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Forensic Technology Center Of Excellence

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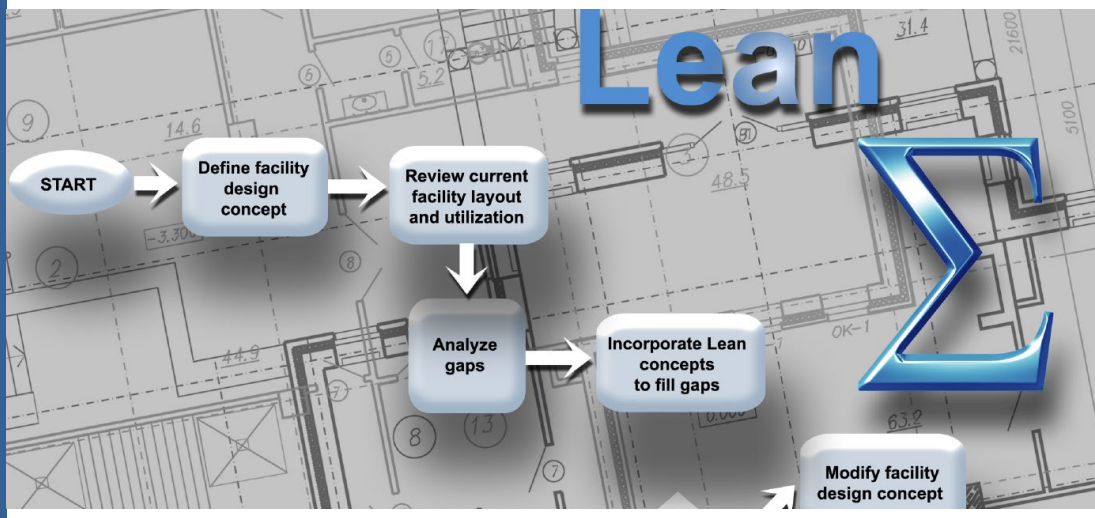
# Development of a Lean Facility Design Roadmap for Design-Bid-Build Forensic Facilities

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The information shared in this report represents the opinions of the individual practitioners and researchers who participated in this FTCoE project and not the opinions of their agencies or the National Institute of Justice. For more information or questions about this report, visit www.forensiccoe.org, or contact Jeri Ropero-Miller at jerimiller@rti.org or 919-485-5685.

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# BACKGROUND

## Forensic Technology Center of Excellence (FTCoE)

The FTCoE is a collaborative partnership of RTI International and its Forensic Science Education Programs Accreditation Commission (FEPAC)–accredited academic partners: Duquesne University, Virginia Commonwealth University, and the University of North Texas Health Science Center. In addition to supporting the National Institute of Justice's (NIJ's) research and development (R&D) programs, the FTCoE provides testing, evaluation, and technology assistance to forensic laboratories and practitioners in the criminal justice community. The NIJ funds the FTCoE to transition forensic science and technology to practice (Award Number 2011-DN-BX-K564).

The FTCoE is led by RTI, a global research institute dedicated to improving the human condition by turning knowledge into practice. With a staff of more than 3,700 providing research and technical services to governments and businesses in more than 75 countries, RTI brings a global perspective. The FTCoE builds on RTI's expertise in forensic science, innovation, technology application, economics, DNA analytics, statistics, program evaluation, public health, and information science.

# PUBLIC DOMAIN NOTICE

# Commonly Used Words and Phrases

For the purpose of this document the following are defined:

**Architect-Engineer Services,** as defined in 48 CFR 2.101 (Title 48, Federal Acquisition Regulations System; Chapter 1, Federal Acquisition Regulation; Subchapter A, General; Part 2, Definitions of Words and Terms; Subpart 2.1, Definitions):

A. Professional services of an architectural or engineering nature, as defined by state law, which are required to be performed or approved by a person licensed, registered, or certified to provide such services;

B. Professional services of an architectural or engineering nature performed by contract that are associated with research, planning, development, design, construction, alteration, or repair of real property; and

C. Such other professional services of an architectural or engineering nature, or incidental services, which members of the architectural and engineering professions (and individuals in their employ) may logically or justifiably perform, including studies, investigations, surveying and mapping, tests, evaluations, consultations, comprehensive planning, program management, conceptual designs, plans and specifications, value engineering, Construction Phase services, soils engineering, drawing reviews, preparation of operating and maintenance manuals, and other related services.

**Benchmarking:** The process of analyzing and comparing facility design projects with industry standards.

**BIM:** The process of generating and managing building data during the life cycle of a building. BIM uses three-dimensional, real-time, dynamic building modeling software. BIM includes building geometry, spatial relationships, geographic information, and quantities and properties of building components. BIM can include four-dimensional simulations to see how part or all of the facility is intended to be built and five-dimensional capability for model-based estimating. BIM provides the platform for simultaneous conversations related to the design of the "product" and its delivery process.

**Certificate of Occupancy:** A document issued by the governing jurisdiction permitting the owner to occupy the building for approved use and population.

**Change order:** A revision to the contract for construction that is signed by the owner, contractor, and architect.

**Commissioning:** The process of inspecting, testing, starting up, and adjusting building systems, and then verifying and documenting that they are operating as proposed and meet the intended design criteria.

**Concept drawings:** Graphics showing alternatives used to define a project's scope during the programmatic stage of the project.

**Construction contract:** A mutually binding legal relationship obligating the seller to furnish the supplies or services (including construction) and the buyer to pay for them. Includes all types of commitments that obligate the Government to an expenditure of appropriated funds and that, except as otherwise authorized by the FAR, are in writing. In addition to bilateral instruments, contracts include (but are not limited to) awards and notices of awards; job orders or task letters issued under basic ordering agreements; letter contracts; orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance; and bilateral contract modifications.

**Construction documents:** Documents that compose the construction contract, such as the Government contractor agreement (Standard Form 252, which includes general provisions and clauses; special contract requirements; other provisions in the uniform contract format; specifications, plans, and/or drawings; all addenda, modifications, and changes thereto, together with any other items stipulated as being specifically included).



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**Contracting Officer:** Individual who has the authority to execute a contract on behalf of the Government agency having jurisdiction and to make changes, amend contracts, approve payments, terminate contracts, and close out contracts upon satisfactory completion. The sole authorized agent in dealing with the contractor.

**Contractor:** The person, firm, or corporation with whom the Government has executed a contract and who is responsible for performing the work.

**Critical path:** A method for scheduling a set of project activities. The uninterrupted sequence of path of project activities that represents the time duration from that point to project completion and often continually changes with time.

**Design-Bid-Build:** The traditional delivery method in which design and construction are sequential and contracted for separately, with two contracts and two contractors.

**Design program:** A deliverable during the design phase that translates requirements identified in the needs assessment into data that can be used by architects and engineers to design the facility.

**Gemba:** The Japanese term for the place where value is added or where the work takes place (See Table 3).

**Integrated Master Schedule (IMS):** A tool that defines each distinct project activity and the critical path tasks that, if delayed, delay the completion of the project. This tool can be utilized during the Facility Relocation Phase.

**Muda:** Japanese word for waste or non-value-added activity (See Table 3).

**Needs assessment:** An essential planning tool, typically developed by independent professionals (e.g., forensic science consultants), that considers research, user, and facility needs; assesses the existing facility condition, limitations, and challenges; defines all space requirements; and refines preliminary opinions of construction cost.

**Poka-yoke:** Japanese term for mistake-proofing method or device developed to prevent an error or defect from happening or being passed on to the next operation (See Table 3).

**Project management plan (PMP):** A deliverable that outlines the strategy for planning, designing, constructing, commissioning, and relocating into the facility. The PMP is a dynamic document that is continually updated and refined throughout the project life cycle.

**Punch list:** A deliverable prepared at the end of construction defining outstanding items requiring construction completion. The general contractor does not receive final payment until the punch list has been resolved.

**Request for Information (RFI):** A question from the contractor regarding the drawings or specifications.

**Request for Proposals (RFP):** A document an organization uses to solicit bids. It outlines the contract terms and bid formatting requirements.

**Scope of Work** (sometimes referred to as 'Scope'): The narrative description of a project, including the physical size and characteristics, functions, and special features.

**Stakeholder:** Individuals and organizations that are involved in or may be affected by the undertaking.

**Value Engineering:** Process aimed at reducing project costs while maintaining basic functions.

**Value stream mapping:** A diagram showing every step involved in the material and information flows needed to bring a product from request to delivery.



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# INTRODUCTION

Since 1998, the National Institute of Justice (NIJ), in cooperation with the National Institute of Standards and Technology (NIST), supported two working groups and published two extensive reports to assist with planning, designing, constructing, and moving or renovating forensic laboratory facilities (NIJ, 1998, NIST, 2013). Over the past decade, several tools have been developed to increase organizational efficiency and reduce backlogs, including process mapping and Lean Sigma Six (LSS). In 2011, a variation of LSS, named Lean Design was introduced as a novel approach to health facility design (Mersereau & Jimmerson, 2011). While the Lean Design approach has been successfully implemented in a number of health care research and development and quality management laboratories, it has not yet been applied to the planning and construction of forensic facilities.

In 2013, NIST published an update to its widely acclaimed *Forensic Science Laboratories: Handbook for Facility Planning, Design, Construction and Relocation*. The "White Book," as it is often called, was developed by a group of 16 professionals with expertise in laboratory management, planning, architecture, and engineering. It offers advice for law enforcement agencies on 21st century planning, design, construction of, and relocation to, publicly funded forensic facilities (http://www.nist.gov/oles/forensics/facilities_forensics.cfm).

A detailed review of the White Book by a Forensic Technology Center of Excellence (FTCoE) Technical Assistance Group (TAG) revealed that, despite its guidance on integrating the latest scientific developments, efficiency improvements, and sustainability practices in building forensic facilities, it contains few references to Lean Design. Lean Design is a powerful way of aligning employee satisfaction, process efficiency, and product quality with customer satisfaction. It does so by focusing on the systematic identification and elimination of unnecessary and nonvalue-added activities involved in producing a product or delivering a service to clients.

In an effort to incorporate Lean Design thinking into the planning, construction, and relocation of forensic facilities, the National Institute of Justice's FTCoE initiated a project to develop guidelines and checklists for Lean Facility Design (LFD). This document reports on the development of these LFD guidelines and checklists and their integration with the guidance in the White Book to develop an LFD roadmap for planning and constructing 21st century Design-Bid-Build forensic facilities. Throughout this report, direct sections of the NIST White Book are included to demonstrate how it was used to develop the LFD Roadmap guidelines, which integrate Lean Design concepts throughout the supplementing outcome and processes described. These fundamental principles of Design-Bid-Build for publicly funded crime laboratories are credited to the NIST White Book and included as used in the context of this document.



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## LEAN FACILITY DESIGN

LFD is a strategy to optimize the logical and systematic flow of work, people, and information through a facility. It mirrors the standard approach to facility design and links the classical design criteria of materials, personnel, equipment, and finished product with operational considerations like information flow and value stream performance measurement (Reynolds & Scharton-Kersten, 2013). In doing so, it answers questions such as the following:

- How can we improve our current work process?
- How should the physical space be configured to support this improved work process?
- How can we ensure the delivery of a quality product? (Anderson & Mersereau, 2012).

Lean thinking, along with process analysis, development, and improvement during the design phases, allows for the creation of a physical space that supports improved processes of work, resulting in higher staff productivity and morale, and a better quality of product or service (Aziz & Hafez, 2013). The LFD approach has been effectively applied to the construction of a number of facilities, primarily in the healthcare field, where it was found useful for building new facilities, remodeling facilities, upgrading and changing equipment, and implementing new or improved processes and products (Lehmann, 2011). It was also found that successful LFD requires collaboration between laboratory staff, the facility design team, and facility architects and engineers (Evans & Valentine, 2014).

## OBJECTIVES AND GOAL

We identified three objectives for this project: (1) to develop LFD guidelines for operational excellence in crime laboratories through efficient facility layout and effective space utilization, (2) to develop LFD checklists for the planning, design and construction of publicly funded forensic facilities, and (3) to integrate the guidelines and checklists with the NIST-provided guidance on building 21st century forensic facilities.

Our overall goal was to develop a roadmap for the planning, design, construction of, and relocation to Design-Bid-Build forensic facilities. The roadmap supplements the guidance in the NIST White Book and serves as a stand-alone document for crime laboratories interested in building new forensic facilities, or remodeling existing ones, using Lean concepts and principles to improve process efficiency, staff productivity and morale, and the quality of the delivered product and service.



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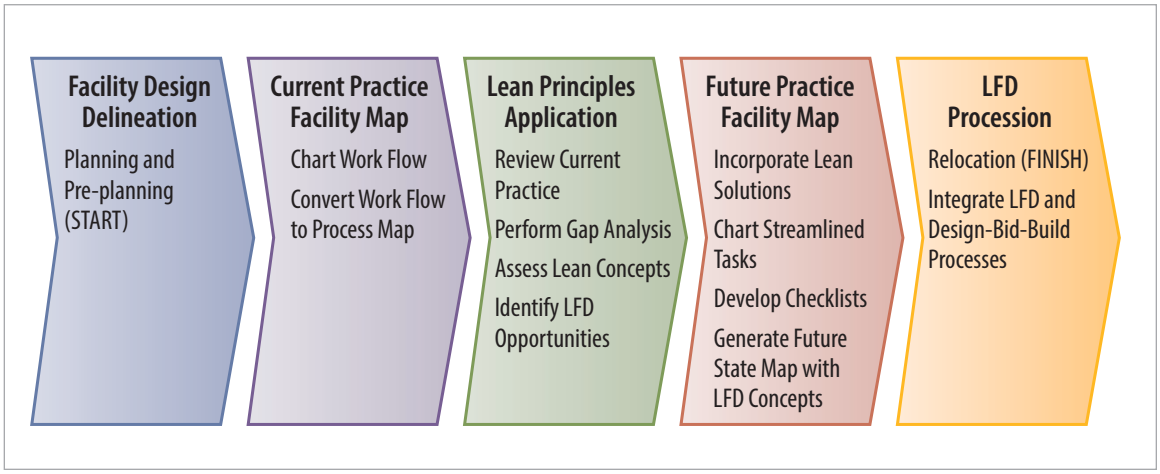
# METHODOLOGY

We chose a value stream design approach to develop the guidelines, checklists, and LFD roadmap. The approach follows the sequence of steps outlined by the Institute for Operational Excellence (Duggan, 2014), yet incorporates a number of enhancements and modifications to target the main objective of this project: the development of a Lean Facility Design Roadmap. To achieve this goal, we created the following five steps for Lean Facility Design value stream mapping: Facility Design Delineation; Current Practice Facility Mapping; Lean Principles Application; Future Practice Facility Mapping; and Lean Facility Design Procession (see **Figure 1**). A glossary of terms is included at the beginning of this report.

**Figure 1. Lean Facility Design (LFD) Roadmap Using Design-Bid-Build Process.**




In *Facility Design Delineation*, we established the boundaries of value stream design (Dugan, 2014). With the development of a LFD roadmap as a goal, we decided to set forensic facility planning and pre-planning as the start of value stream analysis, and relocation to the new or renovated facility as the end. The specific process targeted for analysis was Design-Bid-Build, a proven and well accepted practice for building new publicly funded facilities, in particular forensic facilities.

In *Current Practice Facility Mapping,* we charted the work flow associated with forensic facility planning, design, construction, and relocation. We also converted flow charts to a process map to illustrate in detail the current practice of planning, designing, and constructing new forensic facilities, as well as relocation to the new forensic facility.

In *Lean Principles Application,* we reviewed the current practice of Design-Bid-Build forensic facilities. We performed a gap analysis to identify existing gaps, assessed Lean concepts and principles to streamline the process, and identified opportunities to incorporate Lean into forensic facility planning, design, construction and relocation.

In *Future Practice Facility Mapping*, we incorporated the Lean solutions to fill the gaps. We charted the flow of streamlined forensic facility planning, design, construction, and relocation tasks; generated checklists to guide critical activities in need of completion; and generated a Future State Map to illustrate the LFD process.

Finally, in *Lean Facility Design Procession,* we integrated the LFD process map with the forensic



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facility planning, design, construction, and relocation guidance provided in the White Book. Figure 1 outlines the developed roadmap for how to implement LFD for Design-Bid-Build forensic facilities.

We formed a Technical Assistance Group (TAG) to generate the LFD process map and the checklists needed to develop the roadmap (**Table 1**). The group's unofficial charter called for the development of a resource that crime laboratory directors can use to incorporate Lean thinking into the design of new or reconstructed forensic facilities to improve laboratory performance.

We recruited TAG participants from state and local crime laboratories in the process of building a new facility, renovating an existing crime laboratory, or having just completed construction of a new facility. The group was supplemented by a representative from a commercial architecture and engineering (A&E) firm familiar with the forensic facility design process and the building guidance provided in the NIST White Book. The person representing the forensic facility renovation project dropped out because of scheduling difficulties.

We contracted a process management consultant to educate TAG members on Lean concepts and principles and to facilitate the LFD meetings. Three meetings were scheduled to develop the LFD guidelines, checklists, and roadmap: one in Belleville, Illinois, and two in Olathe, Kansas.

**Table 1. LFD Technical Assistance Group and project participants.**

| Name | Organization (Location) | Position |
|---|---|---|
| Steve Avedisian | Metro-East Forensic Sciences Laboratory (Belleville, Illinois) | Crime Laboratory Director |
| Allen Hamm | Johnson County Sheriff's Office (Olathe, KS) | Assistant Crime Laboratory Director |
| Gary Howell | Johnson County Sheriff's Office (Olathe, KS) | Crime Laboratory Director |
| Ken Mohr* | Crime Laboratory Design (Saint Louis, MO) | Planning Principal |
| Linda Netzel | Kansas City Police Department (Kansas City, MO) | Crime Laboratory Director |
| Thomas L.G. Price | Kansas Bureau of Investigation (Topeka, KS) | Assistant Crime Laboratory Director |
| Joe Brancaccio | The Brazos Group (Flower Mound, TX) | Process Management Consultant |
| David Baldwin | Midwest Forensics Resource Center (Ames, IA) | Program Director |
| Rudi Luyendijk | Midwest Forensics Resource Center (Ames, IA) | Principal Investigator |

* Also member of the Technical Working Group that developed the 2013 NIST White Book.



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# RESULTS

The primary purpose of the preliminary TAG meeting held at the Metro-East Forensic Sciences Laboratory in Belleville, IL, was to review the NIST White Book and its guidance on building 21st century forensic facilities. Another goal was to assess the need for streamlining the building process to create a physical space with improved work and operation processes. We performed a gap analysis to determine the steps needed to accomplish these goals. The gap analysis consisted of listing the forensic facility planning, design, construction, and relocation process steps outlined in the White Book, and comparing them to the associated steps derived from a post-occupancy evaluation of the state-of-the-art, 2014-completed Metro-East Forensic Sciences Laboratory. **Table 2** highlights the main gaps to be filled in order to ensure the new facility is designed for optimal use and operation, both now and in the future.

**Table 2. The three Themes revealed by the gap analysis.**

| Theme I | Theme II | Theme III |
|---|---|---|
| Involve Crime Laboratory Members in Facility Project Team | Define Future State of the New Forensic Facility | Develop Performance Management Plan and Metrics |

The first theme highlights the lack of a dedicated crime laboratory facility design project team. Such a team forms an integral part of the Whole Building Design process (Prowler, 2012). Crime laboratory personnel should be fully engaged during the actual building design process and fully integrated with the crime laboratory consultant and the A&E firm from the very beginning of facility pre-planning and planning. Integration ensures that crime laboratory needs are correctly identified and communicated, and properly incorporated and addressed in the design of the new facility. Coordination with the crime laboratory consultant and the A&E firm further ensures that design decisions support improved workflow.

The second theme reveals the lack of information and data regarding the future state of forensic facilities. The assessment of the facility's future-state needs and loads ensures that the new forensic facility is designed to address not only today's needs, but also those of the future. It is extremely important that budget decisions do not limit future facility planning and needs. Listing and evaluating the needs will also allow for the value stream mapping of key processes and operations, which can be used to formulate action plans for overall system improvement. The information and data collected can also aid in the organization of the new space and directly feed into the design of the new facility, while the current facility remains operational.

The third theme reveals the lack of metrics to measure the performance of the new facility. Performance metrics can provide a basis for comparison between new and old facility operational outcomes. Yet, to be useful, performance metrics must be selected based on technical feasibility and relevance to the project. For example, to assess how well the newly constructed facility matches the crime laboratory's needs, a metric should be selected that can measure the impact of the facility's design on crime laboratory operations. Similarly, to assess the impact of the new facility on staff productivity and product or service quality, metrics should be selected that can measure crime laboratory operation and process efficiency. Such metrics can be tracked and monitored, and provide data that can be used to manage the new facility's operation and provide feedback to the facility's designer.



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The LFD TAG met at the Johnson County Sheriff's Office Criminalistics Laboratory in Olathe, Kansas, to discuss the three Themes revealed by the gap analysis and to discuss their impact on forensic facility design. The group found that the current crime laboratory design practice as described in the White Book focuses more on facility layout and space allocation than on space utilization. Further, the group resolved that if 21st century crime laboratories are to meet the mission requirement of providing the justice system with quality service in a timely manner, forensic facility design must incorporate elements of operation efficiency and effectiveness.

A closer look at the three themes showed that the various tasks and activities governing each theme are, in essence, key principles of Lean thinking (**Table 3**), and TAG members then began to realize that incorporating them into the current practice of facility design could change the primary driver of the design model from emotion to data and analysis. By optimizing operation performance, the transparency and effectiveness of the operations are improved and resources are freed up (Connolin, 2015), resulting in more efficient processes, higher staff productivity and morale, and better product quality and service. From this, a strategy was developed to incorporate Lean concepts and principles into forensic facility design. The strategy consisted of three steps: assess what is, imagine what can be, and map the journey forward. We assessed current state of forensic facility design in terms of the various processes and steps outlined and described in the White Book. We identified and analyzed all relevant tasks and activities. Supplemental tasks and activities were provided by TAG members who were in the process of, or had just completed the process of, planning, designing, constructing, or relocating to a new forensic facility. We used the collected information to develop a flow chart of the project delivery process. The flow chart illustrates the forensic facility operations performed and the sequence in which the operations were executed. The result is a top-down view of the actual forensic facility building processes, tasks, and activities (**Figure 2**) We converted the flow chart into a process map of current practices of forensic facility design by incorporating decisions and adding activity inputs and outputs to illustrate relationships. The process map (**Appendix A**) facilitated a better understanding of the forensic facility project delivery process, the roles and responsibilities of crime laboratory stakeholders, and the various considerations pertinent to both the function and operation of the new forensic facility.

**Table 3. Lean principles than can be linked to the three gap analysis Themes.**

| Theme | Activity | Lean Principle |
|---|---|---|
| Family Design Team | Identify crime laboratory members | Poka-yoke* |
| | Identify roles and responsibilities | 5 S* |
| | Document procedures | Standardized Work* |
| Facility Future State | Identify growth potential | 5 S* |
| | Develop design charrette | Poka-yoke* |
| | Organize workspace | 5 S* |
| Facility Performance | Identify performance indicator | 5 S* |
| | Document use of performance metric | Standardized Work* |
| | Assess impact on design / of design | Muda*, Gemba* |

* See Glossary for description of terms.



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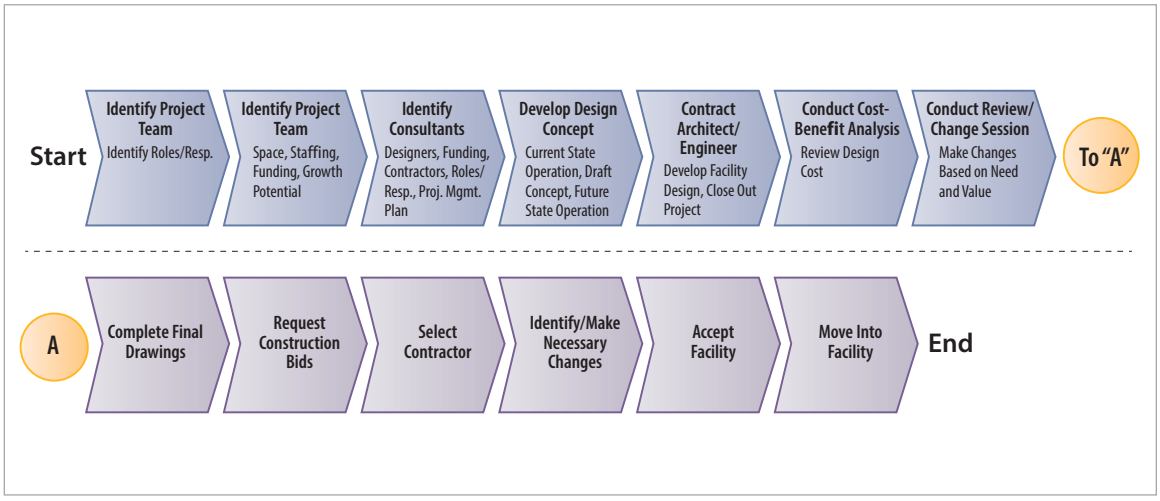
Figure 2. High-level view of the Lean facility building process.




A third and final meeting of the LFD TWG was held at the Johnson County Sheriff's Office Criminalistics Laboratory in Olathe, Kansas. The primary purposes of the meeting were to review the current practice of forensic facility design for accuracy and completeness, and to highlight value-added and non-value-added steps within the project delivery process. An additional goal was to identify opportunities for incorporating into crime laboratory design the three Themes of ideal state design: active participation by crime laboratory management and staff; design of a 21st century forensic facility that addresses today's crime laboratory needs and those of the future; and development of measurable metrics and a performance management plan that tracks and monitors the effectiveness and efficiency of the new space.

To achieve these goals, we conducted an in-depth assessment of the project delivery process, targeting all operations, tasks, and activities identified in the current state process map. We identified a number of process shortcomings, inefficiencies, and redundancies, along with a need for tools to measure product quality and performance efficiency. We used the collected information to revise the current state process map and to develop the future-state forensic facility design process to capture efficiency through the elimination of unnecessary tasks and the reduction of wasteful activities. By incorporating Lean concepts and principles, the future-state process map depicts the LFD process (**Appendix A**).

The LFD process map provides a detailed outline of the various operations, tasks, and activities involved in the planning, design, and construction of, and relocation to, a new forensic facility. It provides a solid understanding of the various steps that need to be taken, tools that need to be integrated and utilized, and roles and responsibilities that need to be defined and executed to ensure the procurement of a 21st century crime laboratory. We developed a checklist of specific actions and steps during the LFD process (Table 4). The checklist complements those developed for the traditional forensic facility design process described in the White Book. Collectively, they set the stage for the building of a LFD crime laboratory.



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Table 4. Lean Facility Design checklist to accompany the Lean Facility Design process map.

**Lean Facility Design Process Checklist**

- ❑ When selecting team members consider the following: Champion, Project Mgr., SMEs, Facilities Mgr., EH&S, QA/QC.
- ❑ Identify Roles/Responsibilities (White Book, pg. 3): Include SMEs as part of review process at all levels.
- ❑ Conduct a System Gap Analysis (identify current issues).
- ❑ Map key work processes.
- ❑ Identify customer satisfaction, productivity & quality metrics methodology: items per analyst, cases per analyst, turn-around time (TAT),; use more statistical terms like "95% completed within xx days."
- ❑ Survey internal & external customer to see if their needs are being met: (White Book, pg. 8).
- ❑ Visit other labs for ideas; what to do and what not to do.
- ❑ Amenities: break room, gym, lactation room, parking, bathrooms, lockers, mock scene room, lobby, displays.
- ❑ Establish future projection plan, 5, 10, 20 years out:
  - project the staffing level (White Book, pg. 14)
  - project the case load
  - project the future area demographics
  - project the future goals
  - identify known future technologies
- ❑ Identify funding source(s).
- ❑ For designing a new lab, use input from other laboratories and design guidelines (White Book, pg. 16–24).
- ❑ Select delivery method (White Book, pg. 44).
- ❑ Identify contractors using guidelines (White Book, pg. C-1–C-2, 35). Consider previous experience.
- ❑ Write RFP using Internet example or input from other labs.
- ❑ Consider A&E teams with previous crime lab experience.
- ❑ Select A&E team based on qualifications, reputation, past experience, bid & ability to communicate effectively: (White Book, pg. 17).
- ❑ Check LEAN techniques: Gemba (work area), Polayoke, (prevention techniques), Muda (waste), Work Flow, Cycle Time reduction & 5S: Sort, Set, Shine, Standardize & Sustain.
- ❑ Review design for accuracy and completeness (White Book, pg. 18).
- ❑ When make agreements, consider majority or consensus decisions.
- ❑ Review construction documents (White Book, pg. 22–24).
- ❑ Evaluate 3-D mock-ups for Design for Repair (DFR)/Design for Maintenance (DFM), functionality, performance, placement.
- ❑ Develop move plan (White Book, pg. 33–40); ensure Certificate of Occupancy is issued prior to move-in.
- ❑ Shut down evidence intake 'xx' days prior to move; consider moving each section sequentially.
- ❑ Assign responsible team member to manage move plan; collect post-move metrics, compare to pre-move, and analyze findings; re-assess work processes and correct unproductive or negative impact.

White Book: *Forensic Science Laboratories: Handbook for Facility Planning, Design, Construction, and Relocation.*

## LFD ROADMAP

The LFD process map and checklist provide guidelines for the planning, design, construction of, and relocation to a Lean forensic facility. While the guidelines allow for the visualization and, to some extent, the identification of tools needed to support the Lean project delivery process, they fall short of providing the detailed set of instructions needed to execute the outlined process. To achieve this goal, the guidelines are supplemented by relevant information taken from the White Book to generate the LFD roadmap, which serves as a "How-To" guide for implementing LFD.

The roadmap covers all of the steps involved in the actual building process, starting with the formation of the LFD project team and ending with the relocation of the crime laboratory to the Lean facility. A process diagram is provided in the associated appendices to illustrate each process, along with a narrative description of the various tasks and activities supporting the process step. If they are described in the White Book, the information is included in this roadmap with cited page references.



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# LFD PLANNING

Facility design and construction projects rely on project teams with diverse memberships and skillsets. Because of the unique nature and complexity of crime laboratory operations and processes, expertise from both inside and outside the organization must be leveraged to ensure the new facility meets the needs and requirements of the crime laboratory's stakeholders (**Appendix B**). The White Book identifies four different stakeholders required to build a forensic science laboratory: the property owner, the user (crime laboratory), the design team, and the construction team.

The term "property owner" typically refers to the organization funding the building of the new facility. For publicly funded crime laboratories, this is most often another government agency. The user group is the organization and individuals using the facility to perform its mission. The design team is the group of individuals who work closely together with the user group to plan the facility and to prepare the construction document needed to build the facility. Finally, the construction team is the organization that designs and builds the facility using the information provided by the design team. **Table 5** lists the four stakeholders along with their roles and responsibilities in LFD (**NIST, 2013, page 3**).

During the initial phase of the project, the owner and the facility user group meet to discuss the general concept for the new forensic facility. They conduct a self-evaluation to define the mission requirements that must be addressed by the new facility. The evaluation highlights current, past, and future (projected) mission requirements, as well as organizational requirements (Toosi, 2006). These mission and organizational requirements are developed collaboratively among the facility owner and crime laboratory managers and staff to ensure that all facility stakeholders have an opportunity to identify both the short and long-term requirements for the new forensic facility (**NIST, 2013, page 9**).

**Table 5. LFD Project Team Responsibilities.**

| Stakeholder | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Makes decisions, represents property owner's interest |
| | Commissioning Agent | Verifies new facility operates and functions as designed |
| User Group (crime laboratory) | Laboratory Director | Initiates project and makes decisions |
| | Technical Manager | Serves as project point of contact, manages day-to-day activities |
| | Project Committee | Ensures new facility meets current- and future-state forensic objectives |
| | Contracting Agent | Issues Request for Proposals and procures resources and consulting services |
| Design Team | Forensic Consultant | Leads Design Team and ensures effective design of the Lean facility |
| | LFD Design Committee | Ensures integration of Lean concepts / Lean principles in forensic facility design |
| Construction Team | A&E consultant | Prepares all major LFD deliverables |
| | General Contractor | Validates proposed design concepts and builds the Lean facility |



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The property owner then appoints a commissioning agent to assist in setting goals for facility design and validating those goals, and to verify that the new facility operates as proposed and meets all intended design criteria. The laboratory director appoints a technical manager to oversee the execution of all project activities, to establish a project committee to conduct initial planning activities, and to find out if facility design expertise resides within the crime laboratory organization. If so, the technical manager checks the availability of resources and their ability to actively participate in all aspects of the building construction process. If not, the Technical Manager identifies all external resources needed to complete the Project Team (**NIST, 2013, page 5**).

"Once the need for external capabilities has been identified, the technical manager seeks funding for forensic science consultant services." The project committee prepares the baseline budget, scope, and schedule, and the technical manager provides the justification for project funding. Concurrently, he/she appoints a contracting agent to assist in the contracting of external facility design services. If funding is available, and the request has been approved, a consultant statement of work is defined and a Request for Proposals is issued. The services of the external consultant are procured and an LFD design committee is assembled to help in the preparation of the needs assessment (**NIST, 2013, page 10**).

It is recommended that the LFD design committee should be composed of the user group, with one exception: if the necessary expertise does not reside within, or is unavailable at, the crime laboratory, the design committee should include the forensic science consultant leading the effort and other facility planning and design subject matter experts. The selection of crime laboratory staff on the design committee is to ensure that the various needs driving the design of the Lean facility are correctly identified, communicated, coordinated, and incorporated in the building of the new crime laboratory. To become a LFD design committee member, individuals must be seasoned crime laboratory staff with a long tenure in the organization or in a specific discipline, and should possess a desire to improve both the physical layout of the new laboratory and its operation. Ideally, the LFD design committee should consist of a mixture of managers and scientists with at least one individual who can serve as a Lean Champion to promote the consideration and/or incorporation of Lean concepts and principles in forensic facility construction. Such an individual may be Lean certified.

After all members have been identified and selected, the actual LFD team is assembled. **Table 6** lists the team members' roles and responsibilities. The technical manager then begins to conceptualize the project management plan, which outlines the strategy for planning, designing, constructing, commissioning, and relocating to the new facility. To ensure a Lean forensic facility is designed and constructed that meets the requirements of the self-evaluation and the needs of a productive work environment, training is provided on Lean design concepts and principles by a certified Lean instructor or process management firm. The project team and members of the LFD team are introduced to Lean thinking (Reynolds, 2009) and how to capture efficiency through elimination of non-value added activities and reduction of waste (Deshpande, Filson, Salem, & Miller, 2012). They are also introduced to Design Quality Indicators (DQI), a metric developed to track and monitor space utilization in the Lean facility (Construction Industry Council, 2015).



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Table 6. LFD Planning Phase Project Team Responsibilities.

| Group | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Identifies facility requirements and appoints commissioning agent |
| | Commissioning Agent | Participates in facility goal setting and design planning |
| User Group (crime laboratory) | Laboratory Director | Conducts crime laboratory self-evaluation, appoints technical manager |
| | Technical Manager | Appoints contracting agent, establishes project committee, identifies external resources needed, develops project management plan |
| | Project Committee | Assesses internal resource skills and capabilities |
| | Contracting Agent | Procures forensic science consulting service (if needed) |
| Design Team | Forensic Consultant | Assembles design team and defines roles and responsibilities |
| | LFD Design Committee | Selects design team members, identifies Lean champion |
| Construction Team | A&E Consultant | Not usually contracted yet |
| | General Contractor | Not usually contracted yet |
| Relocation Team | Move Captain | Not designated yet |
| | Moving Contractor | Not contracted yet |

## LFD NEEDS ASSESSMENT

In traditional facility design, facility needs are assessed utilizing survey instruments and interviews, supplemented by touring comparable facilities, and assessing existing facilities. The data collected is then organized and translated into information that can be compared and checked against mission goals, operational needs, standards, operational codes, and resource restraints. The synthesized data and information are assembled into a draft needs assessment, which is reviewed and finalized. (**NIST, 2013, page 12**).

LFD employs a similar approach (**Appendix C**). Surveys of internal and external customers are conducted, along with interviews of crime laboratory staff, managers, operation and maintenance engineers and technicians, to gain a full and thorough understanding of what is driving the construction of a new forensic facility. Some of the driving issues may include "advances in technology or methodologies, lack of existing space/capacity, growth in staff or scientific requirements, increased demand for forensic science services, or the need to update facilities and major infrastructure systems because they have outlived their design life" (**NIST, 2013, page 8**).

The information collected is supplemented by key workflow process maps to determine the current state of crime laboratory operation and efficiency.

In-house mappers and facilitators are used to accurately map a workflow process. When these resources are unavailable, the services of a process mapping consultant are obtained. However, there is no substitute for the knowledge obtained from



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the people doing the work and utilizing the space. The maps generated by in-house mappers are typically the most complete, illustrating in detail the flow of work and information throughout a facility. To gain a full and thorough understanding of crime laboratory operations, if time permits, several key processes are mapped. If time is limited, the evidence flow process is mapped.

Process maps provide simple yet powerful tools to answer questions like "What is happening", "Where is it happening", "When is it happening", "Who is doing it", and "How are process inputs and outputs handled and distributed." They can also reveal valuable information about the efficiency of an operation or process. In crime laboratories, this is true when process maps are accompanied by productivity metrics, customer satisfaction metrics, or product quality metrics measuring not just process output (e.g., backlog reduction), but more importantly process performance (e.g., cycle time). When properly implemented, such metrics can serve as benchmarks for describing the current state of crime laboratory performance, and after relocation to the new facility they can also serve as indicators for assessing the Lean facility's performance.

Once all information is collected about the current state of the physical and logical crime laboratory environment, an assessment is made of the facility's future state. This is accomplished by projecting future forensic facility goals and mission requirements and by assessing the growth potential of the new facility 5, 10, and 20 years into the future. Tools to determine the facility's growth potential are available in the form of regional demographic service area projections. The information provided by these projections is used to estimate caseload growth, staffing levels to process the caseloads, and the laboratory space needed to accommodate the analysis of evidence.

**Table 7** lists the average space-to-staff ratio for laboratories. Note that "as the size of a facility increases, economies of space reduce the space-to-staff ratio." For example, regardless of the laboratory's size, it needs only a single firing range, reception/waiting room, and space for standards and references (**NIST, 2013, page 14**).

Other considerations to assess the future state of the crime laboratory include mission growth (Mount & Hackman, 2012), investigation activities (Denmark & Mount, 2013), the physical environment (Mount and Hackman, 2012), and workspace activities (Denmark & Hackman, 2013). Finally, new ideas may be generated by visiting other forensic facilities that are in the process of building a new facility, or those that have recently completed the construction of and relocation to a new facility. Collectively, demographic projections, forensic science trends, and facility design advancements determine the future state of the crime laboratory, and subsequently the objectives for the new forensic facility. Once the objectives are known, a gap analysis of laboratory space, resources, and processes should be performed in order to document how well the current space meets the targeted set of objectives identified for the new forensic facility.

**Table 7. Space-to-staff ratios used in forensic facility design (NIST, 2013).**

| Laboratory Category | Staff Size | Total Laboratory Size | Space to Staff Member |
|---|---|---|---|
| Small | Up to 30 | <30,000 GSF | 930 – 1,000 GSF / staff member |
| Medium | 30 – 70 | 30,000 – 60,000 GSF | 860 – 930 GSF / staff member |
| Large | 70 – 110 | 60,000 – 90,000 GSF | 790 – 860 GSF / staff member |
| Very Large | Over 110 | >90,000 GSF | 720 – 790 GSF / staff member |

Note: GSF – gross square feet.



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The gaps are then translated to requirements for the new Lean forensic facility and are addressed in the design charrette, a collaborative process in which the design team validates the requirements for the new forensic facility and brainstorms alternatives to current process flows, laboratory space, and resource layouts and configurations. The goal is to satisfy the baseline budget, scope, schedule, sustainability, security, and safety requirements outlined by the users and customers of the new facility. The designs are then discussed and are altered or reworked utilizing the information provided by the Design Quality Indicators (functionality, build quality, and impact), until a design acceptable to the entire design team is generated. A design program is then developed to outline the concepts that satisfy the requirements and objectives of the future-state crime laboratory facility.

**Table 8** lists the roles and responsibilities of the project team for the needs assessment. While the user group and the design team are primarily focused on assessing the forensic facility's needs and requirements, the property owner should be busy validating facility layout and utilization, and identifying the proper construction delivery method for the new facility. A significant number of construction delivery methods are available, including Design-Bid-Build (DBB), Construction Management at Risk (CMAR), Design-Build (DB), and Integrated Project Delivery (IPD). This roadmap outlines the DBB method, as it is currently the most commonly used construction delivery method for publicly funded crime laboratories. (**NIST White Book, pages 10-12**).

**Table 8. LFD Needs Assessment Project Team Responsibilities.**

| Group | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Identifies construction delivery method |
| | Commissioning Agent | Validates facility layout and utilization |
| User Group (crime laboratory) | Laboratory Director | Visits other new crime laboratories, tracks and monitors DQI |
| | Technical Manager | Visits other new crime laboratories, issues gap analysis, reviews DQI data |
| | Project Committee | Conducts surveys, interview customers, map process(es) |
| | Contracting Agent | Procures external resource services (if needed) |
| Design Team | Forensic Consultant | Conducts gap analysis and design charrette, develops design program |
| | LFD Design Committee | Validate facility requirements, assess regional demographic projections, analyze trends and advancements in forensic science/ facility design |
| Construction Team | A&E Consultant | Not usually contracted yet |
| | General Contractor | Not usually contracted yet |
| Relocation Team | Move Captain | Not designated yet |
| | Moving Contractor | Not contracted yet |



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## LFD A&E CONSULTANT SELECTION

The services of an external architecture and engineering (A&E) firm are procured if insufficient forensic science laboratory design expertise resides within the agency, or is unavailable during the building design process. To hire the A&E consultant, the project team develops a statement of work and issues a Request for Proposal (RFP) for LFD A&E services (**NIST, 2013, page 12**). After proposals have been received, candidate A&E firms are contacted and interviewed. Considerations for contracting include experience of the A&E candidate with the specifics of forensic science laboratory design in general, and the specifics of Lean design in particular. Other considerations include the A&E firms' performance history and reputation. A list of references is requested, checked and interviewed. After all collected information has been reviewed, the A&E firm is selected and a contract awarded.

## LFD DESIGN DEVELOPMENT

As the project moves from the conceptual design phase to detailed design, the process becomes more formal (**Appendix D**). In general, the actions of formulation, analysis, search, decision, specification, and modification still hold, but they represent specific steps with less random actions. This is particularly true for the last step in LFD design development—modification, which is a change in the concept design of the facility, or a total re-design, when problems and issues are discovered during the review and assessment of the facility layout and workflow that require drastic solutions.

During the early stages of LFD development, the design team and A&E consultant meet with the user group to review the design program and to assess the design charrette's concept facility layout and space, along with the placement of equipment, casework, utilities, telecommunications and IT systems, and the accessibility of equipment and utilities to ensure they can be properly maintained, repaired, or replaced. Challenges and issues regarding the concept facility space and layout are identified, and solutions are brainstormed to organize the workplace, optimize layout, and standardize work. The involvement of the user group in the design for maintenance and repair, and in brainstorming solutions related to laboratory layout and space, increases standardization and ensures less design rework.

Similarly, at the onset of the design phase, the A&E consultant and the Design Team meet with the user group to assess the work and information flow through the proposed facility. Each process is defined and every process step is categorized as value added (critical and needed to provide the forensic service), non-value added (not critical or needed to provide the forensic service), or non-value added but necessary (not critical but needed to provide the forensic service, like regulatory requirements, ISO certification, etc.). The time required to complete each step is also recorded. After each process has been examined, non-value added steps are eliminated or their numbers reduced to streamline the process. This is achieved by re-engineering the process or by replacing non-value added tasks and activities with value added ones. The end result is an



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efficient process that takes less time to complete and results in improved product quality and crime laboratory staff morale[1].

The information derived from the two assessments is incorporated in the LFD concept (**Table 9**). A new LFD plan is drafted and a cost estimate for executing the plan is prepared.

A cost-benefit analysis is then performed to determine if the expected benefits resulting from the new LFD plan outweigh the incurred costs. Based on the outcome of the analysis, a decision is made to continue with the old or the new design. Ultimately, an LFD plan is developed "identifying a detailed solution that can be built within [the allocated] budget" (**NIST, 2013, page 20**).

**Table 9. LFD Design Phase Project Team Responsibilities.**

| Group | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Approves design drawings and construction specification documents |
| | Commissioning Agent | Validates facility layout and utilization |
| User Group (crime laboratory) | Laboratory Director | Approves design drawings and construction specification documents |
| | Technical Manager | Participates in facility design sessions/facility design decision making |
| | Project Committee | Participate in facility design (maintenance and repair) sessions |
| | Contracting Agent | Procures external forensic resource services (if needed) |
| Design Team | Forensic Consultant | Leads facility design sessions to develop facility design drawings |
| | LFD Design Committee | Integrate Lean concepts and principles in facility design drawings |
| Construction Team | A&E Consultant | Translates drawings to construction documents, creates BIM* model |
| | General Contractor | Does not usually participate |
| Relocation Team | Move Captain | Not designated yet |
| | Moving Contractor | Not contracted yet |

Note: BIM refers to Building Information Model (see Glossary).

1 Employee and management morale are critical to the operation of a (forensic) facility and dictate the quality and timeliness of the product delivered. It encompasses more than "contentment" as it includes things like "being valued" and "being heard". Studies, like the ones referenced, have shown (Tumarkin, 2014) that while employee morale is a lagging indicator for management ability, it is a leading indicator for such things as process improvement, customer loyalty, and operation performance.



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## LFD DESIGN REVIEW

The project team, including design team members and consultants, reviews the LFD drawings included in the plan to ensure the design is complete, accurate, and addresses the crime laboratory's future-state needs and requirements. If necessary, changes are made and modifications incorporated. After project team approval is obtained, facility design drawings are submitted to project stakeholders for review and comment. Requested changes are incorporated, and updated design drawings are re-examined by the project stakeholders until approval consensus is reached.

## LFD FINAL REVIEW

Following the review of Lean facility design drawings, the A&E consultant and his/her team of subject matter experts take the updated Lean facility design drawings and translate them into construction documents that contractors can use to bid and ultimately construct the facility. The construction documents include both specifications that define material quality and drawings that define the physical placement of materials. "Site plans are finalized and project detail drawings are prepared. A final cost estimate is provided with the drawings". The laboratory director and/or technical manager reviews and approves the construction documents or requests corrections to ensure the facility fits the project delivery method and allocated resources (**NIST, 2013, pages 5, 22**).

"The A&E team uses the completed construction drawing to finalize construction specifications for all materials", and then prepares documents and creates a Building Information Model (BIM) for bidding construction of the Lean facility (**NIST, 2013, page 22**). BIMs provide a shared knowledge resource for information about a facility and its physical and functional characteristics. As such, BIMs enable virtual information about the facility to be handed from the design team to the general contractor and subcontractors, and vice versa. Companies interested in contracting construction of the Lean forensic facility can access and utilize the information to prepare a bid and/or use the information to convey how the proposed project can reduce uncertainty, avoid conflicts, and accelerate project delivery.

Subcontractors can use the information presented to show digital mockups of products that can be demonstrated in virtual rooms and can be tested by the design team for functionality or design. After a mock up room is correctly sized and operations are tested, detail can be added as a response to the simulations. Engineers, equipment planners, and interior designers can participate at key points to offer solutions and to understand the impact of the future state on their contributions to the design. Finally, subcontractors can use the information presented in the BIM to show how their product interacts or can be integrated with other products or systems in the facility.

Once the construction specifications have been finalized and the BIM model has been developed, project stakeholders review and approve the items or request changes to each, "as necessary to match the project's intent and to fit within resources". Once the facility designs have been approved, the construction phase of the Lean facility begins (**Appendix E**) (**NIST, 2013, page 22**).



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## Commit to Build

The project team reaches agreement on a commitment to build and determines the general management strategy for construction (**Table 10**). The project team appoints the technical manager to serve as the point of contact for the general contractor, and assigns the A&E team to respond to the "general contractor's questions, change orders, and design intent." They also identify the roles of the user group and the commissioning agent. Typically, the user group assists the technical manager and the A&E team in reviewing documents and change orders submitted by the general contractor, while the commissioning agent supports the technical manager and A&E team in inspecting, testing, and adjusting installed building systems and equipment. The agent reports the findings in a report to document that all are operating as proposed or to request corrections that will meet intended design criteria (**NIST, 2013, page 25**).

"The technical manager [then] ensures [the] availability of funding required for construction, [and the] contracting agent assists in the identification of processes and deadlines for committing funds to the project." Depending on the delivery method selected, the bidding process can be complex. The process for Design-Bid-Build includes solicitation, a pre-bid conference, document issuance, Request for Information (RFI) response addenda issuance, and bid opening (**NIST, 2013, page 28**). Finally, the user group assists the contracting agent with RFIs and addenda, and the project team establishes criteria for evaluation of the bids, including performance bonds and past performance qualifications to

**Table 10. LFD Construction Phase Project Team Responsibilities.**

| Group | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Approve change orders, accepts new facility |
| | Commissioning Agent | Inspects, tests, and adjusts installed building systems and equipment; issues Certificate of Occupancy |
| User Group (crime laboratory) | Laboratory Director | Designates move captain, develops move plan, approves change orders |
| | Technical Manager | Develop move plan, approves change orders, conducts final inspection, formally accepts facility |
| | Project Committee | Reviews contractor-submitted documents and change order requests |
| | Contracting Agent | Procures facility construction and crime laboratory relocation services |
| Design Team | Forensic Consultant | Approves change orders |
| | LFD Design Committee | Review change order requests |
| Construction Team | A&E Consultant | Approves change order requests, approves punch list completion |
| | General Contractor | Constructs facility, requests change orders, prepares punch list, completes punch list items, requests final inspection |
| Relocation Team | Move Captain | Prepares Integrated Master Schedule, identifies moving services needed |
| | Moving Contractor | Prepares bid, signs moving contract |



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"mitigate the risk that the low bidder cannot adequately perform the work" (**NIST, 2013, page 28**). Once the bids have been certified (i.e., the bidder is determined to be properly licensed and has provided all required bid documentation), bids are evaluated with regard to technical merit and price. Based on "best value" identification, the lowest responsive bidder is selected. The results are made public and a notice of award is issued. The technical manager ensures all appropriate signers of the contract are identified and the construction contract is signed (**NIST, 2013, page 28**).

## LFD CONSTRUCTION CHANGES

When different site conditions are encountered during the construction process than those communicated by the project team (**Table 11**), the contractor prepares a notice of change to document the obstacle(s) encountered. The notice initiates the study of the unanticipated conditions to allow alternative construction methods to be evaluated. The design team and the A&E team review the alternative construction methods identified by the contractor and conduct an assessment of their impact on the application and integration of Lean principles and concepts in the construction of the facility.

**Table 11. LFD Relocation Phase Project Team Responsibilities.**

| Group | Role | Activities |
|---|---|---|
| Property Owner | Project Manager | Does not participate |
| | Commissioning Agent | Does not participate |
| User Group (crime laboratory) | Laboratory Director | Designates crime laboratory move captain, reviews facility design quality indicator data, tracks and monitors key performance indicator data |
| | Technical Manager | Reviews facility design quality indicator data, participates in LFPE* |
| | Project Committee | Schedule pick-up of moving boxes and crates, participate in LFPE |
| | Contracting Agent | Contacts vendors to re-install equipment (if needed), track warranties |
| Design Team | Forensic Consultant | Reviews DQI and LFPE data/information |
| | LFD Design Committee | Participate in LFPE/DQI surveys, review LFPE/DQI outcomes |
| Construction Team | A&E Consultant | Conducts LFPE |
| | General Contractor | Delivers O&M manuals, executes building construction warranties |
| Relocation Team | Move Captain | Oversees laboratory move to new forensic facility |
| | Moving Contractor | Moves laboratory content, calibrates instruments, test functionality |

Note: LFPE refers to Lean Facility Design Evaluation (see next paragraph).



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The technical manager and owner (or owner representative) review and evaluate the merit of the change order. If they determine that the referenced work is outside the scope of the original contract, and the change can be mitigated to include Lean techniques, a change order is appropriated to document an increase in construction cost associated with additional time or material modifications necessitated by the conditions and approved change. If acceptable to the contractor, the project team (owner/ owner representative, technical manager, design team consultant, and A&E team leader) and the contractor approve and sign the change order.

## MOVE LOGISTICS

During the building construction phase, the laboratory director, technical manager, and user group meet to develop a moving plan (**Appendix F**). The plan identifies all relative tasks and activities, the order in which they must be accomplished, and the party responsible for each task. It also designates a move captain to coordinate the inventory of forensic instrumentation, make decisions about what to move, what to dispose of, how to install and deploy instrumentation at the new facility, and how to streamline the move utilizing a Radio Frequency Identification (RFID) or other tracking system (**NIST, 2013, pages 44-47**).

The move captain prepares an Integrated Master Schedule to ensure maximum uptime at the old and new facilities, and attends all construction meetings to inform the project team of any construction changes and subsequent changes in the move schedule. Finally, the move captain communicates to crime laboratory staff relocation to the new facility and requests the decluttering of both personal and workplace areas by removing all outdated supplies, books, and manuals, and by identifying and labeling all obsolete and outdated equipment. The move captain then identifies the types of services required to move and/or install the items identified for relocation, understanding that extreme care must be taken in preparing and transporting scientific instruments and valuable samples. The contracting agent then determines the type of contracts to be used and the bidding processes to be followed **(NIST, 2013, pages 44-47**).

"Qualified bidders are invited to prepare bids for the move of the forensic science laboratory" and the installation of associated laboratory instrumentation. The bidding process includes multiple steps requiring the technical manager/ move captain's participation, including solicitation, document issuance, a bid conference, question responses, and bid award. The user group is available to the contracting officer to assist with questions and addenda. Once the successful bidder is identified and selected, the contract is awarded. The contracting officer or technical manager signs the contract, and the user group ensures the contract is executed (**NIST, 2013, page 35**).

Also, at scheduled completion points during the construction phase, the technical manager arranges for service of the installed equipment and completed systems. The commissioning team (composed of the commissioning agent, user group, contractor, technical manager, and personnel responsible for building operation and maintenance) tests the building systems to confirm that all systems and equipment are properly installed and function as intended. The team also ensures that all building systems are


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accessible and can be maintained and repaired without causing delays in facility operation. The commissioning team findings and assessments are documented and provide input for final acceptance of the facility.

At the point of "substantial completion," the contractor requests a pre-final inspection and submits to the A&E team a comprehensive list of items still to be completed or corrected. The A&E team reviews the "punch list" and inspects the facility to determine if the work is substantially complete. The A&E team lead then determines the date of substantial completion and issues a certificate of substantial completion. When the punch list is completed, the contractor requests a final inspection.

The technical manager, general contractor representatives, and members of the user group conduct a final inspection. A determination is made that all items listed on the punch list have been resolved and that the work has been completed to the laboratory's satisfaction. The owner representative and the technical manager formally accept the facility from the contractor, and a local government official issues a certificate of occupancy. The facility is then ready for move-in.

## FACILITY OCCUPANCY

The move contractor moves boxes, equipment, and other laboratory material into the facility following the detailed project plan. A decision is made by the user group to have instrument vendors re-install and calibrate the relocated equipment or to have laboratory staff perform the work. In both cases, prior to commencing casework, laboratory staff perform instrument and equipment verification tests to ensure all are functioning as expected. The user group then schedules pick-up of the moving boxes and crates, and establishes maintenance procedures for all newly purchased instruments and equipment. The contractors (and vendors) deliver operations and maintenance (O&M) manuals (**Table 11**).

## LEAN FACILITY DESIGN EVALUATION

Following the transition to the new forensic facility, a number of measurements are taken and an evaluation is performed to determine if and how well the Lean facility meets the needs of the current-state facility and supports the requirements of the future-state crime laboratory. The Laboratory Director and Design Team select a set of Key Performance Indicators (KPIs) to monitor the accomplishments of the new facility and to monitor progress towards pre-established goals (e.g., turn-around-times of 30 days). The Laboratory Director implements the KPIs selected at the existing facility to serve as a baseline benchmark and tracks their performance on a periodic basis starting with the current state at the existing facility and (after the move) extending into the future-state at the new crime laboratory. The KPIs measure the effectiveness of crime laboratory operations, the efficiency of the processes used, the quality of the service provided, the timeliness of the work performed, and the productivity of the



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forensic scientists doing the work. In comparing the measurements to pre-established standards, the results provide answers to the following questions:

- Are we doing the right things?
- Are we doing things correctly?
- Are we giving the customer what was asked for?
- Are we delivering the product on-time?
- Are we generating enough goods or services?

To determine how well LFD meets and supports the requirements of the future-state crime laboratory, the A&E consultant in collaboration with the LFD Design Committee conducts a Lean Facility Performance Evaluation (LFPE). Using questionnaires, interviews, workshops, site visits and observations, Lean facility performance data are gathered by a team of data analysts not directly involved in the Lean building construction process. The data collected are analyzed and interpreted by members of the Project Committee to assess how well the facility is operating, in terms of resources, efficiency, effectiveness and impacts, and to identify opportunities for improvement. The Design Team reviews the findings to identify opportunities for making process and facility improvements. The data gathered during the LFPE and the outcome of the data analysis and interpretation are then shared with the Forensic and A&E consultant to feed information back into the design process so as to improve LFD effectiveness and service delivery.

## PROJECT SUMMARY AND CONCLUSION

In this project, we developed a crime laboratory design model that provides better communication between the designer, builder, and user of the forensic facility; facilitates the planning, design and construction of forensic facilities build to achieve operational excellence both now and in the future; and allows for assessment of the Lean Facility Design impact on crime laboratory construction, and crime laboratory operation process improvements. The Lean Facility Design model is based on the Lean principles of respect for the opinion of others; the elimination of non-value added facility planning, design, construction and relocation activities; and the optimization of the efficiency of all value-added work.

We also developed a comprehensive set of checklists and guidelines to integrate Lean concepts and principles into the traditional approach to building 21st century forensic facilities as described in the NIST White Book. The checklists and guidelines were converted into a roadmap to facilitate easy implementation and use of the Lean Facility Design process. The roadmap covers all activities involved in the Lean Forensic Facility building process starting with the formation of the Lean Facility Design project team and ending with the relocation of the crime laboratory to the new Lean forensic facility.

By integrating Lean in the construction of new, and the renovation of existing, forensic facilities, the focus of crime laboratory improvement initiatives to achieve operational excellence shifts from individual tests and activities to the flow of samples, data, and information through the entire laboratory. This shift allows the crime laboratory director to set performance metrics at the outset of the new facility or facility renovation planning process. In so doing, the crime laboratory director can ensure that the new or renovated facility is capable of meeting the needs of the crime laboratory not just at the time of construction or renovation but also as it grows and evolves.



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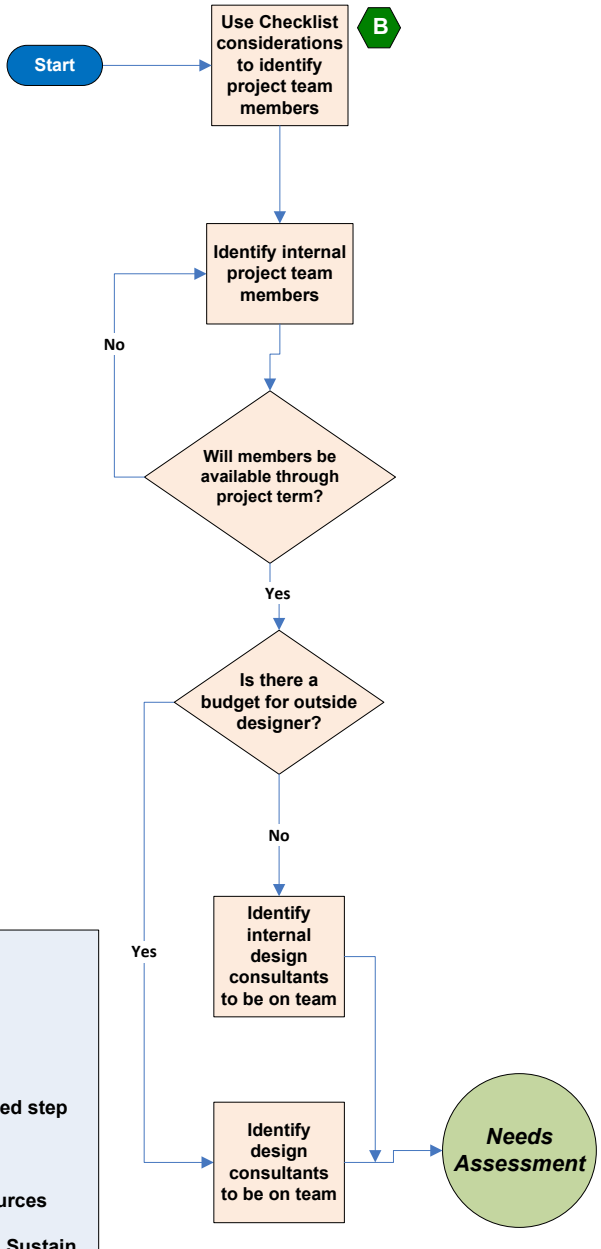
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development

## Team Identification

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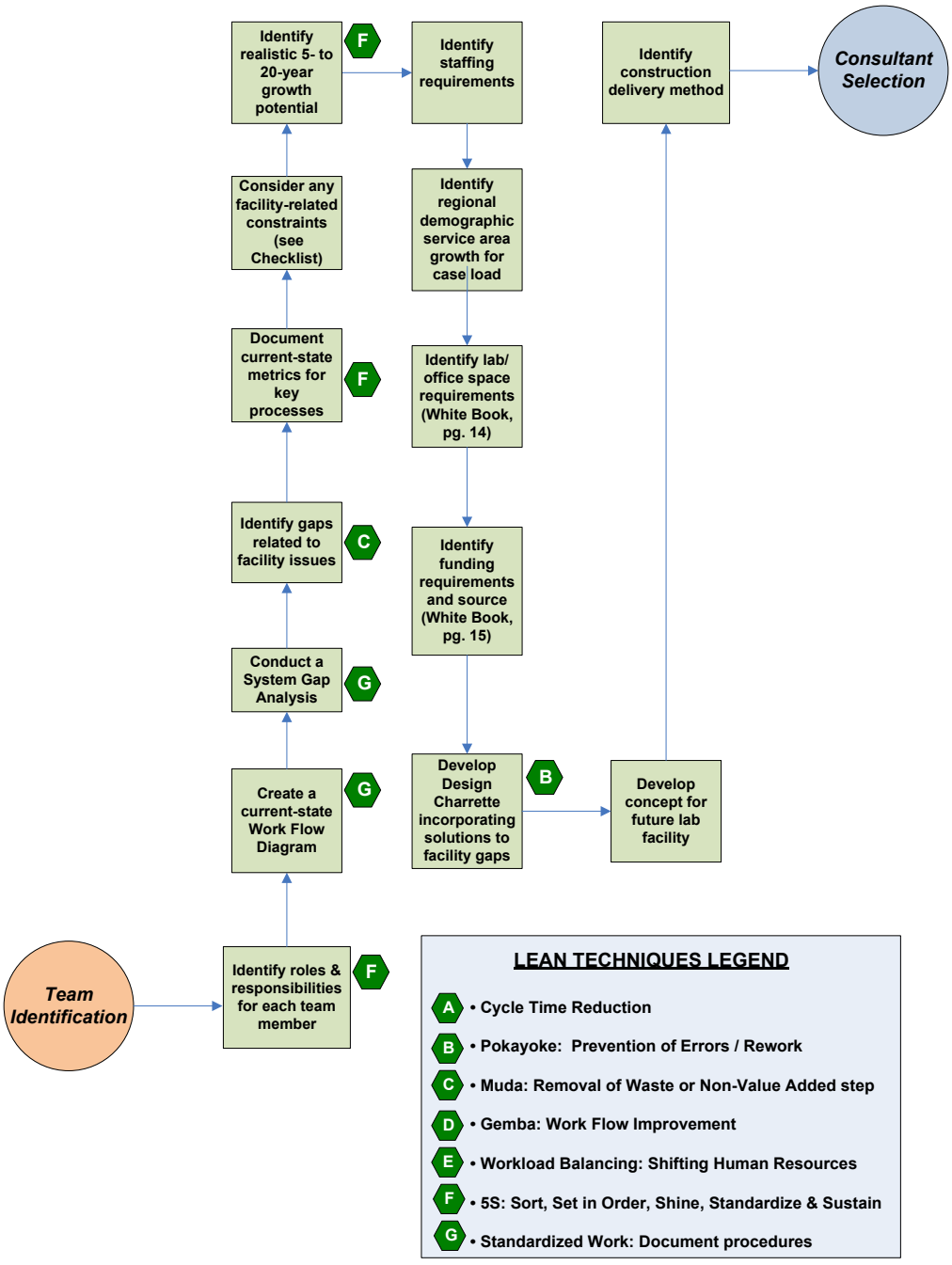
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Needs Assessment

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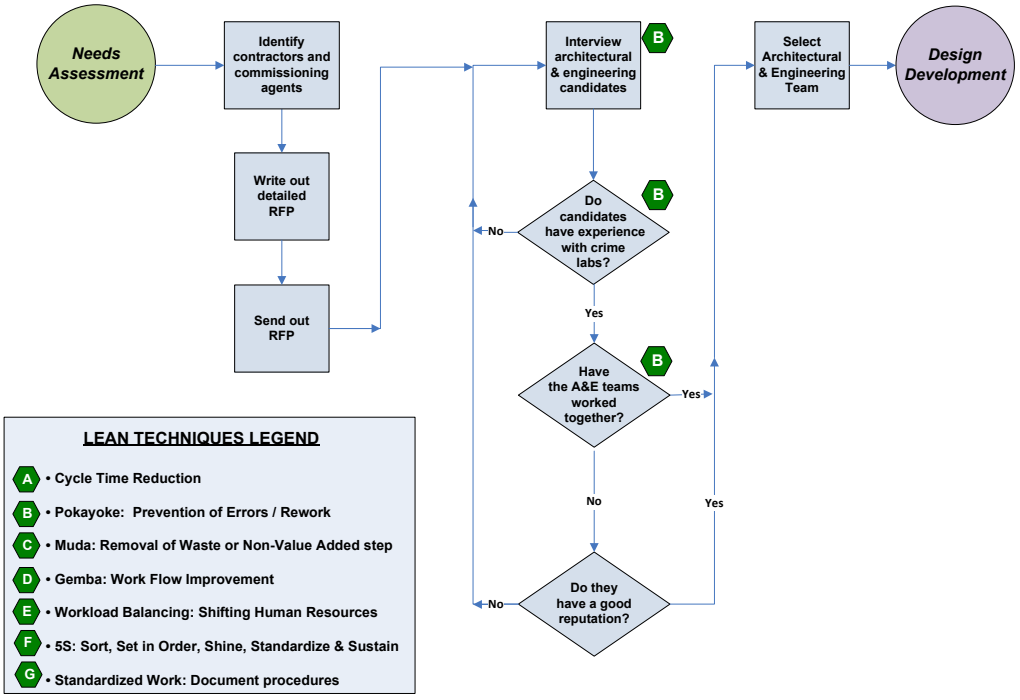
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Consultant Selection

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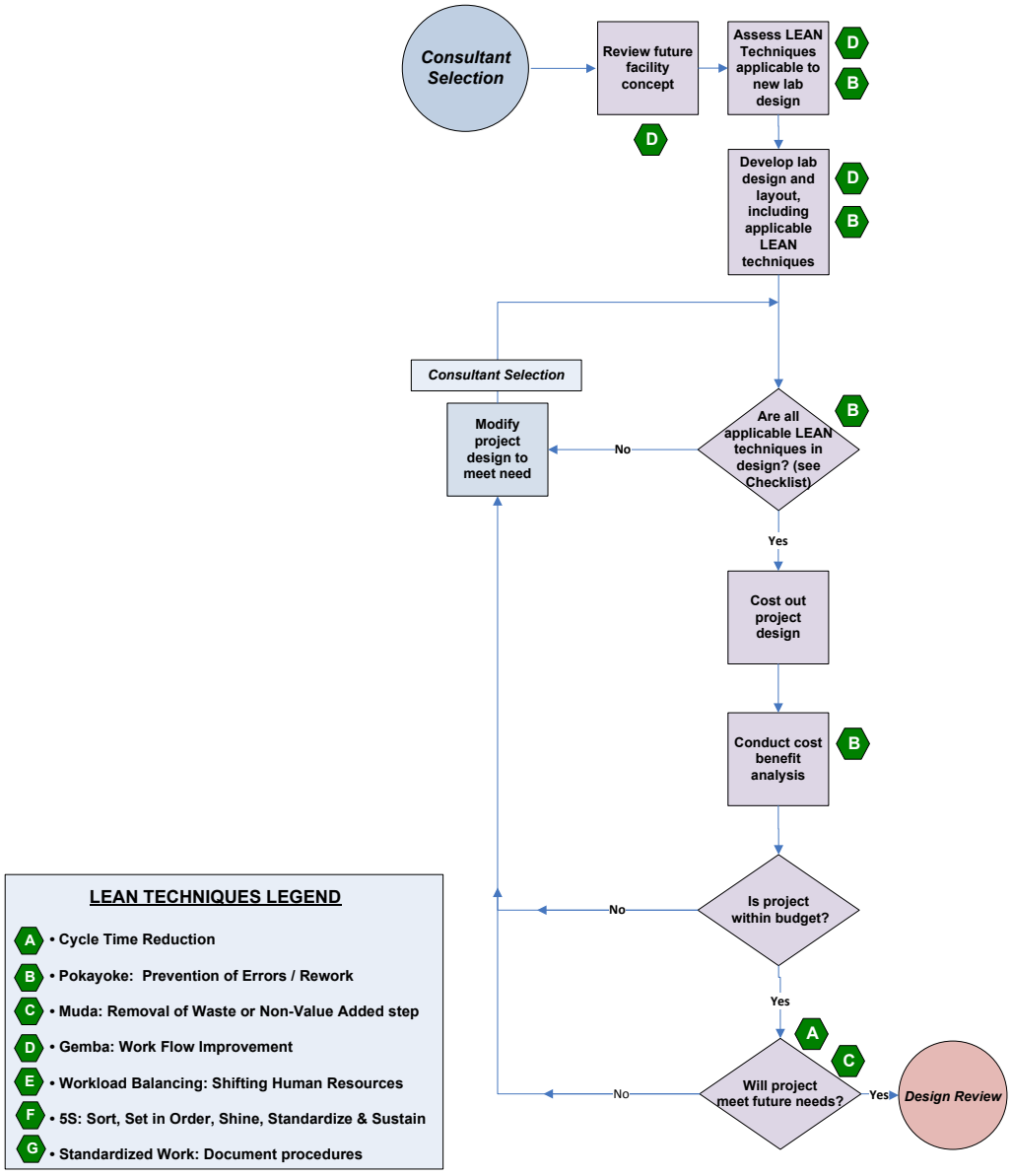
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Design Development

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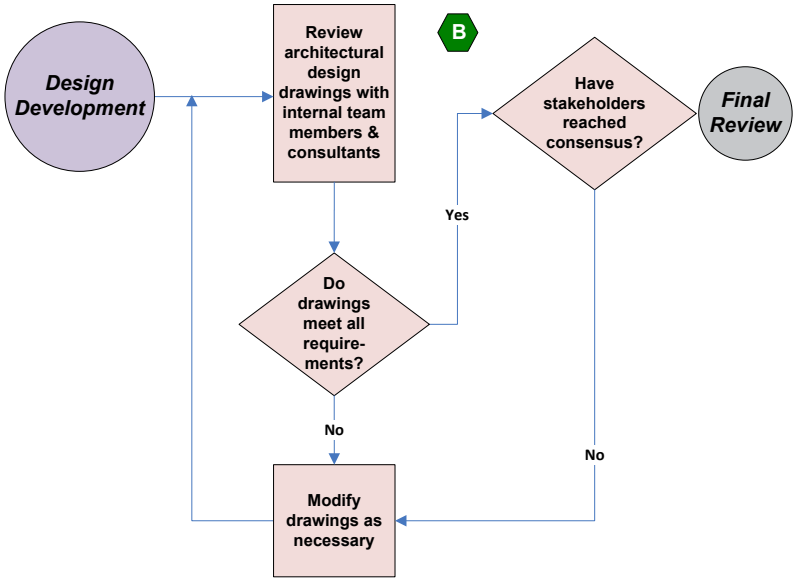
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Design Review




**LEAN TECHNIQUES LEGEND**

- A • Cycle Time Reduction
- B • Pokayoke: Prevention of Errors / Rework
- C • Muda: Removal of Waste or Non-Value Added step
- D • Gemba: Work Flow Improvement
- E • Workload Balancing: Shifting Human Resources
- F • 5S: Sort, Set in Order, Shine, Standardize & Sustain
- G • Standardized Work: Document procedures

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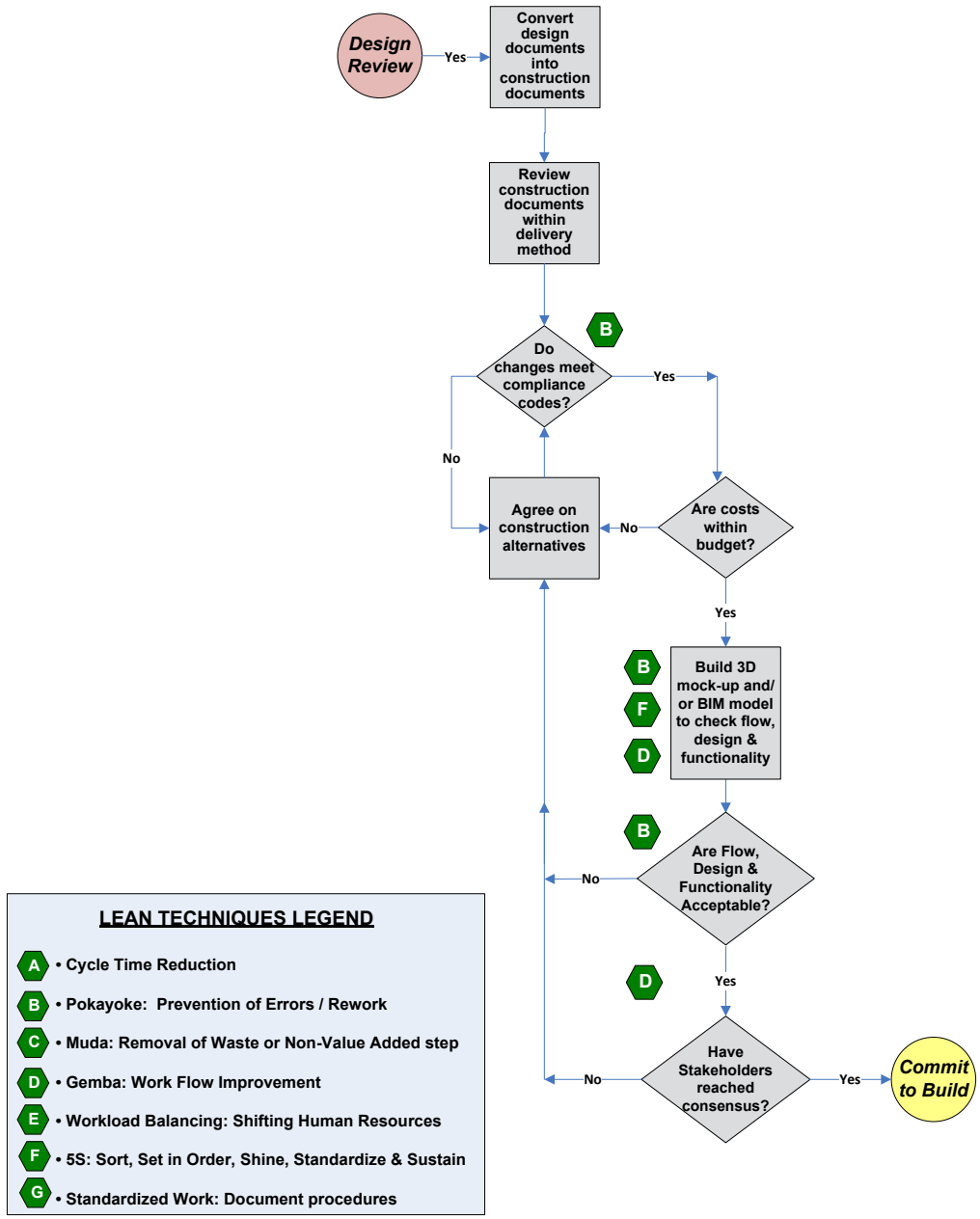
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Final Review

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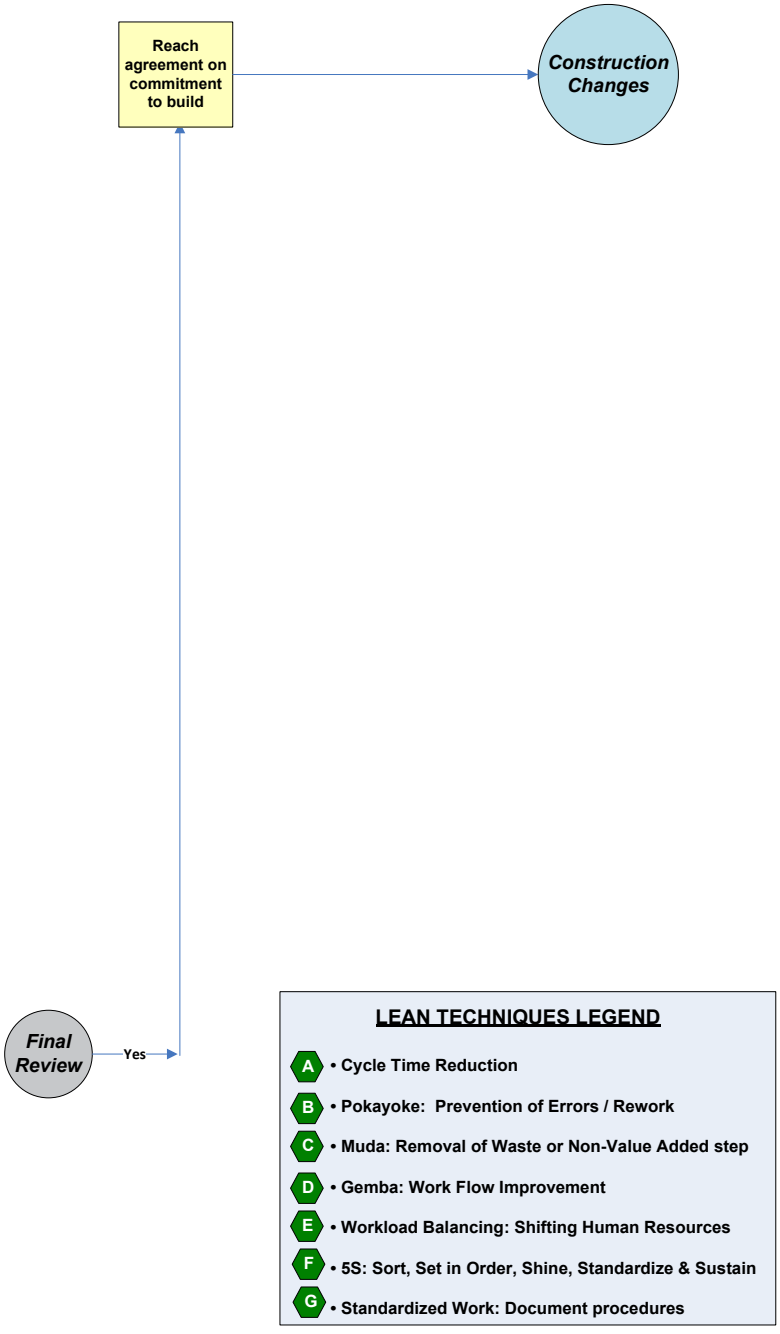
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Commitment to Build

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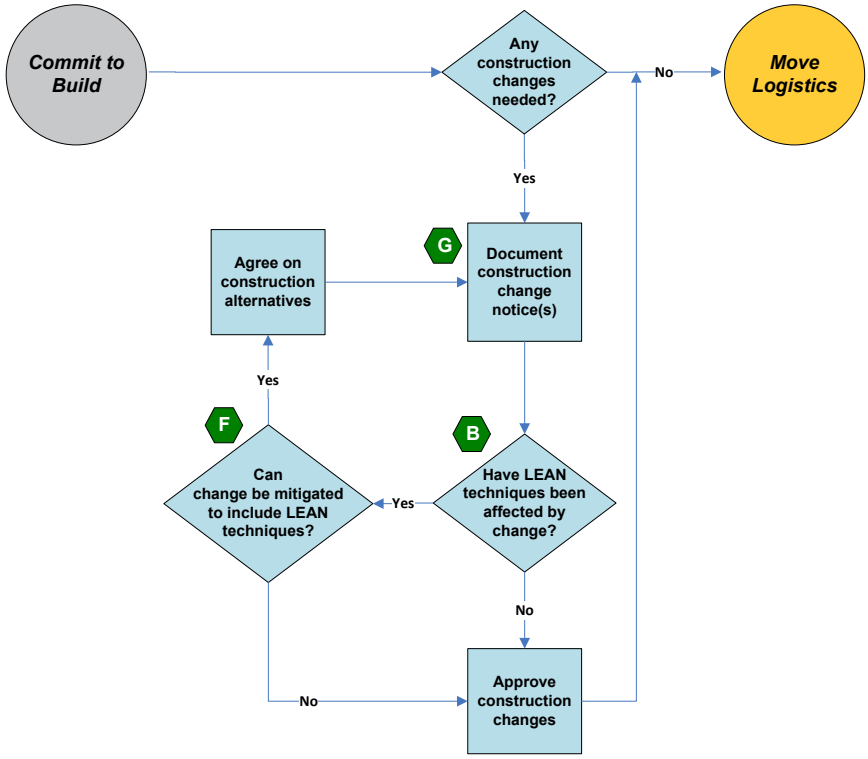
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Construction Changes




**LEAN TECHNIQUES LEGEND**

- A • Cycle Time Reduction
- B • Pokayoke: Prevention of Errors / Rework
- C • Muda: Removal of Waste or Non-Value Added step
- D • Gemba: Work Flow Improvement
- E • Workload Balancing: Shifting Human Resources
- F • 5S: Sort, Set in Order, Shine, Standardize & Sustain
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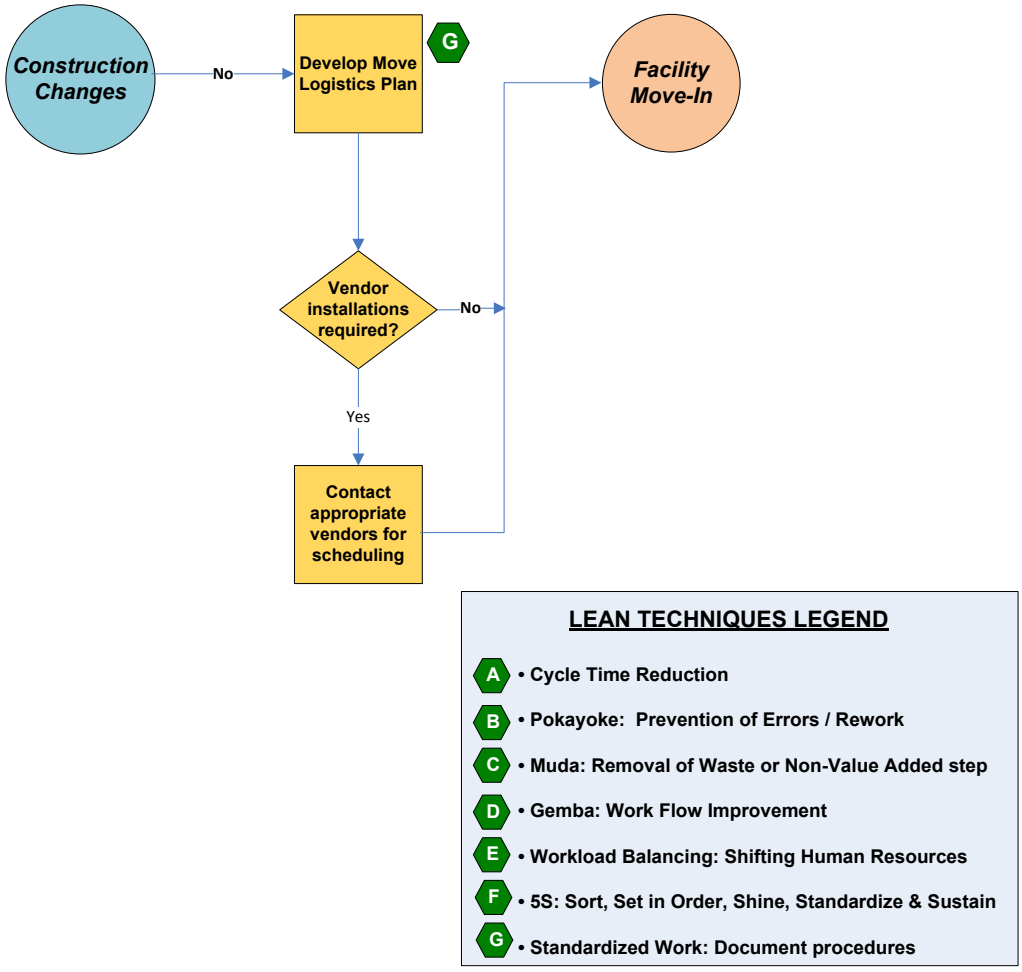
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Move Logistics

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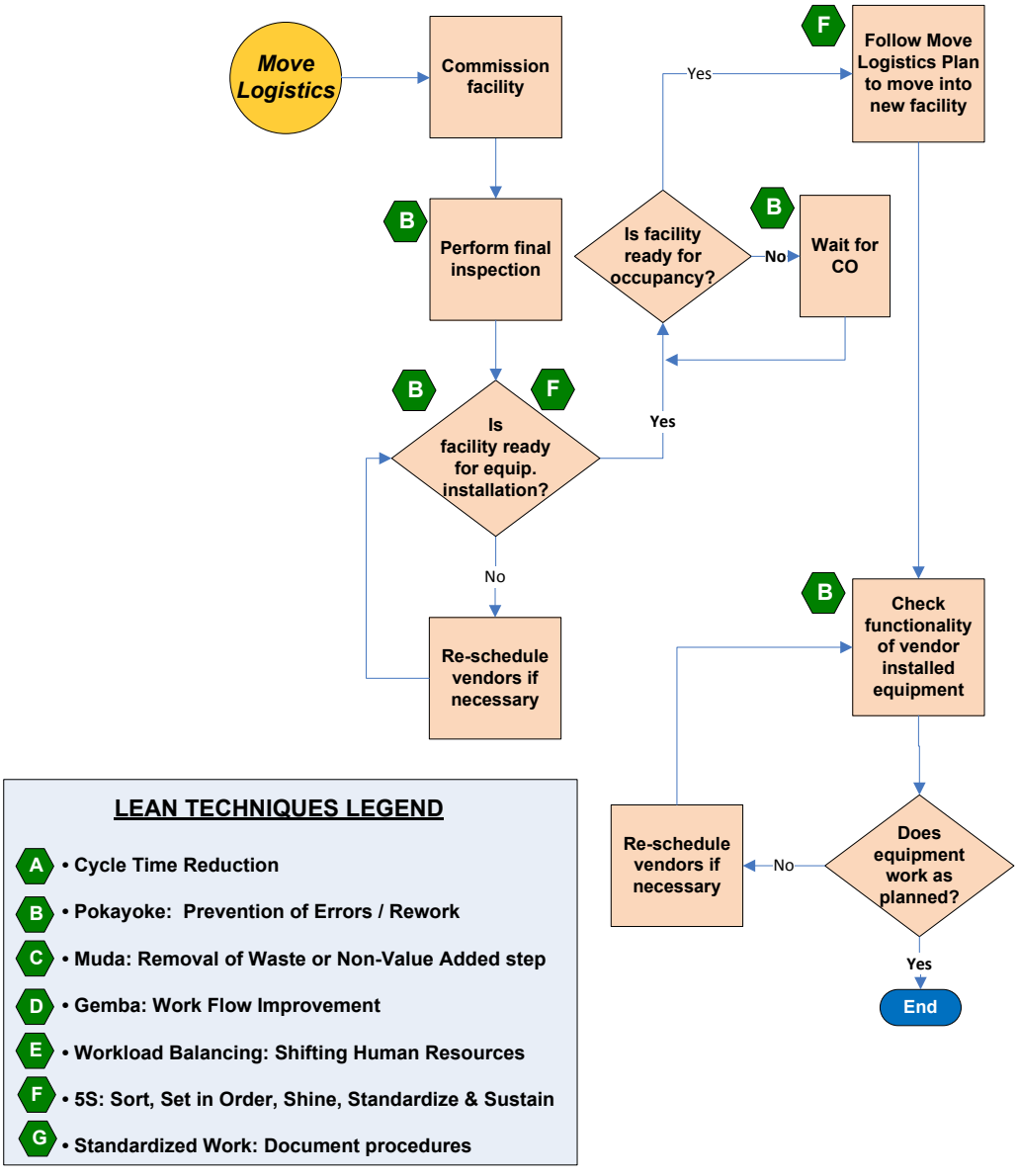
# APPENDIX A: Lean Facility Design Process Map Showing Team Identification through Design Development *(continued)*

## Facility Move-in

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# APPENDIX B: LFD Roadmap Planning Checklist

Key activities that must be completed as part of the LFD Planning Phase.

- ❑ Identify LFD Project Team Stakeholders
- ❑ Discuss New Forensic Facility Concept
- ❑ Conduct Self-Evaluation
- ❑ Appoint Technical Manager
- ❑ Assemble Project Committee
- ❑ Identify Resource Capability Needs
- ❑ Develop Baseline Project Budget, Scope and Schedule
- ❑ Appoint Contracting Agent
- ❑ Acquire Consultant Funding
- ❑ Define and Issue Consultant SOW and RFP
- ❑ Select and Contract Consultant
- ❑ Select LFD Sub-Design Team Members
- ❑ Assemble Project Design Team
- ❑ Identify Team Member Roles and Responsibilities
- ❑ Conceptualize Project Management Plan
- ❑ Provide LFD Training
- ❑ Identify Design Quality Indicators



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# APPENDIX C: LFD Roadmap Needs Assessment Checklist

Key activities that must be completed as part of the LFD Needs Assessment.

- ❑ Assess In-House Information Gathering Skills
- ❑ Conduct Facility Customer Survey(s)
- ❑ Interview Crime Laboratory Staff
- ❑ Map Key Crime Laboratory Workflow Process(es)
- ❑ Assess Current-State Crime Laboratory Environment
- ❑ Obtain Regional Demographic Service Area Projections
- ❑ Determine Forensic Case Load Growth
- ❑ Determine Required Forensic Staffing Levels
- ❑ Determine Facility Workspace Needs
- ❑ Determine Other Future-State Crime Laboratory Considerations
- ❑ Perform Gap Analysis
- ❑ Identify Lean Facility Requirements
- ❑ Conduct Design Charrette
- ❑ Draft Lean Facility Concept
- ❑ Perform Value-Stream Engineering
- ❑ Develop Lean Facility Concept
- ❑ Identify Lean Facility Construction Delivery Method



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# APPENDIX D: LFD Roadmap Design Phase Checklist

Key activities that must be completed as part of the LFD Facility Design Phase.

- ❑ Review Design Program
- ❑ Assess Concept Facility Layout and Space
- ❑ Identify Concept Facility Layout/Space Issues and Challenges
- ❑ Brainstorm Solutions
- ❑ Assess Concept Facility Work/Information Flow
- ❑ Value Engineer/Streamline Process(es)
- ❑ Draft New Lean Facility Design Plan
- ❑ Prepare Cost Estimate
- ❑ Conduct Cost-Benefit Analysis
- ❑ Develop Lean Facility Design Plan
- ❑ Review Lean Facility Design Drawings
- ❑ Make Changes / Incorporate Modifications
- ❑ Approve Lean Facility Design Drawings
- ❑ Translate Drawings into Construction Documents
- ❑ Review/Approve Construction Documents
- ❑ Create Building Information Model
- ❑ Commit to Build



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# APPENDIX E: LFD Roadmap Construction Phase Checklist

Key activities that must be completed as part of the LFD Facility Construction Phase.

- ❑ Develop Construction Management Strategy
- ❑ Identify Project Team Roles and Responsibilities
- ❑ Commit Construction Funding
- ❑ Initiate Construction Bidding Process
- ❑ Establish Bid Evaluation Criteria
- ❑ Issue Request for Construction Bid Proposals
- ❑ Evaluate Construction Bids
- ❑ Select and Identify Successful Construction Bidder(s)
- ❑ Award Construction Contract
- ❑ Inspect/Assess Site Conditions
- ❑ Prepare Change Notice
- ❑ Evaluate Alternative Construction Method(s)
- ❑ Assess Impact on Lean Process
- ❑ Assess Change Order Merit
- ❑ Approve Change Order
- ❑ Execute Construction Changes



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# APPENDIX F: LFD Roadmap Relocation Phase Checklist

Key activities that must be completed as part of the LFD Facility Relocation Phase.

- ❑ Develop Facility Move Plan
- ❑ Designate Move Captain
- ❑ Prepare Equipment Inventory
- ❑ Implement Tracking System/Tool
- ❑ Prepare Integrated Master Schedule
- ❑ Identify Contracted Move Service Requirements
- ❑ Acquire Contracted Services
- ❑ Coordinate Move Responsibilities
- ❑ Pack Materials/Equipment/Instrumentation
- ❑ Test New Facility Building Systems
- ❑ Document Findings and Assessments
- ❑ Review Punch List
- ❑ Conduct Final Inspection
- ❑ Issue Certificate of Occupancy
- ❑ Move Staff/Equipment into New Facility
- ❑ Calibrate/Validate Equipment in New Location
- ❑ Test Functionality
- ❑ Obtain New Equipment/Instrumentation O&M Manuals
- ❑ Assess Facility Design Quality Indicators



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