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ECONOMIC RESULT OF LEARNING LESSONS

E. William East
(Principal Investigator, U. S. Army Construction Engineering Research Laboratory, Champaign, IL USA)

Jeffrey G. Kirby
(Principal Investigator, U. S. Army Construction Engineering Research Laboratory, Champaign, IL USA)

ABSTRACT
Learning Corporate lessons occur when employees recognize better ways of accomplishing work. Ideally these lessons can be reused by not only the original developer of the lesson but also other persons involved in future projects. Unfortunately these lessons cannot be easily shared outside the immediate project team. The U.S. Army Construction Engineering Research Laboratory has developed the Corporate Lessons Learned (CLL) architecture for the distributed capturing, storing, and sharing of corporate lessons. The first phase of this system development, which addresses design quality lessons learned, has been fielded and there is enough experience to begin estimating the benefits derived from its usage. A recently completed economic analysis shows a payback of $120 for every dollar spent to document and approve a lesson learned. Sharing of an initial set of lessons captured at one Corps office has the potential to save all Corps offices $53 Million during the first seven years of operation of this system.

KEYWORDS (Lessons Learned, Collaboration, Learning, Process Improvement)

1. INTRODUCTION

A review of the U.S. Army Corps of Engineers' guidance documents and command memoranda reveals that sharing lessons learned is an essential management objective of virtually all Corps' business areas. While significant management emphasis has been given to lessons learned, the tools needed to support lessons learned capture, review, and sharing were not available. Many other references also recognize the need to capture lessons learned and share knowledge across the project development team (Sandia National Labs 1999), (Kurihara, T.Y., and Kaetzel, L.J.,1997). Many have attempted to build stand-alone lessons learned applications such the Department of Energy (DOE, 1997) or develop means to capture knowledge of departing key personnel (Epstein, W.C. 1995). Typically, attempts to centralize lessons learned to date have not been successful since users are unable or unwilling to access central "knowledge stores". Previous attempts to develop distributed systems have resulted in system designs that lack long-term sustainability. Stand-alone databases are also difficult to locate and access by those that are geographically remote and/or by those that participate in a different business process.

Within any existing business process there are many opportunities for the capture of lessons learned. At a minimum, these opportunities occur wherever employees must resolve the results of repetitive deficiencies. Two examples of these opportunities within the design quality arena are when design reviewers prepare design review comments on a set of design documents or when quality assurance personnel prepare construction contract change orders. In both of these situations, employees should be able to "flag" problems for consideration beyond the scope of the current project. Currently, these opportunities to capture lessons learned are lost since no means exists to capture those issues within the existing legacy software systems.
If lessons were captured, there are typically organizational local, regional, or national experts whose current jobs include the requirement to evaluate requests for changes to technical or policy guidance. Since "field" lessons are rarely submitted to these personnel for review, guidance they develop is often based only those issues that are "local" to the evaluator. This "narrow" guidance is then released to all potential interested parties.

Currently, some offices have stand-alone lessons learned databases associated with specific topics or specific technical subjects. These systems are primarily operated by local champions and have not been fully integrated into the business processes that produced the data. As a result, a majority of employees rarely have the opportunity to utilize the corporate knowledge that has been gathered. Unless there is an easy-to-use method to retrieve and automatically apply lessons learned, these paper or electronic lessons will not be used. The utilization problem is more difficult if multiple offices have lessons learned databases on different topics. Even if the employee wanted to

use the data, it is unlikely that they would be able to find the locations of all relevant data sources much less be able to effectively post queries to numerous systems with various interfaces.

For those offices that have existing lessons learned databases or paper documentation, lessons learned that are no longer valid must be manually removed. If this does not occur on a timely basis, the set of lessons learned stored will always be out-of-date. Furthermore, retrieval of appropriate information from such systems may be very difficult since large amounts of out-of-date data will continue to accumulate but will rarely, if ever, be removed.

2. DESIGN OF CLL

In a large and distributed organization, such as the Corps of Engineers, similar projects are often completed by various teams composed of individuals with different historical experience levels. As a result, lessons learned by one team are often not readily nor easily available to other teams and must be re-learned at many sites. Without effective communication methods, recurring problems are inevitable. By building an effective lessons learned sharing and use mechanism into users' daily business process, such problems will virtually disappear because the correct solution to the current problem can be easily identified and applied. Allowing customers to participate in the identification and development of customer and location specific lessons will strengthen the bond between the project provider and it's customers. The initial application focus of CLL was the Design Quality Business Area. However CLL can be used with any business process and can also collect needed information vertically or horizontally across staff efforts that support line activities.

Several key initial CLL design requirements were set: (1) local capture and reuse capability should be easy to add to any existing legacy software application, (2) data transmission and communication would be via the World Wide Web, and (3) the design should be such that no or minimal corporate firewall issues would occur.

In the CLL system, the "LL Registry" is the sharing mechanism that allows employees to quickly find lessons learned repositories across a distributed organization's knowledge stores that relate to their current problem issue. The Registry is the worldwide address book that identifies the locations of all repositories on all LL topics. The design of local lessons entry (1), local lesson approval (2), and retrieval by the Registry (3) is portrayed in Figure 1 below. Note that LL topics that are of a national (organization wide) level are reviewed and retained at a national site (4). These key numeric components of CLL are displayed in Figure 1.

The CLL Registry will be designed to adapt to changes in content and scope of local and national lessons learned repositories. As new business processes or national lessons learned centers are created, the location and method for accessing these repositories will automatically be transmitted to a distributed set of CLL registries. New repositories and registries may be brought on-line without human intervention. An XML data exchange standard will be developed to allow the registries to communicate. The reliability of the distributed CLL approach is expected to be much higher than that of centralized databases and the platform has the potential to include all project stakeholders.

3. PROTOTYPE CLL DEVELOPMENT

An evolutionary strategy was selected as the development methodology. This choice was made because all requirements from other Corps business processes could not be established prior to the first software build. A broad range of existing design quality requirements were developed to allow an initial prototype build to support two Corps of Engineers business practices: the Design Review and Checking System (DrChecks) and the Corps-wide effort on the Whole Barracks Renewal Program. DrChecks successfully demonstrated the concept of CLL Modules 1 and 2 in Figure 1 (local collection, evaluation, and re-use of lessons). The Whole Barracks Renewal Program successfully demonstrated CLL Module 4 in Figure 1 (national collection of lessons from a number of Corps district offices, centralized review and approval of lessons, and wide re-use of lessons). The demonstrated prototype CLL success with these two systems caused this approach to be recognized as the best conceptual method for the Corps of Engineers to follow in developing a corporate lessons learned system.

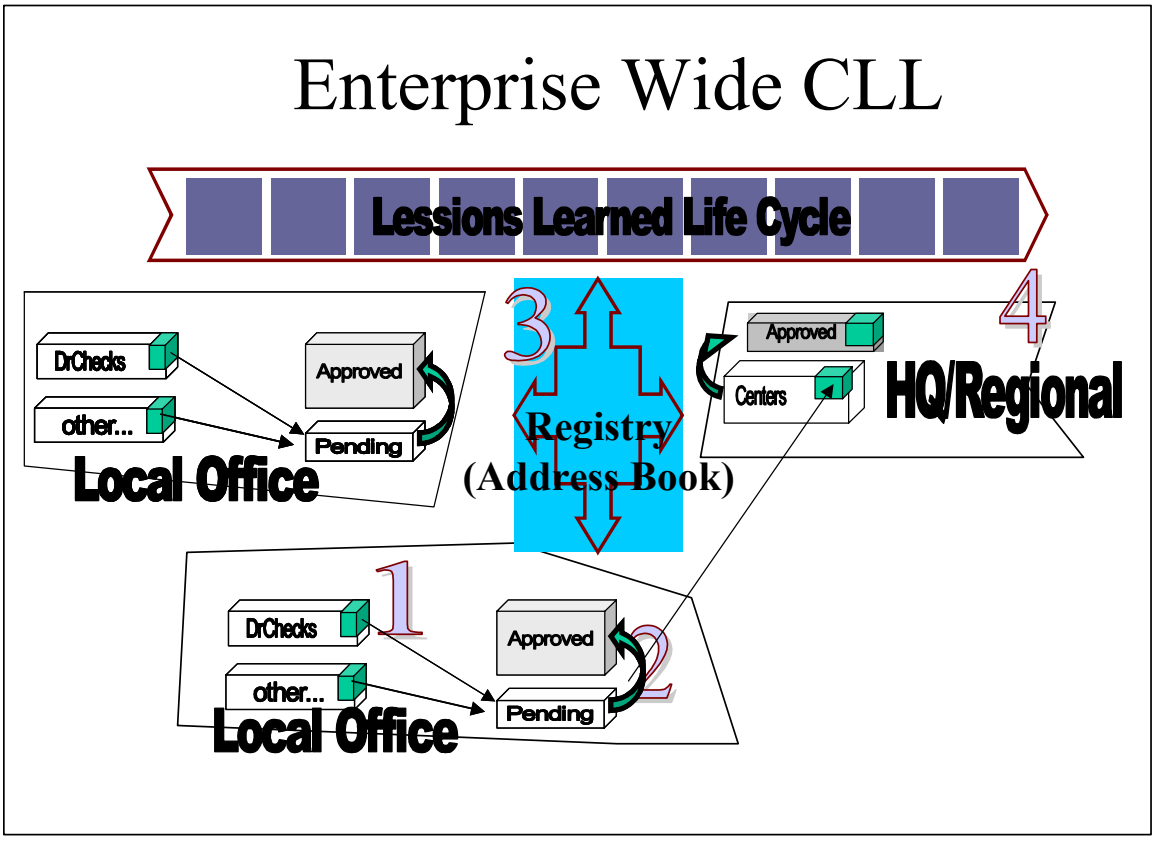

Figure 1. Corporate Lessons Learned Architecture

4. THE DESIGN REVIEW AND CHECKING SYSTEM

The Design Review and Checking System (DrChecks) provides a web-based platform for the review and feedback on project related documents. While currently oriented toward review of construction plans and specifications, DrChecks was designed to be easily updated to support review of other project related documents. DrChecks also seamlessly integrates with the Corporate Lessons Learned (CLL) system and is the first CLL compliant application.

DrChecks empowers project teams to improve design quality through an integrated web-based business process. DrChecks assists review comment authors and designers to reach agreement on the resolution of each improvement suggestion. Reports allow users to see others' work, review the progress, identify reluctant participants, and identify issues that impact scope, time, or cost. The design goal of DrChecks was to support the successful resolution of problem issues before project milestones are reached. DrChecks was developed at the Engineering Research and Development Center of the U.S. Army Corps of Engineers (East, E.W. etal, 2001).
There are three major categories of DrChecks users: reviewers, designers, and managers. Reviewers can be in-house professionals associated with the delivery of the final constructed facility, customers who will purchase and occupy the facility, or operational individuals who will maintain the facility over time. Each of these individuals typically enters comments and backchecks comment responses. Screeners can also be used for intermediate comment review prior to submission to designers for action. Designers responded to comments, and managers track progress and control program features. DrChecks stores comments by phase within a review and also stores a complete history of actions from submittal until closure. Each action during the comments life span and the individual who was involved is recorded. Numerous status reports are available. Comments from prior reviews or checklists and approved lessons learned can be retrieved and copied into current reviews. The process is diagrammed in Figure 2.

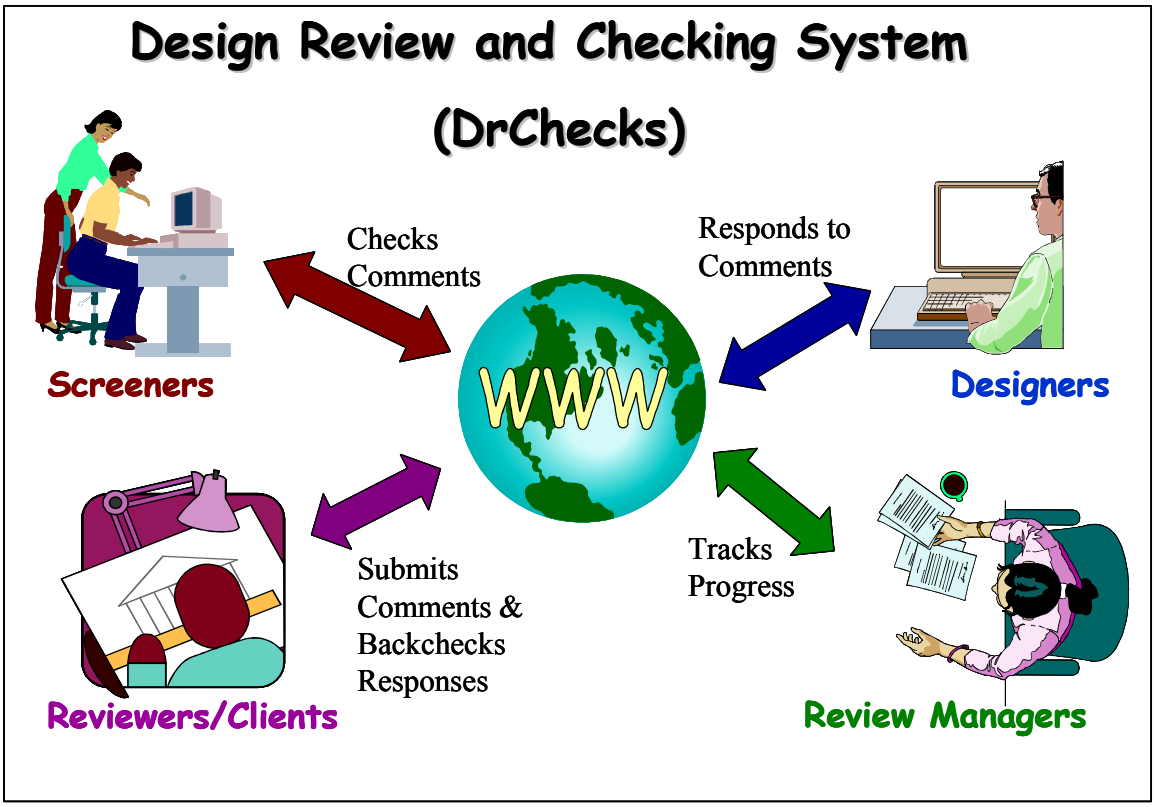

Figure 2. Design Review and Checking System (DrChecks)

5. CLL APPLICATION WITHIN DRCHECKS

Within DrChecks, the CLL Module 1 was added (Figure 1, Local Capture) which allows the capture of potential lessons during the comment add portion of the design review process. To submit a lesson learned for evaluation, the reviewer need only click a "LL" button within the "comment add" screen. The CLL module captures the comment text, project and review phase indices, and prompts the submitter for any suggested solutions. This information is then emailed to a local pre-designated subject matter expert for review. Currently, the design discipline of the comment is used as the routing criteria. The evaluator received an email that a potential lesson learned submission has been made and the submitter received a confirmatory message that the potential lesson learned has been routed for review. The same process is utilized if the potential lesson is of an organizational wide interest: in this case, the submission is routed to a "national" reviewer for evaluation. Project type is being used as the index that identifies the issue as one of a national (organization wide) interest. The lesson learned reviewer can approve, modify and approve, or reject the submission. The result of the decision is automatically emailed to the submitter. If the lesson is approved, it becomes available for retrieval by future users of the application from which it was developed and will be available to other application users via the Registry. Note that since the registry can retrieve lesson learned from distributed databases, it is not necessary (or desirable) to create and maintain a single organizational wide database for lesson learned. The CLL process of lesson learned approval is displayed in Figure 3.

Prototype testing of this CLL development project was accomplished with the deployment of DrChecks at the Corps of Engineers Districts of Seattle, Huntington, and Baltimore in fiscal year 1998. The software that was installed at these sites to test the Design Review and Checking System included the integrated lessons learned capability of CLL. Both the functionality and benefits of prototype CLL were clearly identified. While Phase 1 testing only evaluated the local creation, local approval, and local re-use of lessons, it was clear that CLL could effect a significant improvement in the design quality business process. As a result of this test and subsequent growth in the use of DrChecks with CLL, the Corps of Engineers has mandated the use of DrChecks throughout the Corps and is funding the development of the complete enterprise version of CLL. At present the Department of State, the Navy, and GSA are also utilizing CLL with DrChecks.

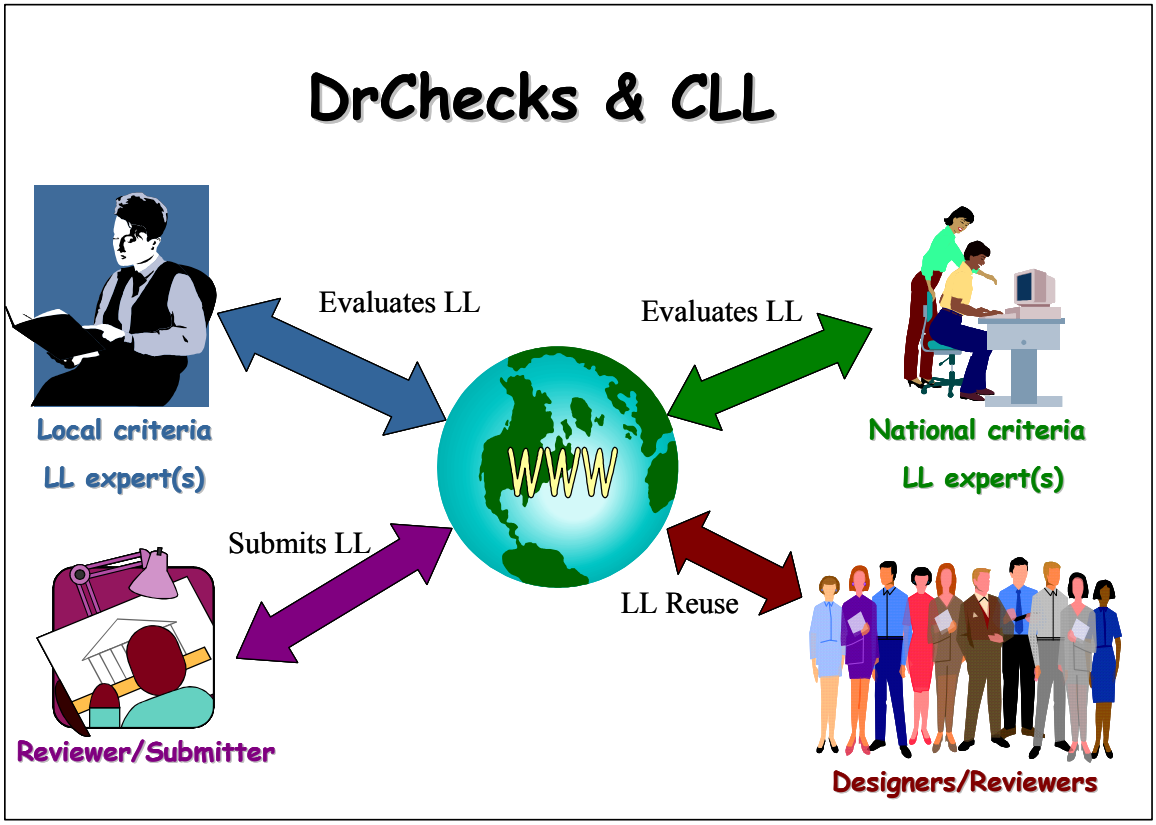

Figure 3. CLL Process and linkage to DrChecks

6. ECONOMIC RESULTS OF USING LESSONS LEARNED

The Corps of Engineers and others have been using the prototype CLL with DrChecks for over three years. To date the economic cost/benefits from lessons learned appear very positive. At present over 600 design reviews have been conducted with DrChecks and on the order of 150,000 comments have been resolved. The gate keeping process of review and approval of potential lessons learned has been very comprehensive. Across all sites, the percentage of comments that become lessons learned range from .1% to .2% with an average of .12% across all comments.

A detailed examination of all lessons learned was conducted for one DrChecks/CLL site (PERTAN Group, 2001). At the time of the study, the user had generated about 25,000 comments in DrChecks and had 29 locally approved lessons learned. Of these lessons, 21 were found to have quantifiable benefits. The remaining 8 were difficult to assign financial savings as they related to improve safety or improve quality. These were still viewed as benefits but no dollar saving value was assigned. Observed types of benefits were classified according to whether they impacted cost or time, quality or productivity. The distribution of the type of lesson was also evaluated (note some lessons impact more than one factor hence the numbers do not add to 29). These findings are displayed on Table 1.

Table 1. Observed Types of Benefits

Categories of Benefits of Lesson Learned					
Avoid Contingencies		Improve Final Product		Improve Productivity	
Avoid Claims	Avoid Delay	Improve Quality	Improve Safety	Lower Cost	Shorter Duration
20	12	18	5	2	0
Representative in % of Observed Lessons Learned					
69%	41%	62%	17%	7%	0%

Benefits (Cost Savings) From Lessons Learned

The financial impact of each lesson was evaluated by the development of a cost associated with each of the lessons. Cost estimates included in-house labor to negotiate a contract modification and the actual contract modification (labor and material) amount. The annual frequency of occurrence at the project site was also determined to identify an annual "local" cost per lesson issue. Estimated savings per lesson in the Corps district was calculated by determining if the lesson related to a specific project type or was viewed as "general" in nature. For the former, the savings per lesson was determined by multiplied by the anticipated number of similar projects per year. If the lesson was viewed as general in nature, the estimated savings per year was calculated by multiplying the percentage of project savings by the entire district program amount.

The results from the analysis of the above 29 lessons was that an estimated district wide annual saving of $672,000 per year would occur from lesson reuse. This represented 0.61% of the $110 million new construction placed by that district when the analysis was conducted (2000-2001). Since that time, the district has increased its number of approved lessons to 68 and a new version of DrChecks will allow the sharing of these lessons (and those developed by other districts) among all Corps districts. On this limited study, it was found that each LL on average reduced the developing district's construction cost by .02% per year (or $23K/LL). If this analysis is limited to only those lessons learned with quantifiable savings, the anticipated district savings was .03% ($32K/LL) per year.

Cost of a Lessons Learned Program

Cost associated with developing, implementation, and maintenance of the CLL program for this district was determined from historical records and interviews. Included within these costs were both initial cost (development) and recurring (operational) costs associated with training new users, software administration, and software licensing fees. These findings are displayed on Table 2.

Table 2. Lessons Learned Cost Distribution

Cost Element	
Nonrecurring Cost/ Initial Prototype User	**Recurring Cost/User/Yr**
Initial Software Development (Proportion of Total)	Local Site Administrator Duties
Hardware ($0 – web based)	Annual Training of New Users by Site Administrator
Software ($0 – web based)	Annual Cost of Evaluation of Lessons
Initial System Administrator Training	Annual Web Software Use Fee
Total Cost = $5800	Total Cost = $29,000

Benefit/Cost of Lessons Learned

An economic evaluation software package was used to develop a detailed life cycle analysis of the CLL program (EconoPack V2.0). Two separate analyses were performed (PERTAN Group, 2001). The first analysis conducted was of the observed experience with operations with the CLL prototype discussed above and the second analysis estimated the potential from developing the complete enterprise level CLL (fully functional Registry, and legacy CLL Module 1). The findings were very encouraging.

Prototype CLL Findings

Over the next seven years, an anticipated savings of $3M is expected at the district that developed the analyzed 29 lessons. Based upon these lessons only, the Savings to Investment Ratio (SIR) is greater than 120. The Discounted Payback period (DPP) was found to be only two (2) years A sensitivity analysis was conducted to determine the effect on the findings and it was found that if only one fourth (1/4) of these 29 lessons were reused consistently the SIR would still be greater than 25. Obviously these are very conservative estimates as this district has, since the time of the analysis, increased it's approve lessons from 29 to 68.

Enterprise Wide CLL

The analysis of development of an enterprise wide CLL with only one compliant application (DrChecks) has provided even more dramatic finding. The seven years savings after deployment with only these identified 29 lessons is estimated at $53M Corps-wide. The SIR is 140 and the DPP is also only two (2) years. These are also very conservative estimates as they do not include estimates of the benefits that will occur when other legacy (or new) software applications become CLL compliant and are able to submit and share lessons. This evaluation also does not consider the benefits that will be obtained from other lessons that will be developed and shared through DrChecks. While not all lessons will be of interest to all CLL compliant applications, some will be and benefits will accrue both within and across business practices.

7. CONCLUSIONS

An economic benefit analysis of the initial prototype lessons learned system (CLL) has shown a high return on investment (ROI). Based upon the finding presented within this paper, the Corps of Engineers has found for every dollar invested in CLL a minimum savings of 120 dollars will occur. The Corps of Engineers is currently funding the development of the enterprise version of CLL. Estimated time to complete design, coding, and testing is approximately three calendar years. In the interim, DrChecks has been revised to be an enterprise application and the benefits of developing and sharing lessons learned across all individual districts will accrue. Once CLL is developed, the Registry will search and retrieve lessons that are stored in other existing stand-alone design quality lesson repositories and also those of other existing other business practices. Given the large success at one site in only design and construction area, the benefits are expected to be significant.

8. REFERENCES

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