimate(s)

LCCEs are developed for each viable alternative identified for the project. These estimates are prepared to support the AoA. A subset of the LCCEs for the preferred alternative can also be used to confirm or revise the TPC range and the expected funding profile for the project at the time of CD-1 approval if no further estimates are developed as part of a conceptual design process. These estimates will be submitted to Mr. Sam Brinker, NNSA.

E2 Overview of Estimate Approach

In general, most estimates are derived from two base estimates—those associated with new facility construction using an LI approach (see Alts. 3 and 6 below) and those associated with new facility construction using private financing and leaseback (see Alts. 5 and 7 below). Estimates are Class 5 quality, as defined in DOE G 413.3-21 and are generally developed using parametric techniques and factoring, although actual rates provided by LLNL and SNL are used in some places.

Other cost elements are estimated as follows:

- Annual O&M costs for line item scenarios are estimated based on current O&M costs experienced by both LLNL and SNL at their respective locations. For alternative financing cases, industry-standard regional rates published by the BOMA are used.
- End-of-life D&D costs (for newly constructed facilities) are estimated parametrically based on building volumes.

All costs are time-phased using a summary-level schedule developed for the proposed overall facility life of 35 years. The time-phased costs are appropriately escalated and a NPV is calculated in accordance with OMB Circular A-94 using the January 2015 nominal discount rate presented therein for a 30-year life (maximum provided). A more specific estimating approach is discussed for each alternative in the next section.

E3 Discussion of Estimate Methodologies and Approaches

Alt. 3: Build New Facilities (Line Item)

The base estimate is developed as if it is to be done from a commercial standpoint, and not a DOE-managed perspective (see Alt. 5 description below). Appropriate adjustments are then made to account for DOE processes, practices, and site considerations. These include extra costs for a "DOE premium," as well as slightly higher contingency.

Alt. 5: Build New Facilities (Lease Financing)

The TPC is derived under the assumption that a commercial developer builds the new facilities on site—one at LLNL (HPCIC) and one at SNL (CREATE). The developer will then lease the buildings. The cost estimate is prepared using conventional Construction Specifications Institute (CSI) format. Unit rates are applied for most construction divisions using common reference sources, such as RSMeans. In some cases, we use factored costs based on percentages of other costs. The hard construction costs are adjusted to the Livermore geographical area to account for the higher-than-national-average wage and material rates. Other project costs are added to the construction costs, such as contractor general conditions, engineering support, and construction management. Contingency and escalation are also included to derive the TPC.

The annual lease payments are determined based on a 25-year note to retire the debt service, and a final 10-year lease. Lease payments include money over and above the amortized debt to provide a rate of return for the Lessor (i.e., a for-profit scenario). In addition to the lease, other annual expenses are included:

- The annual O&M costs, based on O&M rates provided by each laboratory.
- Allowance for major refurbishment approximately midway through the building life.
- Final building D&D.

Alt. 6: Single New Facility (Line Item)

Instead of two separate buildings on separate campuses, a single 175,000-sf building is constructed on land operated and managed by SNL/CA. The estimating approach is similar to Alternative 3. The proposed site for the single building is approximately a half-mile from the utility tie-ins, so higher costs are factored into the estimate to account for the increased distance. Also, the new site would trigger potential NEPA issues—perhaps permitting delays, extra filings, etc. This is accounted for through the higher contingency for this alternative.

Alt. 7: Single New Facility (Lease)

Instead of two separate buildings on separate campuses, a single 175,000-sf building is constructed on land operated and managed by SNL/CA. The estimating approach is similar to Alternative 5. The proposed site for the combined building is approximately a half-mile from the utility tie-ins, so higher costs are factored into the estimate to account for the increased distance. Also, the new site would trigger potential NEPA issues—perhaps permitting delays, extra filings, etc. This is accounted for through the higher contingency for this alternative.

Leasing considerations are similar to those identified in Alternative 5.

Alt. 8: Multiple Small Constructed Facilities

This alternative entails a phased construction of buildings at the LLNL-managed LVOC for HPCIC, and similar phased construction of buildings at the SNL-managed LVOC for CREATE.

An average cost of $500/sf is assumed, based on data used in other AoA studies (this unit cost is also very close to recent construction costs experienced at LLNL). Thus, a single structure (limited to $10 million) will be able to add 20,000 sf of new building space. This cost is replicated as needed over a 5-year timeframe to accomplish the goal of replacing the existing facilities, meaning that 10 small buildings will be needed to provide 200,000 sf of new space, consistent with the underlying assumption for this analysis. It is assumed that one building is available for move-in at each laboratory starting in 2017. Thus, the total annual cost for two small buildings is $20 million.

Alt. 11: Renovate LLNL Facility / Develop New CREATE Facility

The cost estimate prepared by LLNL for refurbishment of B543 is used as a basis. The estimate is $55.4 million in FY 2013 dollars, and is escalated accordingly to 2015 dollars. For the CREATE building, we use the same cost estimating approach and assumptions used for Alternative 3 (LI).

E4 Conformance with GAO Best Practices

The LCCEs for the LVOC have been developed in accordance with GAO 12 steps, which are aimed at achieving estimates that are credible, well-documented, accurate, and comprehensive. These steps are shown in Table E-1, with appropriate comments on how they are applied or tailored for the LCCE used for this analysis.

Table E-1: Compliance with GAO's 12-Step Guidance

Step	Description	Associated Task	Notation
1	Define purpose of estimates	1. Determine estimate's purpose, required level of detail, and overall scope.	The estimate's purpose is described in this Report. The estimates will inform the NNSA/DOE decision makers, as well as Congressional appropriators, regarding the basis for the alternative analysis and selection.
		2. Determine who will receive the estimate.	
2	Develop estimating plan	1. Determine the cost estimating team and develop its master schedule.	An estimate plan and schedule were developed at the outset of the effort. Cost estimating team members are identified.
		2. Determine who will do the independent cost estimate (ICE); outline the cost estimating approach.	
		3. Develop the estimate timeline.	
3	Define program characteristics	1. Identify the program's purpose and its system and performance characteristics, and all system configurations.	Program characteristics and alternative descriptions, as well as the documents used to support the CDR process, are documented in this Report.
		2. Identify any technology implications.	
		3. Develop the program acquisition schedule and acquisition strategy.	
		4. Define its relationship to other existing systems, including predecessor or similar legacy systems.	
		5. Support (manpower, training, etc.) and security needs and risk items.	

Table E-1: Compliance with GAO's 12-Step Guidance

Step	Description	Associated Task	Notation
		6. System quantities for development, testing, and production.	
		7. Deployment and maintenance plans.	
4	Determine estimating structure	1. Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated information system may have only a cost element structure).	The estimating structure follows conventional CSI format for construction projects.
		2. Choose the best estimating method for each WBS element; Identify potential cross-checks for likely cost and schedule drivers.	This report describes the estimate methodology and approach used for each alternative and can be considered a checklist to ensure capture of all relevant items.
		3. Develop a cost estimating checklist.	
5	Identify ground rules and assumptions	1. Clearly define what the estimate includes and excludes.	The set of assumptions is described in this Report. Final estimate documentation fully describes all assumptions used for the LCCE for each alternative.
		2. Identify global and program-specific assumptions, such as the estimate's base year, including time-phasing and life cycle.	
		3. Identify program schedule information by phase and program acquisition strategy.	
		4. Identify any schedule or budget constraints, inflation assumptions, and travel costs.	
		5. Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development.	
		6. Identify prime contractor and major subcontractors.	
		7. Determine technology refresh cycles, technology assumptions, and new technology to be developed.	
		8. Define commonality with legacy systems and assumed heritage savings.	
		9. Describe effects of new ways of doing business.	
6	Obtain data	1. Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data.	Data acquisition is ongoing. Data used is fully described and documented in this Report. Data is being provided by both laboratories, including previous cost estimates, actual O&M costs, interest rates, and lease terms. Other data sources, such as RSMeans cost works, are used. Costs are normalized among all alternatives (e.g., common escalation factors, unit rates, contractor markups and general conditions, project life cycle).
		2. Investigate possible data sources.	
		3. Collect data and normalize it for cost accounting, inflation, learning, and quantity adjustments.	
		4. Analyze data for cost drivers, trends, and outliers and compare results against rules of thumb and standard factors derived from historical data.	
		5. Interview data sources and document all pertinent information, including an assessment of data reliability and uncertainty.	
		6. Store data for future estimates.	

Table E-1: Compliance with GAO's 12-Step Guidance

Step	Description	Associated Task	Notation
7	Develop point estimate and compare it to an ICE	1. Develop the cost model, estimating each WBS element, using the best methodology from the data collected, and including all estimating assumptions.	These steps have been completed, as appropriate, and documented in this Report. Costs are developed in 2015 base year dollars, and are escalated using standard escalation indices across the entire life cycle. An ICE/Report (R) will be done by DOE's Office of Acquisition and Project Management organization and used to confirm the reasonableness of the LCCEs.
		2. Express costs in constant year dollars.	
		3. Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule.	
		4. Sum the WBS elements to develop the overall point estimate.	
		5. Validate the estimate by looking for errors, such as double counting and omitted costs.	
		6. Compare estimate against the ICE and examine where and why differences arose.	
		7. Perform cross-checks on cost drivers to see if results are similar.	
		8. Update the model as more data becomes available or as changes occur, and compare results against previous estimates.	
8	Conduct sensitivity analysis	1. Test the sensitivity of cost elements to changes in estimating input values and key assumptions.	Key assumptions are identified and Sensitivity Analyses has been conducted. The results of those analyses are communicated in this Report.
		2. Identify effects on the overall estimate of changing the program schedule or quantities.	
		3. Determine which assumptions are key cost drivers and which cost elements are affected most by changes.	
9	Conduct risk and uncertainty analysis	1. Determine and discuss with technical experts the level of cost, schedule, and technical risk associated with each WBS element.	A qualitative analysis of risk and uncertainty has been done for each alternative LCCE, and those results will be used to inform the AoA decision making process. The analyses is fully described and documented in this report.
		2. Analyze each risk for its severity and probability.	
		3. Develop minimum, most likely, and maximum ranges for each risk element.	
		4. Determine type of risk distributions and reason for their use.	
		5. Ensure that risks are not correlated.	
		6. Use an acceptable statistical analysis method (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate.	
		7. Identify the confidence level of the point estimate.	
		8. Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate.	
		9. Recommend that the project or program office develop a risk management plan to track and mitigate risks.	
10	Document the estimate	1. Document all steps used to develop the estimate so that a cost analyst that is unfamiliar with the program can recreate it quickly and produce the same result.	The LCCE for each alternative is fully described and documented in this Report.
		2. Document the purpose of the estimate, the team that prepared it, the approver(s) of the estimate, and the approval date(s).	

Table E-1: Compliance with GAO's 12-Step Guidance

Step	Description	Associated Task	Notation
		3. Describe the program, its schedule, and the technical baseline used to create the estimate.	
		4. Present the program's time-phased LCC.	
		5. Discuss all ground rules and assumptions.	
		6. Include auditable and traceable data sources for each cost element and document for all data sources how the data was normalized.	
		7. Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (prefer more detail over less).	
		8. Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified.	
		9. Document how the estimate compares to the funding profile.	
		10. Track how this estimate compares to any previous estimates.	
11	**Present estimate to management for approval**	1. Develop a briefing that presents the documented LCCE.	A briefing to NNSA management was given.
		2. Include an explanation of the technical and programmatic baseline and any uncertainties.	
		3. Compare the estimate to an ICE and explain any differences.	
		4. Compare the estimate (LCCE) or ICE to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality.	
		5. Focus in a logical manner on the largest cost elements and cost drivers.	
		6. Make the content clear and complete, so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results.	
		7. Make backup slides available for more probing questions.	
		8. Act on and document feedback from management.	
		9. Request acceptance of the estimate.	
12	**Update the estimate to reflect actual costs and changes**	1. Update the estimate to reflect changes in technical or program assumptions or to keep it current as the program passes through new phases or milestones.	These estimates are only intended to be used to support the AoA process; therefore, this step is not applicable in this situation.
		2. Replace estimates with earned value management (EVM) estimate at completion (EAC) and independent EAC from the integrated EVM system.	
		3. Report progress on meeting cost and schedule estimates.	
		4. Perform a post mortem and document lessons learned for elements for which actual costs or schedules differ from the estimate.	
		5. Document all changes to the program and how they affect the cost estimate.	

E5 Estimate Basis and Assumptions

E5.1 Estimate Basis

Building Size

- HPCIC – 98,000 sf
- CREATE – 86,000 sf
- Single (combined) building – 175,000 sf
- Small building – 20,000 sf

Lease Assumptions

- Interest rate for construction financing – 4%
- Bond interest rate – 5%
- Bond repayment – 25 years
- Residual lease period – 10 years
- Annual O&M – based on industry-standard regional rates published by the BOMA

Time Value of Money Assumptions

- Base year for estimates: 3rd Quarter FY 2015
- Escalation Rates:
  - Construction costs and other project costs – 3% per year based on recent history (ENR)
  - O&M costs and other variable lease costs – 2% per year based on average CPI for past 5 years, consistent with DOE and GSA guidance
- Discount Rate: 3.4% per year (OMB A-94 Nominal Rate, 30 years)

Other LCCE Assumptions

- D&D costs are estimated using parametric costs.
- D&D Schedule: D&D of existing facilities is assumed to start in the first year following end of building life. D&D costs are spread over 2 years.
- Major refurbishment of new buildings occurs at the approximate midpoint of building life, and is based on 25 percent of TPC. Costs are spread over 2 years.

Benefits

- HPCIC, $/Year $63,540
- CREATE (one-time) $187,000

Schedules

The construction schedules for the two basic cases (Lease and LI) of construction are developed. Figure E-1 shows a typical schedule for a lease acquisition and construction. Figure E-2 shows a typical schedule for an LI acquisition and construction.

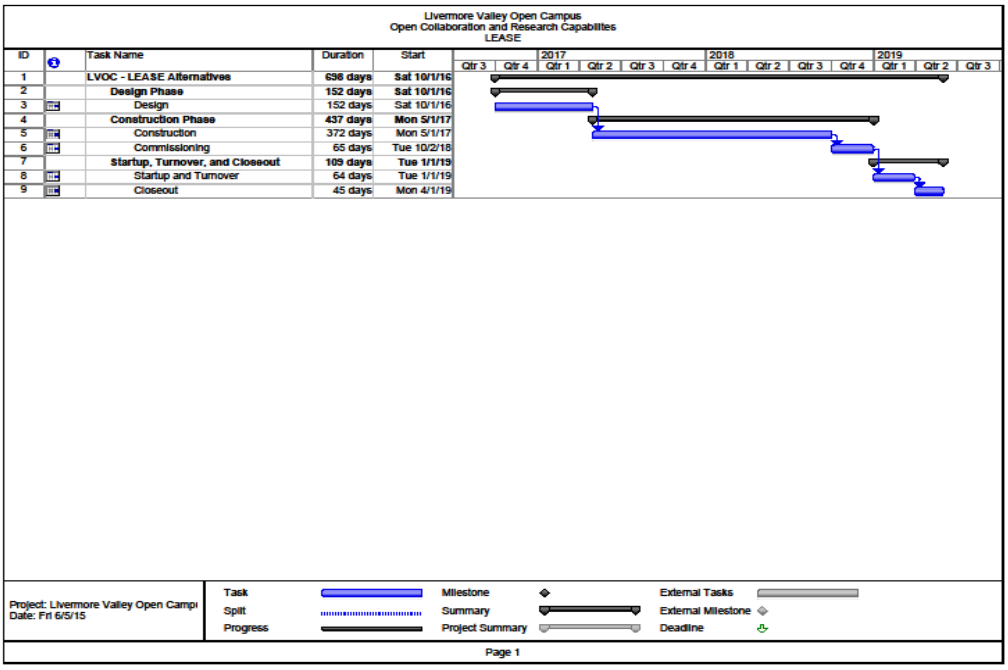

Figure E-1: Lease Schedule

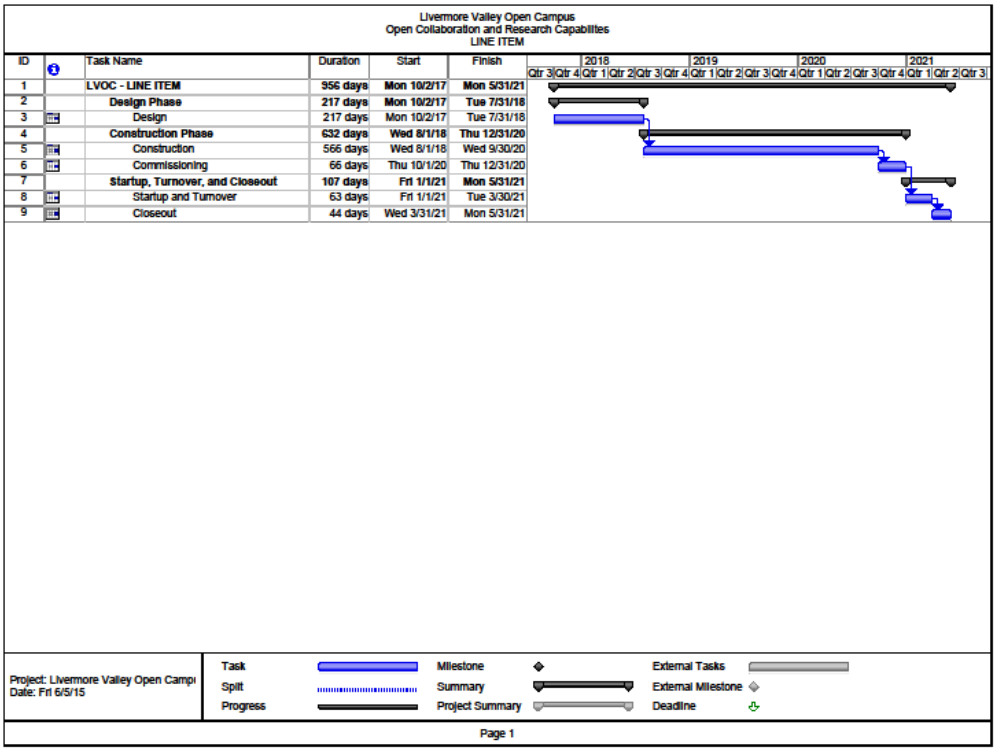

Figure E-2: Line Item Schedule

E5.2 Operations and Maintenance Costs

O&M unit costs used for line item cases are based on actual expenses currently realized at each laboratory, and reflect the rates used by the laboratories in their respective conceptual design studies. The O&M unit costs used for the lease cases are based on industry-standard regional rates published by the BOMA. The reported average costs are as follows:

Table E-2: O&M Costs

	LLNL, $/sf	SNL, $/sf
O&M Costs – LI	16.73	15.94
O&M Costs – Lease	5.63	5.63

E5.3 Cost of Building Lease

The basis for the lease cost calculation is the specific building construction cost, including financing charges and interest. This amount is then amortized over a 25-year bond note period at 5 percent interest rate. This rate is consistent with government financing achieved in some recent DOE alternative financing arrangements (at Argonne, Pacific Northwest, and Oak Ridge National Laboratories).

To determine the total fixed lease payment, the annual debt service is marked up by a factor of 1.2. That amount captures the cost of lessor management, administration, and profit margin. Following retirement of the debt, lease payments are reduced for the final 10 years to only the landlord's profit and management expense.

The lease payments do not include the estimated costs for O&M, future upgrades/refurbishments, or end-of-life D&D; however, all of those costs are included as separate LCC elements for this analysis.

E5.4 D&D Costs

The costs for D&D are based on a parametric factor of $1.63 per cubic foot, and on the calculated building volume. This results in a D&D unit cost of about $45/sf, which is reasonable. D&D of clean office-type buildings (no hazardous materials) should be about 10 to 15 percent of new construction cost.

D&D costs are only applied to the new buildings constructed in this AoA study. This occurs at the end of the 35-year useful life. Our study assumes no D&D of existing buildings.

E5.5 Schedule Assumptions

The general schedule assumptions used to develop the LCCs and perform the NPV analysis are as follows:

- Line item design/construction starts, at the earliest, in FY 2018, and is completed in FY 2021.
- Private developer design/construction can start as soon as FY 2017, and is completed in FY2019.
- O&M costs are incurred in FY 2021 for the LI scenario and in FY2019 for the lease scenario, based on the end of construction and turnover.
- Small GPP-type buildings are available in FY 2018, at the rate of two buildings per year for 5 years. O&M costs for small buildings are prorated based on the expected square footage available for occupancy.

E5.6 Benefits

Two quantitative benefits are identified and captured in the NPV analyses. The first benefit is a $63,500 per year reduction in LLNL costs due to not having to pay rent for the current trailers that house personnel who would be moving to a new building. This is a recurring savings distributed throughout the 35-year life. The second benefit is a one-time $187,000 savings in deferred maintenance costs for SNL. This savings occurs in year 5 for purposes of the AoA study.

E6 Estimate Results

Table E-3 presents the results from the NPV analyses for each alternative considered.

Table E-3: NPV Results ($M)

Alternative	NPV	Ranking
3 – Build New Facilities (Line Item)	165.2	4
5 – Build New Facilities (Lease Financing)	131.0	1
6 – Single New Facility (Line Item)	164.4	3
7 – Single New Facility (Lease)	135.9	2
8 – Multiple small constructed facilities	225.2	6
11 – Renovate LLNL Facility/Develop New CREATE Facility	181.1	5

E7 Sensitivity Analysis

A cost sensitivity analysis was conducted by varying 10 key parameters, and results are shown in Table E-4.

The analysis concludes that very few variations in key parameters will alter the ranking of the alternatives relative to the NPV of LCCs. Changes to just a few parameters have a minor impact on that ranking. These are summarized as follows:

- Decreasing the assumed O&M escalation from 2 to 1 percent reverses the rankings of Alternatives 3 and 6.
- Assuming the same contingency for the single-building concept as for the separate buildings concept makes Alternative 7 slightly more favorable in terms of NPV compared to Alternative 5. (For the base case, contingency rates for the single building alternatives were 5 percent higher than the other alternatives based on the increased level of risk identified with a single building alternative.)

The only exception is the O&M rate. For the base case, actual O&M rates at LLNL and SNL/CA are approximately three times higher than O&M rates assumed for alternative financing (based on industry-standard regional rates published by the BOMA). Sensitivity analysis shows that the line item scenarios (Alt. 3 and 6) become slightly more favorable from a life cycle cost basis when the commercial rate gets within 20% of the current actual rates.

Table E-4: Sensitivity Analysis

			NPV of LCC for Alternates ($M)					
			2LI	2LS	1LI	1LS	Mult	Reno/New
Sensitivity Parameter			3	5	6	7	8	11
Original Results - Base Values			$165.2	$131.7	$164.4	$140.2	$225.2	$181.1
	Ranking		4	1	3	2	6	5
	Value							
Construction Escalation %/yr	2%		$158.8	$126.8	$157.7	$131.1	$209.7	$176.0
	Ranking		4	1	3	2	6	5
	5%		$184.2	$145.7	$183.1	$149.4	$276.4	$196.8
	Ranking		4	1	3	2	6	5
O&M Escalation %/yr	1%		$151.8	$127.4	$152.0	$131.8	$211.8	$168.1
	Ranking		3	1	4	2	6	5
	4%		$203.4	$143.6	$199.8	$147.2	$262.8	$219.5
	Ranking		4	1	3	2	6	5
Bond Interest Rate	4%		$165.2	$123.3	$164.4	$127.0	$225.2	$181.1
	Ranking		4	1	3	2	6	5
	6%		$165.2	$140.4	$164.4	$145.2	$225.2	$181.1
	Ranking		4	1	3	2	6	5
	7%		$165.2	$149.5	$164.4	$154.8	$225.2	$181.1
	Ranking		4	1	3	2	6	5
Mark-up on debt service for lease	1.1		$165.2	$122.2	$164.4	$125.7	$225.2	$181.1
	Ranking		4	1	3	2	6	5
	1.25		$165.2	$135.1	$164.4	$139.5	$225.2	$181.1
	Ranking		4	1	3	2	6	5
Small Building Construction Cost ($/sf)	$300		$165.2	$131.7	$164.4	$135.9	$185.8	$181.1
	Ranking		4	1	3	2	6	5
	$700		$165.2	$131.7	$164.4	$135.9	$264.6	$181.1
	Ranking		4	1	3	2	6	5
Renovation Cost	$45M		$165.2	$131.7	$164.4	$135.9	$225.2	$170.7
	Ranking		4	1	3	2	6	5
Contingency (same for separate and single bldgs)			$165.2	$131.7	$160.9	$131.5	$225.2	$181.1
15% lease; 20% LI	Ranking		**4**	**2**	**3**	**1**	**6**	**5**
O&M Cost (LI versus LEASE)			$165.2	$168.1	$164.4	$168.9	$225.2	$181.1
LEASE 20% less than LI	Ranking		2	3	1	4	6	5
(LEASE O&M = (LI O&M Rate)x80%								
DOE Premium	10%		$161.6	$131.7	$160.6	$135.9	$225.2	$179.4
Premium to do work on DOE land	Ranking		4	1	3	2	6	5
	0%		$154.6	$131.7	$153.0	$135.9	$225.2	$175.9
	Ranking		4	1	3	2	6	5

E8 Acquisition Approach

Table E-5 is a comparative table showing the TPC for various acquisition strategies.

Table E-5: TPC Comparisons Based on Acquisition Strategy ($M)

	Alternative Financing (Lease)	Line Item (Federal Direct)	M&O Procurement
HPCIC	31.2	39.0	47.5
CREATE	30.2	37.8	46.0
Single Building	65.9	82.3	100.2

The Alternative Financing option presumes that a third-party developer designs and constructs the new building using specifications and standards provided, and then leases the new building following construction.

The LI option (Federal Direct) assumes no M&O markups. The M&O contractor doesn't issue the sub-contracts for design or construction, and is not responsible for Title III or any of the Quality /Safety requirements. NNSA either does the contracting or, alternatively, USACE or some other entity does the contracting and management of the design and construction. M&O staff is involved at a limited level—limited design reviews, interfaces for installation support, etc. The premium over the alternative financing base case is estimated at 15 percent, based on parameters used in other AoA studies This premium excludes contingency and escalation.

The M&O Procurement option is the typical DOE paradigm, with the M&O(s) issuing the design and construction through sub-contracts. The M&O includes all of their markups and is responsible for everything (design reviews, quality, safety, etc.). We assume a higher premium for this strategy due to the markups and greater involvement required from the M&O staff. The premium over the alternative financing base case is estimated at 40 percent.

The single facility has less square-feet than the combined area of the two separate facilities, yet is estimated to have a higher cost. The location of the single facility requires longer utility runs than the other options, as well as additional infrastructure to include sidewalks and parking. Additional cost factors are added to address the risk of combining the functions into one facility. Additional environmental and NEPA coordination cost are added and the amount of contingency is increased to account for this risk.

E9 Range Analysis

Some of the assumptions and key parameters used for this analysis are obviously uncertain at this early stage, and an analysis was completed to assess the extent of that uncertainty. Table E-6 presents the various key parameters that underpin the LCC estimates and NPV analyses, and shows the range assumed around the estimated base values, as described in Section E5. The results are presented in Table E-7, which shows the range of NPVs for each alternative.

Table E-6: Key Parameters Range Analysis

LVOC LCC Estimates Key Parameters Range Analysis			
	Base	Low	High
Cost Estimating Uncertainty			
HPCIC, $M	$31.2	$27.8	$39.1
CREATE, $M	$30.2	$26.9	$37.6
Single Building, $M	$65.9	$57.8	$81.4
Escalation			
Construction Escalation	3%	2%	5%
O&M Escalation	2%	1%	4%
Small Building Cost/sf	$500	$300	$700
Contingency			
Contingency – Line Item Project			
HPCIC, CREATE	20%	15%	25%
Single Building	25%	20%	30%
Contingency – Lease Project			
HPCIC, CREATE	15%	10%	20%
Single Building	20%	15%	25%
Leasing Parameters			
Bond Interest Rate	5%	4%	7%
Markup on Debt Payments	1.2	1	1.25
DOE Premium (LI)	15%	10%	25%

Table E-7: Range Analysis Results ($M)

Alternative	NPV Based on Range Analysis		
	Base	Low	High
3 – Build New Facilities (Line Item)	165.2	131.3	267.1
5 – Build New Facilities (Lease Financing)	131.0	93.2	227.2
6 – Single New Facility (Line Item)	164.4	126.8	268.7
7 – Single New Facility (Lease)	135.9	94.9	231.4
8 – Multiple Small Constructed Facilities	225.2	153.2	366.4
11 – Renovate LLNL Facility/Develop New CREATE Facility	181.1	154.1	261.7

E10 Estimate Team

Table E-8: Estimating Team

Name	Organization	Phone Number / email	
Doug Gray	Longenecker & Associates	303-437-2745 (cell) / grayda@comcast.net	Lead Estimator
Scott Dam	Longenecker & Associates	703-538-8944 / scott.dam@comcast.net	Quality Assurance

E11 Estimate Development Schedule

The estimate development schedule is shown below:

Finalize estimate plan	May 1
On-site meetings to finalize assumptions and collect data	May 4–7
Complete point estimates for all elements and all alternatives	June 4
Complete NPV calculations for all alternatives	June 10
Complete risk/uncertainty analysis for all estimates	June 10
Complete sensitivity analyses for all alternatives	June 10

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APPENDIX F ALTERNATIVE ANALYSES

After the completion of the LCCEs and the Risk analysis, the following activities are used to complete the AoA.

Activity 6: Determine the scoring scale for each attribute. These are used to score each attribute by alternative. It is the relative ability of the alternative to meet the criteria. Table F-1 shows the values that the team used in the evaluation. Note that the non-linear approach to the scores gives a larger emphasis on fully meeting the criteria.

Table F-1: Attribute Evaluation Scale

Attribute Evaluation	Score
Fully meets the criteria	1
Generally meets the criteria	0.5
Somewhat meets the criteria	0.3
Barely meets the criteria	0.1
Does not meet the criteria at all	0

Activity 7: Score each Alternative by attribute, using the agreed upon scoring system. Table F-2 is the team scoring results for the Alternatives. Table F-3 includes the rationale for the scoring of the Alternatives.

Table F-2: Scoring of Alternatives

D#	Desired Attributes	2LI 3	2LS 5	1LI 6	1LS 7	Mult 8	Reno/New 11
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	1	0.1	0.1	1	1
2	Operations completion within 3 to 5 years is of the highest importance.	1	1	1	1	0.5	0.3
3	Moving out of old and/or temporary space is highly desirable.	1	1	1	1	1	0.5
4	Reduced deferred maintenance is highly desirable.	1	1	1	1	0.5	0.5
5	Co-locating related functions is critical to improving site operations.	1	1	1	1	0.3	0.3
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	1	1	1	0.5	0.3
7	Create a gateway for industrial partnerships.	0.3	1	0.3	0.5	0.3	0.3
8	Lower DOE risks.	0.3	1	0.3	0.5	0.5	0.3
9	Lower LCC (NPV).	0.5	1	0.5	1	0.1	0.3
10	Near-term cash flow; lower is better.	0.3	1	0.3	1	0.1	0.1
11	Ease of making facility modifications in the future.	0.5	0.3	0.5	0.3	0.5	0.5
12	Ease of meeting Freeze the Footprint initiative.	0.1	1	0.1	1	0.3	0.3
13	Ease of transition and relocation.	1	1	1	1	0.5	0.3
14	Increased energy efficiency and sustainability.	1	1	1	1	0.5	0.3
15	Ease of providing space for visitors or part-time staff (flexible space).	1	1	1	1	0.3	0.5
16	Ease of standing up different laboratory functional areas in flex space.	1	1	1	1	0.3	0.5
17	Expedient funding availability.	0.1	1	0.1	1	0.5	0.1
18	Assuring and overseeing safety.	1	0.5	1	0.5	1	0.5
19	Assuring and overseeing security.	1	0.5	1	0.5	1	0.5
20	Ease of constructing within the existing NEPA envelope.	1	1	0.3	0.3	1	1
	Total Score – Unweighted	**15.1**	**18.3**	**13.5**	**15.7**	**10.7**	**8.4**

Table F-3: Rationale for Alternative Scoring

D#	Desired Attributes	Imp.	3	5	6	7	8	11
1	**Less than 0.25-mile distance between synergistic activities is the highest importance.**	**1**	**1**	**1**	**0.1**	**0.1**	**1**	**1**
Flad A&E 11-4-10 Master Plan (pp.4-26–4-29) identified the village concept for synergistic grouping for walking and bicycling between areas, as well as adjacency to "anchor" facilities; NIF and TSF for LLNL, and CRF for SNL.								
2LI	Alt. 3 Rationale	Fully Meets – The location of the new HPCIC and CREATE are within the 0.25-mile distance of the attribute.						
2LS	Alt. 5 Rationale	Fully Meets – The location of the new HPCIC and CREATE are within the 0.25-mile distance of the attribute.						
1LI	Alt. 6 Rationale	Barely Meets – The suggested location of the single building is located off of LLNL on SNL/CA land. The building would not be within 0.25 miles from HPCIC synergistic activities.						
1LS	Alt. 7 Rationale	Barely Meets – The suggested location of the single building is located off of LLNL on SNL/CA land. The building would not be within 0.25 miles from HPCIC synergistic activities.						
Mult	Alt. 8 Rationale	Fully Meets – The location of the multiple buildings would be dictated by the two laboratories and therefore within 0.25 mile of their synergistic activities.						
Reno/New	Alt. 11 Rationale	Fully Meets – The location of the new CREATE facility and the renovated B543 are within 0.25 mile of the synergistic activities.						

D#	Desired Attributes	Imp	3	5	6	7	8	11
2	**Operations within 3 to 5 years is of highest importance**	**1**	**1**	**1**	**1**	**1**	**0.5**	**0.3**
HPCIC timeframe is consistent with Sierra procurement (precursor to Exascale technology, CORAL partnerships); CREATE timing important to meet NW LEP and ALT schedules.								
2LI	Alt. 3 Rationale	Fully Meets – Schedule for line item assumes FY 2021 move-in.						
2LS	Alt. 5 Rationale	Fully Meets – Schedule for lease assumes FY 2019 move-in.						
1LI	Alt. 6 Rationale	Fully Meets – Schedule for LI assumes FY 2021 move-in.						
1LS	Alt. 7 Rationale	Fully Meets – Schedule for lease assumes FY 2019 move-in.						
Mult	Alt. 8 Rationale	Generally Meets – Schedule assumes that construction is funded within 5 years. Construction of final buildings will not be complete in year 5.						
Reno/New	Alt. 11 Rationale	Somewhat Meets – Renovation will take longer to move people out and renovate old facilities. The CREATE facility will be operational within 5 years.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
3	**Move out of old and/or temporary space is highly desirable**	**2**	**1**	**1**	**1**	**1**	**1**	**0.5**
CREATE replaces aged mobile facilities; temporary HPCIC trailers lease renewal uncertain after May 2017								
2LI	Alt. 3 Rationale	Fully Meets – New facilities.						
2LS	Alt. 5 Rationale	Fully Meets – New facilities.						
1LI	Alt. 6 Rationale	Fully Meets – New facilities.						
1LS	Alt. 7 Rationale	Fully Meets – New facilities.						
Mult	Alt. 8 Rationale	Fully Meets – New facilities.						
Reno/New	Alt. 11 Rationale	Generally Meets – CREATE is a new facility. HPCIC will remain in an old facility (though renovated).						

Table F-3: Rationale for Alternative Scoring (Cont'd.)

D#	Desired Attributes	Imp.	3	5	6	7	8	11
4	**Reduced deferred maintenance is highly desirable**	**2**	**1**	**1**	**1**	**1**	**0.5**	**0.5**
Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).								
2LI	Alt. 3 Rationale	Fully Meets – New facilities.						
2LS	Alt. 5 Rationale	Fully Meets – New facilities.						
1LI	Alt. 6 Rationale	Fully Meets – New facilities.						
1LS	Alt. 7 Rationale	Fully Meets – New facilities.						
Mult	Alt. 8 Rationale	Generally Meets – Multiple constructions of facilities would have a longer time with deferred maintenance. Less money available to buy down deferred maintenance.						
Reno/New	Alt. 11 Rationale	Generally Meets – Renovate requires extra moves and renovations of old facilities that were cold and dark.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
5	**Co-locating related functions is critical to improving site operations**	**1**	**1**	**1**	**1**	**1**	**0.3**	**0.3**
CREATE allows consolidation of key externally-focused mission programs with currently distributed support functions and creates efficiency for both researchers and administration; reduced redundancy in badging personnel and processing systems (CREATE); and overall mission improvements with co-locating R&D functions in modern space. HPCIC allows for the co-location of key externally-focused mission programs in HPC and applied HPC, and allows multidisciplinary research staff to increase efficiency and form high functioning integrated project teams (IPTs) for complex projects. Workforce development programs are streamlined through co-location and resource sharing.								
2LI	Alt. 3 Rationale	Fully Meets – New facilities meet the attribute of co-location.						
2LS	Alt. 5 Rationale	Fully Meets – New facilities meet the attribute of co-location.						
1LI	Alt. 6 Rationale	Fully Meets – New facilities meet the attribute of co-location.						
1LS	Alt. 7 Rationale	Fully Meets – New facilities meet the attribute of co-location.						
Mult	Alt. 8 Rationale	Somewhat Meets – The multiple alternative would spread out over multiple buildings for CREATE and multiple buildings for HPCIC. This does not provide the same co-location benefits/synergy as if the functions are located in each in one location.						
Reno/New	Alt. 11 Rationale	Somewhat Meets – The renovation for HPCIC would cause the relocation and splitting up of departments currently located in B543; These departments were located in B543 in an effort to co-locate and increase efficiencies, thus reducing site operations efficiency. CREATE would meet its consolidation goals in a new facility.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
6	**Class A Office space consistent with standards in the Bay Area for recruitment and retention**	**1**	**1**	**1**	**1**	**1**	**0.5**	**0.3**
CA NNSA facilities compete with Fortune 100 Silicon Valley and San Francisco/Mission Bay companies (e.g., new Googleplex, Apple, Autodesk facilities).								
2LI	Alt. 3 Rationale	Fully Meets – New facilities will be designed and constructed consistent with Class A office Space.						
2LS	Alt. 5 Rationale	Fully Meets – New facilities will be designed and constructed consistent with Class A office Space.						
1LI	Alt. 6 Rationale	Fully Meets – New facilities will be designed and constructed consistent with Class A office Space.						
1LS	Alt. 7 Rationale	Fully Meets – New facilities will be designed and constructed consistent with Class A office Space.						

Table F-3: Rationale for Alternative Scoring (Cont'd.)

Mult	Alt. 8 Rationale	Generally Meets – Multiple new facilities will generally meet the overall goal, but will not be as functional as one collaborative work space.
Reno/New	Alt. 11 Rationale	Somewhat Meets – The renovated space will improve the space, but it will be limited to its current footprint. May be limited in the layout and design of renovated space. New CREATE facility would meet the attribute goal.

D#	Desired Attributes	Imp.	3	5	6	7	8	11
7	**Create a gateway for industrial partnerships**	**1**	**0.3**	**1**	**0.3**	**0.5**	**0.3**	**0.3**
Industry partners bring resources and new talent to problems of interest to NNSA. Industry partners are drawn to laboratories for their intellectual property and highly educated and specialized workforce. Creating a physical space that attracts partners and potential new hires requires modern facilities and adequate space to enable and sustain collaborations and networking events.								
2LI	Alt. 3 Rationale	Somewhat Meets – Will create space, but it would be more difficult to allow industry partners to collaborate fully in a government-owned facility. Space would be available at both laboratories.						
2LS	Alt. 5 Rationale	Fully Meets – New space available at both laboratories to allow the collaboration with industry partners. Ease of collaboration with outside commercial entities would have no (or fewer) restrictions on outside work.						
1LI	Alt. 6 Rationale	Somewhat Meets – Will create space, but it would be more difficult to allow industry partners to collaborate fully in a government-owned facility. Would be located only at one laboratory (SNL/CA), reducing the benefit LLNL.						
1LS	Alt. 7 Rationale	Generally Meets – Lease space allows the ease of collaboration with outside commercial entities. Would be located only at one laboratory (SNL/CA), reducing the benefit for LLNL.						
Mult	Alt. 8 Rationale	Somewhat Meets – Will create space, but it would be more difficult to allow industry partners to collaborate fully in a government owned facility. Space would be available at both laboratories.						
Reno/New	Alt. 11 Rationale	Somewhat Meets – Will create space, but it would be more difficult to allow industry partners to collaborate fully in a government owned facility. Space would be available at both laboratories.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
8	**Lower DOE Programmatic Risks**	**1**	**0.3**	**1**	**0.3**	**0.5**	**0.5**	**0.3**
Use qualitative risk analysis results from Risk Tab of the Evaluation Worksheet.								
2LI	Alt. 3 Rationale	Somewhat Meets – See Risk Analysis for specific risks and risk level; overall risk level is Moderate with the third highest risk score (almost equivalent to Alt. 6 and Alt. 11).						
2LS	Alt. 5 Rationale	Fully Meets – Overall risk level is Moderate; lowest ranking risk score (returned a score of 0.01 above a risk level of Low).						
1LI	Alt. 6 Rationale	Somewhat Meets – See Risk Analysis for specific risks and risk level; overall risk level is Moderate, with the highest risk score (almost equivalent to Alt. 3 and Alt. 11).						
1LS	Alt. 7 Rationale	Generally Meets – See Risk Analysis for specific risks and risk level; overall risk level is Moderate, with the second lowest ranking risk score.						
MULT	Alt. 8 Rationale	Generally Meets – See Risk Analysis for specific risks and risk level; overall risk level is Moderate. Almost equivalent to Alt. 7.						
Reno/New	Alt. 11 Rationale	Somewhat Meets – See Risk Analysis for specific risks and risk level; overall risk level is Moderate. (Almost equivalent to Alt. 3 and Alt. 6).						

Table F-3: Rationale for Alternative Scoring (Cont'd.)

D#	Desired Attributes		Imp.	3	5	6	7	8	11
9	**Lower LCC (NPV)**		**2**	**0.5**	**1**	**0.5**	**1**	**0.1**	**0.3**
35-year evaluation; all DOE costs, including capital, O&M, end-of-life D&D, and lease (if applicable).									
2LI	Alt. 3 Rationale	Generally Meets – Alt. 3 and Alt. 6 return essentially the equivalent NPV. See the LCCE.							
2LS	Alt. 5 Rationale	Fully Meets – The lowest NPV. See LCCE.							
1LI	Alt. 6 Rationale	Generally Meets – Alt. 3 and Alt. 6 return essentially the equivalent NPV. See the LCCE.							
1LS	Alt. 7 Rationale	Fully Meets – The second lowest NPV. Almost equivalent to Alt. 5.							
MULT	Alt. 8 Rationale	Barely Meets – The highest NPV. See the LCCE.							
Reno/New	Alt. 11 Rationale	Somewhat Meets – The second highest NPV. See the LCCE.							

D#	Desired Attributes		Imp.	3	5	6	7	8	11
10	**Near-term cash flow; lower is better**		**2**	**0.3**	**1**	**0.3**	**1**	**0.1**	**0.1**
Evaluate first 5 years of cash flow.									
2LI	Alt. 3 Rationale	Somewhat Meets – LI project (Alt. 3 and Alt. 6) had similar projected requirements for near-term cash flow. Approximately four times required by lease in the first 5 years.							
2LS	Alt. 5 Rationale	Fully Meets – Lease projects (Alt. 5 and Alt. 7) require the least cash flow in the first 5 years.							
1LI	Alt. 6 Rationale	Somewhat Meets – LI project (Alt. 3 and Alt. 6) had similar projected requirements for near-term cash. Approximately four times required by lease in the first 5 years.							
1LS	Alt. 7 Rationale	Fully Meets – Lease projects (Alt. 5 and Alt. 7) require the least cash flow in the first 5 years.							
Mult	Alt. 8 Rationale	Barely Meets – Multiple new facilities require the largest amount of cash in the first 5 years.							
Reno/New	Alt. 11 Rationale	Barely Meets – Alt. 11 requires the second greatest amount of cash in the first 5 years.							

D#	Desired Attributes		Imp.	3	5	6	7	8	11
11	**Ease of making facility modifications in future**		**4**	**0.5**	**0.3**	**0.5**	**0.3**	**0.5**	**0.5**
Ability to make changes in future.									
2LI	Alt. 3 Rationale	Generally Meets – For government-owned buildings, it is generally easier to make changes in the future.							
2LS	Alt. 5 Rationale	Somewhat Meets – The government does not own or control these buildings. It will be somewhat harder to make changes in the future.							
1LI	Alt. 6 Rationale	Generally Meets – For government-owned buildings, it is generally easier to make changes in the future.							
1LS	Alt. 7 Rationale	Somewhat Meets – The government does not own or control these buildings. It will be somewhat harder to make changes in the future.							
Mult	Alt. 8 Rationale	Generally Meets – For government-owned buildings, it is generally easier to make changes in the future.							
Reno/New	Alt. 11 Rationale	Generally Meets – For government-owned buildings, it is generally easier to make changes in the future.							

Table F-3: Rationale for Alternative Scoring (Cont'd.)

D#	Desired Attributes		Imp.	3	5	6	7	8	11
12	**Ease of meeting Freeze the Footprint initiative**		**2**	**0.1**	**1**	**0.1**	**1**	**0.3**	**0.3**
Consolidation of staff will enable closure of up to 10 facilities (HPCIC); allows repurposing and elimination of facilities (CREATE).									
2LI	Alt. 3 Rationale	Barely Meets – Enough space has to be identified to construct an LI project of the anticipated size to meet the requirement.							
2LS	Alt. 5 Rationale	Fully Meets – Lease facilities are easiest to meet the requirement.							
1LI	Alt. 6 Rationale	Barely Meets – Enough space has to be identified to construct a line item project of the anticipated size to meet the requirement.							
1LS	Alt. 7 Rationale	Fully Meets – Lease facilities are easiest to meet the requirement.							
Mult	Alt. 8 Rationale	Somewhat Meets – Additional time to establish a strategy to meet the requirements. Multiple buildings are not a good way to consolidate activities and multiple facilities will not be as efficient.							
Reno/New	Alt. 11 Rationale	Somewhat Meets – Renovated space is challenging to meet the attribute.							

D#	Desired Attributes		Imp.	3	5	6	7	8	11
13	**Ease of transition and relocation**		**2**	**1**	**1**	**1**	**1**	**0.5**	**0.3**
Transition and relocation may require double moves; very desirable to eliminate double moves.									
2LI	Alt. 3 Rationale	Fully Meets – Only one move is required.							
2LS	Alt. 5 Rationale	Fully Meets – Only one move is required.							
1LI	Alt. 6 Rationale	Fully Meets – Only one move is required.							
1LS	Alt. 7 Rationale	Fully Meets – Only one move is required.							
Mult	Alt. 8 Rationale	Generally Meets – Coordination challenge over time with the multiple smaller facilities, but minimal impact.							
Reno/New	Alt. 11 Rationale	Somewhat Meets – Multiple moves over time for the renovated space. Moving people out of the area to be renovated and setting up temporary space. Requires multiple moves to complete action.							

D#	Desired Attributes		Imp.	3	5	6	7	8	11
14	**Increased energy efficiency and sustainability**		**2**	**1**	**1**	**1**	**1**	**0.5**	**0.3**
Very important in meeting Department goals.									
2LI	Alt. 3 Rationale	Fully Meets – New facility designed and constructed to meet efficiency and sustainability requirements.							
2LS	Alt. 5 Rationale	Fully Meets – New facility designed and constructed to meet efficiency and sustainability requirements.							
1LI	Alt. 6 Rationale	Fully Meets – New facility designed and constructed to meet efficiency and sustainability requirements.							
1LS	Alt. 7 Rationale	Fully Meets – New facility designed and constructed to meet efficiency and sustainability requirements.							
Mult	Alt. 8 Rationale	Generally Meets – Multiple facilities are not as efficient as a single facility.							
Reno/New	Alt. 11 Rationale	Somewhat Meets – A renovated facility will increase efficiency and sustainability but will not achieve as much as a new facility.							

Table F-3: Rationale for Alternative Scoring (Cont'd.)

D#	Desired Attributes	Imp.	3	5	6	7	8	11
15	**Ease of providing space for visitors or part-time staff (flexible space)**	**1**	**1**	**1**	**1**	**1**	**0.3**	**0.5**
Flexible space allows reconfiguration to meet needs, usually accomplished with open floor plan offices.								
2LI	Alt. 3 Rationale	Fully Meets – New facility designed and constructed to attain flexibility and providing space.						
2LS	Alt. 5 Rationale	Fully Meets – New facility designed and constructed to attain flexibility and providing space.						
1LI	Alt. 6 Rationale	Fully Meets – New facility designed and constructed to attain flexibility and providing space.						
1LS	Alt. 7 Rationale	Fully Meets – New facility designed and constructed to attain flexibility and providing space.						
Mult	Alt. 8 Rationale	Somewhat Meets – Multiple facilities will have less flexibility in the layout and open floor plans. Constrained to smaller footprints.						
Reno/New	Alt. 11 Rationale	Generally Meets – Renovated space will be generally difficult to provide flexibility. Constrained by the current footprint of B543. CREATE would meet the attribute.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
16	**Ease of standing up different laboratory functional areas in flex space**	**4**	**1**	**1**	**1**	**1**	**0.3**	**0.5**
Laboratories (light or educational) are used for various purposes; flexible space allows reconfiguration as needed								
2LI	Alt. 3 Rationale	Fully Meets – New facility can be designed and constructed for ease of reconfiguration.						
2LS	Alt. 5 Rationale	Fully Meets – New facility can be designed and constructed for ease of reconfiguration.						
1LI	Alt. 6 Rationale	Fully Meets – New facility can be designed and constructed for ease of reconfiguration.						
1LS	Alt. 7 Rationale	Fully Meets – New facility can be designed and constructed for ease of reconfiguration.						
Mult	Alt. 8 Rationale	Somewhat Meets – Multiple facilities will have a smaller footprint with less capability of flexibility.						
Reno/New	Alt. 11 Rationale	Generally Meets – The new CREATE facility would fully meet the requirement. Renovation of B543 would barely meet. The addition to B543 would be the laboratory; there is barely any flexibility.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
17	**Expedient Funding Availability**	**1**	**0.1**	**1**	**0.1**	**1**	**0.5**	**0.1**
Funding options include line-item, GPP, IGPP, Alternative finance								
2LI	Alt. 3 Rationale	Barely Meets – The line item alternatives would not compete well with other priorities within the complex.						
2LS	Alt. 5 Rationale	Fully Meets – Lease cost is a small percentage of overhead/fixed cost. Rates will not be raised.						
1LI	Alt. 6 Rationale	Barely Meets – The line item alternatives would not compete well with other priorities within the complex.						
1LS	Alt. 7 Rationale	Fully Meets – Lease cost is a small percentage of overhead/fixed cost. Rates will not be raised.						
Mult	Alt. 8 Rationale	Generally Meets – Multiple facilities would compete year-to-year with operations needs. Much easier to control than line item.						
Reno/New	Alt. 11 Rationale	Barely Meets – The LI alternatives would not compete well with other priorities within the complex.						

D#	Desired Attributes	Imp.	3	5	6	7	8	11
18	**Assuring and Overseeing safety**	**1**	**1**	**0.5**	**1**	**0.5**	**1**	**0.5**
Assuring and overseeing construction and operations safety.								
2LI	Alt. 3 Rationale	Fully Meets – Government retains oversight and control of safety during construction and operations.						

Table F-3: Rationale for Alternative Scoring (Cont'd.)

2LS	Alt. 5 Rationale	Generally Meets – Facility owner/operator would be required to meet all requirements relevant to commercial safety.
1LI	Alt. 6 Rationale	Fully Meets – Government retains oversight and control of safety during construction and operations.
1LS	Alt. 7 Rationale	Generally Meets – Facility owner/operator would be required to meet all requirements relevant to commercial safety.
Mult	Alt. 8 Rationale	Fully Meets – Government retains oversight and control of safety during construction and operations.
Reno/New	Alt. 11 Rationale	Generally Meets – New facility (CREATE) would fully meets. The requirements to renovate B543 increase the concern for safety during construction (renovation, moving fence-line, and constructing roads).

D#	Desired Attributes		Imp.	3	5	6	7	8	11
19	**Assuring and Overseeing Security**		**3**	**1**	**0.5**	**1**	**0.5**	**1**	**0.5**
Assuring and overseeing security during construction and during operations.									
2LI	Alt. 3 Rationale	Fully Meets – Government maintains control and oversight the security.							
2LS	Alt. 5 Rationale	Generally Meets – Current GAA Security Plan would be followed. The facility owner/operator would be expected to define, document, and meet all applicable security requirements. SNL and LLNL would conduct security reviews for potential impacts to lab operations.							
1LI	Alt. 6 Rationale	Fully Meets – Government maintains control and oversight the security.							
1LS	Alt. 7 Rationale	Generally Meets – Current GAA Security Plan would be followed. The facility owner/operator would be expected to define, document, and meet all applicable security requirements. SNL and LLNL would conduct security reviews for potential impacts to laboratory operations.							
Mult	Alt. 8 Rationale	Fully Meets – Government maintains control and oversight the security.							
Reno/New	Alt. 11 Rationale	Generally Meets – Renovation of B543 adds a level of complexity on where people would be able to work and park, due to proximity to high-security area. CREATE fully meets.							

D#	Desired Attributes		Imp.	3	5	6	7	8	11
20	**Ease of construction within the existing NEPA Envelope**		**1**	**1**	**1**	**0.3**	**0.3**	**1**	**1**
Staying within the current environmental framework for the Open Campus (LLNL and SNL/CA).									
2LI	Alt. 3 Rationale	Fully Meets – New facilities (CREATE and HPCIC) fall within the current NEPA envelope.							
2LS	Alt. 5 Rationale	Fully Meets – New facilities (CREATE and HPCIC) fall within the current NEPA envelope.							
1LI	Alt. 6 Rationale	Somewhat Meets – A single, combined-use facility has not been planned in the existing environmental documents. There are certain NEPA and regulatory/state regulatory issues with one facility. Possible impact from regulators viewing the laboratories as "one" site for emission purposes. A determination may be written that could take into the slightly different use that had previously been identified.							
1LS	Alt. 7 Rationale	Somewhat Meets – A single, combined-use facility has not been planned in the existing environmental documents. There are certain NEPA and regulatory/state regulatory issues with one facility. Possible impact from regulators viewing the laboratories as "one" site for emission purposes. A determination may be written that could take into the slightly different use that had previously been identified.							
Mult	Alt. 8 Rationale	Fully Meets – Multiple facilities (CREATE and HPCIC) fall within the current NEPA envelope.							
Reno/New	Alt. 11 Rationale	Fully Meets – Renovation for HPCIC and the new CREATE facility falls within the current NEPA envelope.							

Activity 8: Compute the weighted score (attribute weight times score) for each alternative by multiplying by the attribute weight by the Alternative score.

Table F-4 shows the results of the weighted scoring of the Alternatives.

Table F-4: Alternatives Results – Weighted Score

D#	Desired Attributes	Normalized Relative Weighting (NRW)	2LI 3	2LS 5	1LI 6	1LS 7	Mult 8	Reno/ New11
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	6.7	6.7	6.7	0.7	0.7	6.7	6.7
2	Operations completion within 3 to 5 years is of highest importance.	6.7	6.7	6.7	6.7	6.7	3.3	2.0
3	Moving out of old and/or temporary space is highly desirable.	4.0	4.0	4.0	4.0	4.0	4.0	2.0
4	Reduced deferred maintenance is highly desirable.	4.0	4.0	4.0	4.0	4.0	2.0	2.0
5	Co-locating related functions is critical to improving site operations.	6.7	6.7	6.7	6.7	6.7	2.0	2.0
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	6.7	6.7	6.7	6.7	6.7	3.3	2.0
7	Create a gateway for industrial partnerships.	6.7	2.0	6.7	2.0	3.3	2.0	2.0
8	Lower DOE project success risks.	6.7	2.0	6.7	2.0	3.3	3.3	2.0
9	Lower LCC (NPV).	4.0	2.0	4.0	2.0	4.0	0.4	1.2
10	Near-term cash flow; lower is better.	4.0	1.2	4.0	1.2	4.0	0.4	0.4
11	Ease of making facility modifications in future.	1.3	0.7	0.4	0.7	0.4	0.7	0.7
12	Ease of meeting Freeze the Footprint initiative.	4.0	0.4	4.0	0.4	4.0	1.2	1.2
13	Ease of transition and relocation.	4.0	4.0	4.0	4.0	4.0	2.0	1.2
14	Increased energy efficiency and sustainability.	4.0	4.0	4.0	4.0	4.0	2.0	1.2
15	Ease of providing space for visitors or part-time staff (flexible space).	6.7	6.7	6.7	6.7	6.7	2.0	3.3
16	Ease of standing up different laboratory functional areas in flex space.	1.3	1.3	1.3	1.3	1.3	0.4	0.7
17	Expedient funding availability.	6.7	0.7	6.7	0.7	6.7	3.3	0.7
18	Assuring and overseeing safety	6.7	6.7	3.3	6.7	3.3	6.7	3.3
19	Assuring and overseeing security	2.7	2.7	1.3	2.7	1.3	2.7	1.3
20	Ease of constructing within the existing NEPA envelope.	6.7	6.7	6.7	2.0	2.0	6.7	6.7
		100.0	75.6	94.4	64.9	77.1	55.1	42.5

Activity 9: Rank Alternatives by total normalized score. Table F-5 shows that Alternatives 5 and 7 are the highest ranking alternatives.

Table F-5: Ranking of Alternatives

Rank	Alternative	Score
1	5	94.4
2	7	77.1
3	3	75.6
4	6	64.9
5	8	55.1
6	11	42.5

Activity 10: Sensitivity Analysis is completed by revising importance levels of Desired Attributes. Four cases were considered: #1 – Cost, #2 – Mission, and #3 – Infrastructure Sustainment, and #4 – Schedule.

Table F-6 is a compilation of the revisions to the Importance levels. The numbers in red show the changes from the "Baseline" case.

Table F-6: Sensitivity Analyses for Evaluation Criteria

D#	Criterion	Baseline	S-1 Cost	S-2 Mission	S-3 Infrastructure Sustainment	S-4 Schedule
1	Less than 0.25-mile distance between synergistic activities is the highest importance.	1	3	1	3	3
2	Operations completion within 3 to 5 years is of highest importance.	1	3	1	3	1
3	Moving out of old and/or temporary space is highly desirable.	2	4	4	1	4
4	Reduced deferred maintenance is highly desirable.	2	4	4	1	4
5	Co-locating related functions is critical to improving site operations.	1	3	1	3	3
6	Class A office space is consistent with standards in the Bay Area for recruitment and retention.	1	3	3	1	3
7	Create a gateway for industrial partnerships.	1	3	1	3	3
8	Lower DOE project success risks.	1	3	3	3	3
9	Lower LCC (NPV).	2	1	4	4	4
10	Near-term cash flow; lower is better.	2	1	4	4	1
11	Ease of making facility modifications in future.	4	4	4	1	4
12	Ease of meeting Freeze the Footprint initiative.	2	4	4	1	4
13	Ease of transition and relocation.	2	4	4	4	4
14	Increased energy efficiency and sustainability.	2	4	4	1	4
15	Ease of providing space for visitors or part-time staff (flexible space).	1	3	1	3	3

D#	Criterion	Baseline	S-1 Cost	S-2 Mission	S-3 Infrastructure Sustainment	S-4 Schedule
16	Ease of standing up different laboratory functional areas in flex space.	4	4	4	1	4
17	Expedient funding availability.	1	3	3	3	1
18	Assuring and overseeing safety	1	3	3	3	3
19	Assuring and overseeing security	3	4	4	4	4
20	Ease of constructing within the existing NEPA envelope.	1	3	3	3	3

- Sensitivity #1 – Cost: Attributes related to cost were given an importance of 1: All others were lowered two levels.
- Sensitivity #2 – Mission: Attributes related to Mission were given an importance of 1: All others were lowered two levels.
- Sensitivity #3 – Infrastructure Sustainment: Attributes related to Infrastructure Sustainment were given an importance of 1: All others were lowered two levels.
- Sensitivity #4 – Schedule: Attributes related to Schedule were given an importance of 1: All others were lowered 2 levels.
- Sensitivity #5 – Delete Desired Attribute for Risk; Delete Attribute #8.
- Sensitivity #6 – Delete Desired Attribute for Near-term Cash Flow; Delete Attribute #9.
- Sensitivity #7 – Delete Desired Attribute for NPV; Delete Attribute #10.
- Sensitivity #8 – Combine Changes S-5, S-6, and S-7; Delete Attributes #8, #9, and #10.
- Sensitivity #9 – Revise Risk Matrix to remove risks possibly duplicative of desired attributes; Delete Risks #12, #13, #15, #16, and #17.

Activity 11: Compute the weighted score for the revised Importance levels (Activity 8) and Rank the Alternatives (Activity 9) based on the results of the Sensitivity Analyses. Table F-7 presents the results of these Sensitivity Analyses. Alternative 5, two leased facilities, remains the highest ranking alternative. Alternatives 3 and 7 swap the second and third rankings for the mission sensitivity case.

Table F-7: Sensitivity Analysis on Evaluation Weighting

Alternative	Baseline		Sensitivity 1 Cost		Sensitivity 2 Mission		Sensitivity 3 Infrastructure Sustainment		Sensitivity 4 Schedule	
	Result	Ranking	Result	Ranking	Result	Ranking	Result	Ranking	Result	Ranking
3, 2LI	75.6	3	68.4	3	79.3	2	77.5	3	68.3	3
5, 2LS	94.4	1	94.2	1	95.1	1	91.2	1	94.5	1
6, 1LI	64.9	4	60.0	4	66.2	4	71.9	4	60.3	4
7, 1LS	77.1	2	80.5	2	74.2	3	82.1	2	81.5	2
8, Mult	55.1	5	45.8	5	52.9	5	53.5	5	50.0	5
11, Reno/ New	42.5	6	38.4	6	44.9	6	42.6	6	36.5	6

Table F-8 shows the results of the five sensitivity analyses that evaluated the impacts of removing some desired attributes and some risks.

Table F-8: Five Sensitivity Analyses for Elimination of Selected Desired Attributes and Risks

Sensitivity Analysis		Alternatives & Normalized Weighted Results			
		3 – 2LI	5 – 2LS	6 – 1LI	7 – 1LS
Baseline Analysis	Score	75.6	94.4	64.9	77.1
	Rank	3	1	4	2
S-5: Delete Desired Attribute for Risk	Score	78.9	94.0	67.4	79.0
	Rank	3	1	4	2
S-6: Delete Desired Attribute for Near-Term Cash Flow	Score	76.7	94.2	65.6	76.1
	Rank	2	1	4	3
S-7: Delete Desired Attribute for NPV	Score	77.5	94.2	66.4	76.1
	Rank	2	1	4	3
S-8: Combine Changes S-5, S-6, and S-7	Score	82.5	93.4	70.0	77.0
	Rank	2	1	4	3
S-9: Revise Risk Matrix to remove risks possibly duplicative of desired attributes	Score	76.9	94.4	66.3	80.4
	Rank	3	1	4	2

Note that some of the scores are very close and should be considered equivalent. For example, in S-5, the scores for Alternatives 3 and 7 are essentially equal. Alternative 5, two leased facilities, is the highest ranked alternative by at least 15 percentage points. Alternatives 7 and 3 swap the second and third rankings depending on the sensitivity case. When NPV and near-term cash flow are eliminated, the two LI buildings are rated as second, since NPV and cash flow are mostly correlated to the cost factors. Alternatives 8 and 11 were not recorded for these 5 sensitivity cases, as they remained the two lowest rated.

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APPENDIX G REFERENCES

1. *Mission Need Concept for The Establishment of the Livermore Valley Open Campus, Capabilities at Lawrence Livermore National Laboratory & Sandia National Laboratories, California*, dated June 2009.

2. *Mission Need Statement, Critical Decision 0: Open Collaboration and Research Capabilities in the Livermore Valley Open Campus for the Lawrence Livermore National Laboratory and Sandia National Laboratories,* January 2013.

3. DOE O 413.3B *Department of Energy Program and Project Management for the Acquisition of Capital Assets.*

4. Government Accountability Office, *DOE and NNSA Project Management: Analysis of Alternatives Could Be Improved by Incorporating Best Practices*, GAO-15-37, DRAFT, published December 11, 2014.

5. DOE G 413.3-21 *Cost Estimating Guide*, May 9, 2011.

6. *Livermore Valley Open Campus Master Plan, Final Report, Version 1.2, Flad Architects,* dated November 4, 2010.

7. *Open Collaboration and Research Capabilities on the Livermore Valley Open Campus: Collaboration in Research and Engineering for Advanced Technology and Education (CREATE) and High Performance Computing Innovation Center (HPCIC), CD-1: Alternatives Analysis and Business Case, rev. 3,* submitted February 2015.

8. *Livermore Valley Open Campus Development Options Report,* dated September 10, 2010.

9. Government Accountability Office, *Cost Estimating and Assessment Guide*, GAO 09-3SP, March 2009.

9. DOE G 413.3-7A, *Risk Guide,* 1/12/11.

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