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Implementing a Lessons Learned Process at Sandia National Laboratories

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ABSTRACT

The Lessons Learned Process Improvement Team was tasked to gain an understanding of the existing lessons learned environment within the major programs at Sandia National Laboratories, identify opportunities for improvement in that environment as compared to desired attributes, propose alternative implementations to address existing inefficiencies, perform qualitative evaluations of alternative implementations, and recommend one or more near-term activities for prototyping and/or implementation. This report documents the work and findings of the team.

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EXECUTIVE SUMMARY

The purpose of a lessons learned process and system is to enable people in an organization to learn from past experiences in order to make better decisions now and in the future. The Lessons Learned Process Improvement Team (LLPIT) was tasked to gain an understanding of the existing lessons learned environment within the major programs at Sandia National Laboratories (SNL), identify inefficiencies in that environment as compared to desired attributes, propose alternative implementations to address existing process inconsistencies, perform qualitative evaluations of alternative implementations, and recommend one or more near-term activities for prototyping and/or implementation.

The team was focused on a lessons learned process, recognizing that an effective lessons learned environment is one of several critical dimensions of an overall knowledge management framework that includes effective peer review, education and training, mentoring, document management, etc. Addressing all elements of knowledge management was well beyond the scope of this effort, which was explicitly chartered to address an improved lessons learned framework. Nevertheless, the team recognizes the value that all facets of knowledge management bring to enhancing the productivity and effectiveness of the Laboratory.

Value Proposition and Drivers

As called for by the U.S. Department of Energy (DOE O 210.2A, *DOE Corporate Operating Experience Program)* and the National Nuclear Security Administration (NAP-24, *Weapon Quality Policy)*, the capture, sharing, and utilization of lessons learned are requirements for SNL and its major programs. SNL also has a related corporate procedure entitled “Identify Operating Experience, and Share Lessons Learned”.

The SNL product realization process, as identified in the Realize Product Sub System (RPSS) architecture, requires lessons learned efforts to capture both lessons and best practices with the intent of learning from experiences. Moreover, SNL’s program managers recognize the value proposition that lessons, if learned, can contribute to intangible benefits such as excellence in the practice of engineering, and can point to needed process improvements, technology developments, or other opportunities for improvement. However, a lack of specified process sets the stage for inconsistent approaches and poor communication and sharing of lessons. Product teams do not consistently collect past lessons and best practices and make them applicable to their projects.

The major programs, and more widely Sandia National Laboratories, faces two challenges. First, to improve lessons identification processes and second, to create or nurture the broader organizational elements needed for a true lessons learned system.

Understanding the Lessons Learned Environment

The LLPIT reviewed literature, federal agency lessons learned websites, and interacted with National Aeronautics and Space Administration Jet Propulsion Laboratory to understand the essential elements and effective external implementations of lessons learned processes and systems.

The team also identified and evaluated more than 140 legacy major program lessons documents, reviewed SNL's Realize Product Procedures (RPP) to assess the extent to which they support learning from prior experience, and explored various lessons learned initiatives within major program organizations.

SNL's engineering and product realization division engages in a number of "lessons learned" efforts, emphasizing person-to-person transfer of knowledge that is heavy on mentoring, SMEs, peer review, shared experiences, and corporate memory. These are essential components of knowledge transfer, but the lessons learned literature is clear about the need for a formalized structure. This is particularly true for the major programs, which experience lulls in product realization (for instance, during the 1990s).

The wide variety of current initiatives within SNL indicates continuing concern that lessons identified in the past are not easy to find and access, are not easy to understand and properly apply, and are not necessarily getting to the right people at the right time.

Identify Opportunities for Improvement in the Current Environment

The team used discussions with stakeholders and development program engineers, as well as team member knowledge and experience, to identify inefficiencies in the current approach to capturing and communicating lessons learned. The team placed its observations in context by comparing them to desired attributes of a lessons learned process, a lesson description, and a lesson learned system. We focused on six desired process attributes: accessibility, usability, consistency, shareability, durability, and understandability, with recognition of the importance of human factors. As one reviewer commented, "Ease of use will make or break any LL system."

Comparing Existing and Desired Lessons Learned Process Attributes

Attributes	Existing LL Process	Desired LL Process
Accessible	Multiple organizations Limited access metagroups	Major program access
Usable	Brute force Time intensive User unfriendly Used mostly by quality engineers	Ease of use Timely User friendly Searchable (document and repository) Used by all major programs
Consistent	Multi-media • Paper archive • Electronic archive Lack of format • Bullets • Text Lack of necessary information	Electronic Formatted Necessary information required
Shareable	Find on own Request access once figure out who controls No distribution required	Available for major program access Distribution required and perhaps automated
Durable	No standard policy • Sharing, reading, and using not required consistently Individual, decentralized repositories • Paper archives • Electronic archives Works by heroes	Policy • Sharing expected • Reading and using required • Single corporate-approved repository Process developed to be available, useful, consistent, easy to use, and timely

Attributes	Existing LL Process	Desired LL Process
Understandable	Lack of format Context not always available No consistency Poor searchability	Structured Context available Consistent Indexed/searchable

Alternative Approaches

The LLPIT identified a number of alternative approaches, many of which are already in use within SNL. These approaches include case studies, document collections, spreadsheet listings, SharePoint sites, databases with web interfaces, and variations such as video collections and blog posts. The team performed a qualitative evaluation of each of the alternatives against the six desired attributes identified above. All but one of the alternatives (blog posts) fulfill at least one attribute quite well although none fulfills all of the attributes.

The most commonly found approach within SNL major programs—document collections—fared the poorest. As typically established, these collections and the individual documents within them tend not to be accessible, usable (easy to understand, searchable), or shareable. Some major programs call for a consistent approach to how these documents are written but others do not. Document "understandability" also varies widely, depending on how well written and reviewed each document is.

The team's evaluation identified a database with a good interface or a well-designed SharePoint site as the strongest alternatives when compared to the six desired attributes of a lessons learned process. Such a database or site would serve as a tool to facilitate the capture and sharing of lessons. However, a database or other centralized portal by itself is not a process or a system, and will fail if not supported by education, leadership, and oversight.

Proposals and Recommendations

The team reviewed and discussed its assessment of SNL's existing approach to lessons learned as well as various alternative methods for capturing and communicating lessons compared to the list of desired attributes. Our first set of recommendations was "tool-agnostic"; we recommended to management that SNL would improve its lessons learned process by centralizing lessons documents, or at least providing a centralized portal/starting point, with a database format being preferred; standardizing the content provided in lessons documents; infusing lessons learned awareness into program procedures; and assigning oversight.

The LLPIT turned its attention to developing detailed proposals and supporting materials as a way to understand the relationships and interdependencies of the various roles and steps in a lessons learned system. In addition, the LLPIT wrote a detailed database requirements document, which became a basis for seeking estimates from six internal and external developers; designed a lesson capture form that would balance user desire for quick and easy content creation and retrieval with usability requirements for sufficient detail; and identified the various potential roles of a proposed board of experts.

Although we recognized the value of case studies (i.e., "stories") in helping people to retain lessons, we recommended that major programs first develop a lessons learned database (LLDB) to capture observations and lessons. Database attributes must include accessibility by all in the major programs and usability (easy input and retrieve information; easy to search, etc.). We

recommended the LLDB be developed via the corporate lessons learned platform in order to leverage existing experience and investment.

We further recommended that a technical lessons learned process owner be identified and assigned to oversee the SNL lessons learned process and system. We considered the position to be similar to that of an organizational chief knowledge officer, carrying responsibility not only for lessons learned, but also for how they fit with broader knowledge management efforts. This individual would interact with a group of subject matter experts (SME) to verify and validate lessons and ensure their completeness and usefulness. The lessons learned process would engage relevant SNL management as needed for lessons learned process and system maintenance and sustainability including decisions for how or when to infuse valid lessons into SNL process documents such as general engineering documents and RPPs, and training courses.

Final Recommendations

- Leverage SNL's corporate LLDB, working with the owning organization to ensure program-specific needs can be met.
- Consider SharePoint as an alternative, if the corporate database is not able to meet program needs.
- Create a new full-time SNL lessons learned process owner position as a principal or distinguished-level technical professional.
- Utilize the process owner and a hybrid of an on-call panel of SMEs or a lessons learned advisory board and the major programs as an overall control board.
- Make initial modifications to RPPs to facilitate not just the creation, but also the use of lessons learned.
- Infuse lessons learned awareness not just into requirements documents but also into general engineering documents, other procedures, and training programs.
- Create a recommended structure for consistency in capturing attributes consistent with the desired attributes mentioned above.
- Consider and investigate additional options and sources of information.

In Summary

The LLPIT will leverage the SNL Corporate LLDB, working to get SNL requirements incorporated into the tool's next release. This report summarizes the LLPIT's recommendations for a lessons learned process and, to an extent, a lessons learned system that addresses human behavior, incorporates education and training, and fits into the broader context of knowledge transfer and knowledge management efforts and learning initiatives. Lessons learned initiatives must be integrated into the overall learning system, which spans such efforts as knowledge preservation activities and the training curriculum. This information is being transitioned to an implementation team, which will be responsible for taking the research and examples provided in this report and developing the path forward to implementing an effective lessons knowledge capture system.

NOMENCLATURE

BP	best practice
CALL	Center for Army Lessons Learned
CB	control board
CKO	Chief Knowledge Officer
CLO	Chief Learning Officer
COTS	commercial-off-the-shelf
CM	configuration management
DOE	U.S. Department of Energy
ES&H	Environment, Safety and Health
JPL	Jet Propulsion Laboratory
KM	Knowledge management
LL	lesson(s) learned
LLDB	Lessons Learned Database
LLPIT	Lessons Learned Process Improvement Team
NAP	NNSA Policy Letter
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
NNSA	National Nuclear Security Administration
ROI	return on investment
RPP	Realize Product Procedure
RPSS	Realize Product Sub System
SME	subject matter expert
SNL	Sandia National Laboratories

LESSONS LEARNED PROCESS IMPROVEMENT TEAM CHARTER

A team was convened in autumn of 2013 to recommend improvements to the SNL lessons learned process.

The team's specific objectives were to

- gain an understanding of the existing lessons learned environment within the major programs at Sandia National Laboratories (SNL),
- identify inefficiencies in that environment compared to desired attributes,
- propose alternative approaches to address existing process inconsistencies,
- perform qualitative evaluations of alternative approaches,
- recommend lessons learned process improvements,
- gain concurrence on a path forward, and
- transition the effort to an implementation team.

In accordance with its charter, the team

- reviewed the literature and compiled an annotated bibliography for lessons learned processes and practices,
- investigated existing lessons learned processes of other government entities,
- collected, collocated, and examined lessons learned from major programs,
- identified key program stakeholders and solicited their lessons learned practices and needs,
- examined SNL and major program requirements for lessons learned,
- created an lessons learned taxonomy and standard form,
- identified lessons learned process and practice options, and
- made recommendations to management for improvements to the SNL lessons learned process.

This report documents the work and findings of the Lessons Learned Process Improvement Team (LLPIT).

VALUE PROPOSITION AND DRIVERS

The capture, sharing, and utilization of lessons learned are requirements for SNL and its major programs. The SNL product realization process, as identified in the Realize Product Sub System (RPSS) architecture, requires lessons learned efforts to capture both lessons and best practices (BPs) with the intent of learning from experiences to avoid costly mistakes. Moreover, SNL's managers recognize the value proposition that lessons, if learned, can contribute to intangible benefits such as excellence in the practice of engineering, and can point to needed process improvements, technology developments, or other opportunities for improvement.

Drivers

As shown in Figure 1, the U.S. Department of Energy (DOE), the National Nuclear Security Administration (NNSA), and corporate requirements also serve as drivers for SNL's effort to capture lessons. Three important requirements are

- DOE O 210.2A, *DOE Corporate Operating Experience Program*, which requires an operating experience program "tailored to the nature of the work, hazards, and organizational complexities to develop lessons learned that focus on preventing adverse events, trends, and reliability related events, and on performance improvement or cost savings."

- NAP-24, *Weapon Quality Policy*, which states, "A process shall be established and documented for corrective action." Among other requirements, the process shall "capture and communicate lessons learned for effective use in preventing problems and making improvements." It also requires a focus on prevention rather than detection (see Section 3.1.2), stating that the quality management system shall focus on preventing nonconformance... [and] utilize methods to prevent quality issues.

- SNL corporate procedure, "Identify Operating Experience, and Share Lessons Learned," which makes all members of the workforce accountable for identifying lessons learned, communicating them, and seeking to apply them to their work when possible.

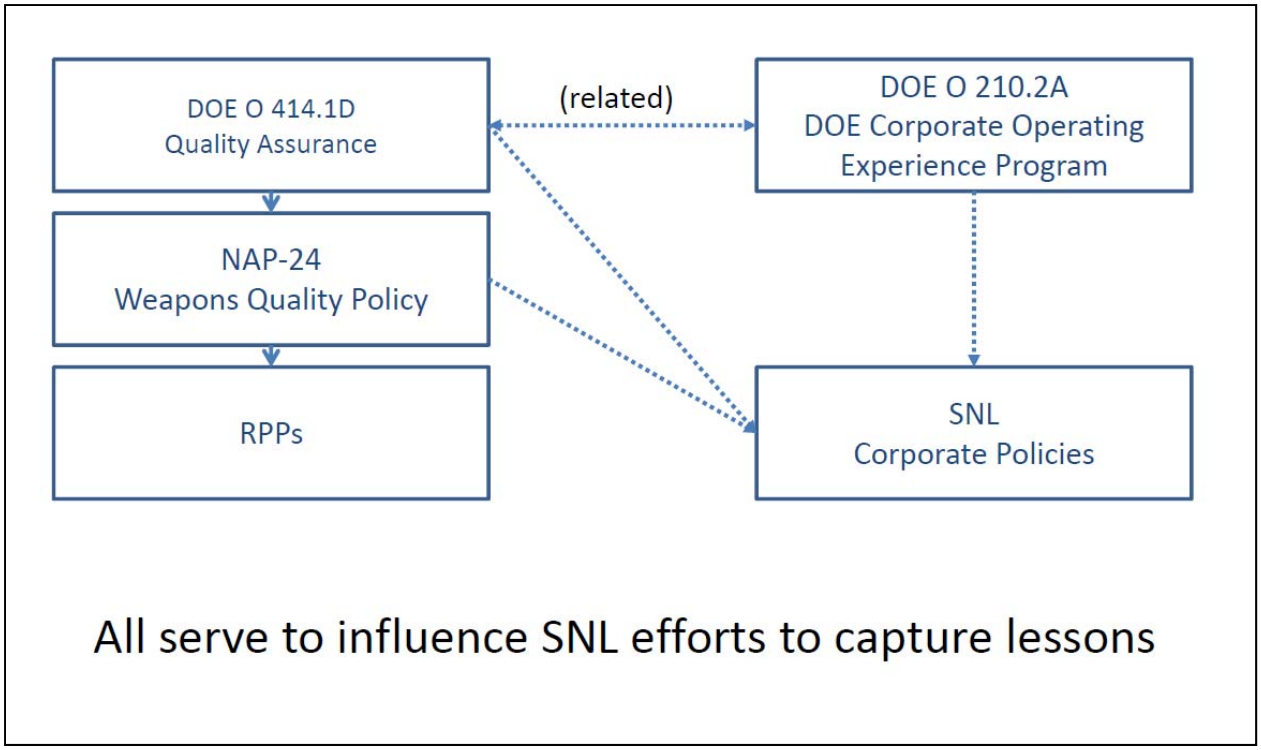

Figure 1. Lessons Learned Requirements

These requirements call for all SNL staff to capture and communicate lessons but do not identify a systematic process for doing so, leaving organizations free to develop their own practices. The lack of specified process sets the stage for inconsistent approaches and inefficient communication and sharing of lessons. Product teams struggle to collect past lessons and BPs and make them applicable to their projects. Existing lessons learned documents are owned by individual product teams, sometimes contain collections of "do" and "don't" statements without ample context to understand the reasons, and lack analysis to determine a root cause and/or solution to the problem. Multiple disconnected repositories have been collected—but not shared. These factors lead to duplication of effort and inefficiency on the part of staff who are tasked with identifying applicable lessons and BPs. These conditions can lead to an inefficient use of resources for collecting, understanding, and trying to apply past lessons as well as missed opportunities. The LLPIT discerned the need for a more systematic approach leading to a lessons learned system that would be accessible, usable, reliable, applicable, shareable, durable, and understandable, ideally built on a base of management commitment to BPs, corporate requirements, optimized learning, and cultural change.

It also became clear that there is lack of agreement both internal and external to SNL about what constitutes a true "lesson learned." The phrase is used so generically that it loses clear meaning.

What is a Lesson Learned?

In common usage, the phrase "lessons learned" is often used to mean any experience or observation of a problem or of a success. For example, the NNSA's NAP-24 calls for a process to "capture and communicate lessons learned." In this report, there are occasional generic references to lessons learned documents, lessons learned initiatives, and lessons learned practices. To be accurate, we need to recognize the difference between an observation, a lesson

identified, and an actual lesson learned, and to recognize that lessons can be learned from both positive experiences ("best" or "good" practices) and problems.[1]

An **observation** is a basic description of an operating experience, either a problem or a success. The experience has been identified and documented in some way as an issue for improvement or a potential "best practice."

A **best practice** can be defined as a positive example of work processes with the potential to be the basis for significant operational improvements or cost savings. (The phrase "good practice" might be more accurate, because "best" implies a single best approach requiring no change.)

A **lesson identified** is an observation that has been subjected to additional analysis to identify such things as potential future consequences or impact, possible root causes, and/or appropriate remedial or corrective action.

A **lesson learned** is an implemented solution that leads to improved performance or changed behavior. For a lesson to become learned it needs support along the way. It must become known (disseminated, explained, and taught) and its recommended (and vetted) solutions must be infused into behavior expectations and job requirements.

Duffield and Whitty (2014) contend that lessons identification processes exist and are exercised, but that problems occur with analysis, dissemination, and application of those lessons. They say, "This situation leads to a false sense that [the] lessons learned process is working and that organisations are learning from their experiences when in fact only the first part of the process (lessons identified–observed) is functioning."

Based on its review of existing lessons learned-related documents and other artifacts and discussions with major program stakeholders, the LLPIT concluded that a large but unquantified number of major program artifacts are observations and sometimes lessons identified. True "lessons learned" are rare.

The SNL major programs, therefore, face two challenges. First, to improve lessons identification processes and second, to create or nurture the broader organizational elements needed for a true lessons learned system.

[1] The definitions that follow of observations, lessons identified, and lessons learned were adapted from various sources, especially USAF 2010, *Air Force Lessons Learned Program*, CALL 2011, *Establishing a Lessons Learned Program*, and NATO 2011, *The NATO Lessons Learned Handbook, 2nd edition*. The definition of best practice is from DOE O 210.2A, "DOE Corporate Operating Experience Program." See the attached bibliography.

UNDERSTANDING THE LESSONS LEARNED ENVIRONMENT

The team's first objective was to gain an understanding of the existing lessons learned environment within the major programs at SNL. We identified and engaged stakeholders and key development programs to discuss their current processes and desires, and to talk through possible paths forward. We also drew on team members' knowledge and connections to identify a variety of ongoing lessons learned initiatives within major programs; these are identified in the Existing Approaches within section.

We collected copies of 143 previous lessons learned documents and discovered that lessons were to be found in isolated, disconnected, and tightly controlled collections, in many different formats, with no standard content. In addition, we reviewed existing Realize Product Procedures (RPP) requirements documents that guide project teams through each phase of a product realization lifecycle. We found that at least 14 of the RPPs explicitly or implicitly mention lessons learned practices or activities. Although there is some focus on requirements to document lessons at the end of an activity, the review of past lessons learned at the beginning of an activity is required only by RPPs concerning life cycle management and technical reviews.

Scanning the Environment

Before the team turned its attention to evaluating various approaches to address existing process inefficiencies, it examined the external and internal environment to learn more about effective lessons learned systems.

External Environment

In examining the external environment, the team reviewed relevant literature, examined related websites, and met with the National Aeronautics and Space Administration (NASA) Jet Propulsion Laboratory's (JPL's) chief knowledge officer (CKO).

The LLPIT conducted a comprehensive literature search, focusing on applied research and institutional best practices or "lessons learned about lessons learned" and generated an annotated bibliography contained in Appendix A: Annotated Bibliography to this report.
The team also studied a number of related web-based portals:

- SNL Corporate Lessons Learned website
- Other DOE sites
- Center for Army Lessons Learned (CALL), http://usacac.army.mil/organizations/mccoe/call
- NASA, http://llis.nasa.gov/
- North Atlantic Treaty Organization (NATO) Joint Analysis & Lessons Learned Centre, http://www.jallc.nato.int/

From these sources, the team gleaned desired attributes of a lessons learned process and a lessons learned system, and identified desired elements of a good lesson description or format. It derived a lessons learned process flow from those in the literature, particularly that of JPL (Oberhettinger 2012).

During a benchmarking visit, David Oberhettinger, CKO and Chair of the JPL Lessons Learned Committee (LLC), highlighted to an SNL team member that the two program attributes of a committee (or control board) and an infusion process are critical to success. To that end, since 1984 JPL has had a Lessons Learned Committee that meets weekly and is charged with validating and prioritizing lesson candidates, developing and approving lessons, and assuring that the lessons are shared. The LLC also is charged with lessons learned *infusion*—integrating each lesson learned recommendation into JPL business practices and procedures so that the spaceflight projects are not dependent on the proper person reading the lesson at the proper point in the project or mission life cycle.

It was also shared that return on investment (ROI) metrics are notoriously difficult to obtain. A lessons learned program should be considered a risk management or safety program in that there is no way to determine what losses the institution might sustain if those programs are not in place. JPL considers that if lessons are viewed roughly 1000 times per month but a single download saves a mission from catastrophic failure, then that lesson's impact far outweighs the many others that were accessed.

Lessons Learned Practices in Literature

The lessons learned literature is clear about the need for a formalized structure that both directly integrates into existing organizational processes and promotes individual learning. For example, Werner and Perry (2004) suggest an integrated, common (standard) infrastructure with the following characteristics:

- a structured process for incorporating lessons learned into existing organizational processes,
- an easily accessible system where project-specific decisions are available to other projects, including timely feedback to those already in service,
- a closed-loop process that ensures corrective actions are implemented, so that underlying sources of problems are corrected system wide,
- a process that includes periodic reviews and feedback, and
- a disciplined, data-driven approach to identify root causes and determine the best actions to break the chain of events that lead to errors or incidents.

Carnes and Breslau (2002), who catalogued the early efforts of setting up the DOE Corporate Lessons Learned Program technical standard,[2] identified a 12-point strategy for optimizing organizational learning as the driving strategy for implementing a lessons learned process:

1. Establish a leader who promotes cohesion and shared values
2. Encourage individual learning
3. Target learning
4. Maximize team learning
5. Challenge existing models
6. Learn from others

[2] Part of the Corporate Operating Experience Program and administered by the DOE Office of Environment, Health, Safety, and Security. Refer to http://energy.gov/ehss/downloads/doe-std-7501-99 (retrieved October 2014).

7. Learn from mistakes
8. Integrate functional disciplines
9. Develop a structure that promotes learning
10. Develop a communication strategy that optimizes learning
11. Measure performance—at project levels and for individuals
12. Manage information to promote learning

We have highlighted only two representative papers from the literature. For additional sources, see the annotated bibliography attached as Appendix A and refer to SAND2013-3671, *Considerations for Implementing an Organizational Lessons Learned Process* (Fosshage 2013.)

Neither the characteristics identified above nor a formal structure or strategy is found across all major SNL programs.

Internal Environment

In addition to the Value Proposition and Drivers described previously, the following artifacts exist within SNL's lessons learned environment.

Existing Lessons Learned

The team identified and collocated key legacy lessons learned (or more accurately, lessons identified) documents for further review and analysis.

In all, we collected 143 documents of various types, including formal and draft reports, presentation slides, memos, lists, and more, and we viewed a handful of lessons learned-related video clips. Sixty-nine of the documents were tracked down and obtained from various major program department archives because one or more of our team members knew about the existence of the documents and could acquire copies. The remaining 74 documents were found in SNL's document management system. However, it was again team members' knowledge of the existence of documents that made it possible to find those records. Almost all of the documents are access controlled with no easy way for most team members to actually open and use the documents.

The team's experience in collecting the set of legacy documents contributed to its understanding of some of the inefficiencies identified earlier in this report. Team members evaluated the documents against criteria gleaned from the literature review and used the experience to refine the list of desired elements of a good lesson.

SNL Major Program Requirements around Lessons Learned

Realize Product Procedures are an important part of the product realization lifecycle. Project teams use RPPs to guide work through each lifecycle phase. We found that at least 14 of the RPPs explicitly or implicitly mention lessons learned. After discussion with SMEs and further analysis, we deemed four RPPs to be especially useful as tools for better codifying a lessons learned process. Table 1 summarizes the team's initial recommendations.

The effort to revise RPPs continued as a parallel effort and the team turned its attention to documenting desired attributes of a lessons learned process, a lessons learned system, and a good lesson description.

Table 1. Recommended Modifications to Four Realize Product Procedures

Topic	Recommendation
Project Management	Review lessons learned during project initiation and/or project planning steps. Document lessons learned during project closure (or throughout).
Development Reports	Require teams to document lessons learned in reports (currently it is recommended but not required).
Project Reviews	Balance existing requirements to capture new lessons with clearer requirements for up-front evaluation of past lessons.
Project Team Responsibilities and Processes	Include steps to evaluate past lessons learned and to ensure new lessons learned are documented.

Existing Approaches within SNL Programs

The team's informal survey of lessons learned initiatives within SNL organizations yielded a wide variety ongoing processes and efforts. As indicated by the brief descriptions, these might better be described as lesson identification initiatives.

- Lessons learned documents in both textual and presentation formats. Analysts performed in-depth lessons learned studies.
- Formalized lessons learned process that uses a SharePoint site with a form for entering lessons.
- One organization follows its division assurance process, which in turn follows SNL's corporate policy, process, and procedure.
- One major program uses a standardized lessons learned form and maintains an access-controlled storage location.
- An analyst was hired to identify practices for improvement based on lessons learned from a past program. The Risk Engineer input lessons learned from reports into a risk management database as potential concerns to be watched. Using the same information, the Quality Engineer created quality statements for project teams to monitor and follow.
- As part of an existing risk process, a department planned to use a risk management database to store lessons learned. It later leveraged the LLPIT's recommended data collection format (see "Lesson Capture Form") when implementing the risk management database pilot effort.
- A system engineer began with lessons learned documents from past programs. The system department hired SMEs to search for production-related lessons they "might not already know about" by interviewing senior, experienced technical staff. This team also had briefings provided by experienced designers and production engineers from a past program to inform them on lessons learned and to determine which apply or might apply to their program. Briefings on information contained in a lessons learned report were also provided to the program management team.
- Several departments reported that they have no formal process although projects/programs and activities try to capture lessons learned.

- One organization is seeking to develop a quality lessons learned process of its own that integrates with the wider effort across SNL programs.

SNL's major programs engage in a number of "lessons learned" efforts, emphasizing person-to-person transfer of knowledge, or as one experienced team member observed, "the lessons learned process has been heavy on mentoring, SMEs, peer review, and 'tribal knowledge'." These are essential components of knowledge transfer, but as stated earlier, the lessons learned literature is clear about the need for a formalized structure. This is particularly true for the major programs, which experiences lulls in product realization (for instance, during the 1990s).

The wide variety of current initiatives within SNL major programs indicates continuing concern that lessons identified in the past are not easy to find and access, are not easy to understand and properly apply, and are not necessarily getting to the right people at the right time (NASA JPL refers to this process as "infusion"[3]). Lessons identified in the past are a potentially valuable source of information for current and future programs. Before SNL can realize the benefits of those lessons, however, it must address inefficiencies in its current approach.

[3] Oberhettinger, 2012

COMPARING THE CURRENT ENVIRONMENT TO DESIRED ATTRIBUTES

The team's second objective was to identify gaps in the existing lessons learned environment within the SNL major programs as compared to desired attributes. We used discussions with stakeholders and development program engineers, as well as team member knowledge and experience, to identify inefficiencies in the current approach to capturing and communicating lessons learned.

Opportunities for Improvement

The team's general impression of the current lessons learned environment was one of inconsistency—inconsistently managed, utilized, documented, and valued. The following list provides some specific observations.

- Reliance on person-to-person transfer of knowledge is not consistently effective due to job rotation and retiring experienced major program engineers.
- Person-to-person transfer of knowledge is not always documented.
- Documented lessons may not be readily available, may be located in decentralized repositories, may offer limited access, and often provide no centralized starting point.
- Documented lessons are found in a variety of non-standardized formats with inconsistent content. Lessons should identify actions that solve problems, not just raise awareness, and should provide context to fully understand the lesson and its applicability to other situations.
- Opportunities to capture observations or identify lessons can be missed.
- Lessons are often captured because it is required by program management or an external stakeholder—not as a characteristic of a learning culture.
- Processes are not used consistently.
- The current RPPs need improved consistency, clear direction for the engineer, and specific requirements to review legacy lessons learned.
- There are no means to coordinate agreement about the significance of an observation before it is identified as a lesson.
- There exists no common definition or understanding of an observation, lesson identified, or lesson learned.

After reviewing the limitations of the existing lessons learned efforts, the team developed the following desired attributes for a lessons learned culture.

Desired Attributes

As a result of its environment scan, the team realized that a lessons learned process needs to be part of a larger system; the two are not the same.

A **lessons learned process** describes the tools and practices whereby information about experiences (lessons or good practices) is collected, verified, stored, disseminated, retrieved for reuse, and assessed for its ability to positively affect organizational goals (Fosshage 2013). Well-written lesson descriptions are an essential part of the process.

A **lessons learned system** encompasses the process and also addresses human behavior, incorporates education and training, and fits into the broader context of organizational knowledge transfer and knowledge management (KM) efforts.

The purpose of a lessons learned process and system is to enable people in an organization to learn from past experiences, good and bad, in order to make better decisions in the present and the future. Staff members must know where to turn for these lessons, they must have relatively easy access, and they must be able to ask questions or in some other way quickly identify those past experiences that will have the most relevance for their current situation. The documented lessons themselves must contain sufficient applicable information to make them actionable. The team considered these criteria as principal when it began exploring alternative approaches.

Desired Attributes of a Lessons Learned Process

The team used information gleaned from its literature review[4] and discussions with internal and external SMEs to identify desired attributes of a lessons learned process that would collect, verify, store, disseminate, retrieve for reuse, and assess lessons learned, resulting in improved process performance. These attributes are accessibility, usability, consistency, shareability, durability, and understandability.

The team also consulted with SNL's Human Factors staff to ensure the process design would not overlook answers to the question "how will people want to use the system?" and to ensure that SNL major programs recognize the importance of understanding human behavior-based factors. Consequently, in addition to the six attributes listed above, we recognize that a lessons learned process must also address communication, training, awareness, and lesson "infusion" whereby actions feed back into the process based on lessons documented in the system.

Desired Attributes of a Lesson Description

The team also explored the attributes of a well-written or well-described lesson or best practice. A good lesson description is accessible, timely, and has unifying context such that it can be applicable to similar events or situations; it contributes to the understandability attribute of a good lessons learned process. As stated in "Attributes of a Good Lessons learned," produced by the DOE's Operating Experience Committee (DOE 2009), a good lesson or BP description contains new and significant information that is clearly stated. All fields are filled in, the information is accurate and credible, there is enough detail to determine relevance, and the content is actionable and easily shared. Characteristics to avoid are opinions, irrelevant or missing details, too many incomplete fields, and restrictions on sharing.

The DOE document provides additional details about what it calls attributes of a good "lesson learned" and we would argue are attributes of a good "lesson identified." The lesson:

- contains new information related to adverse experiences and their prevention or related to BPs and their application;
- contains a strong lessons learned statement that tells readers what to do and why it is important using language that they can easily understand and relate to;

[4] These attributes were drawn primarily from Benner and Carey (2009).

- is associated with preventing a significant adverse consequence or enabling a significant improvement in performance;
- is focused on a single lesson or a collection of related lessons to facilitate clarity of communication;
- contains information that has been validated to be accurate and communicated by a credible source;
- includes a brief discussion of the background information and any actions that were taken to help readers understand the context surrounding the experience and whether it applies to them;
- includes actions that are recommended for others to prevent a similar occurrence for the situation as described in the lesson or one that is closely related;
- includes a brief discussion of any analyses performed to help the reader understand the basis for the recommended actions;
- identifies schedule delays, labor, or other costs or consequences that were experienced or avoided so that readers can assess the potential value to them;
- includes source and reference information to enable readers to follow up if they need to do so;
- includes categorization information and the key words that may help others find the lesson when searching;
- includes clearly stated facts;
- identifies relationships to compliance requirements or processes if applicable;
- is timely as it relates to operations and activities across the organization; and
- is in an electronic format that is accessible and printable using typical desktops.

Formal definitions of the phrase "lesson learned" have undergone an evolutionary process since Juran (1986) generally described it as "a catchall phrase describing what has been learned from experience." For example, a more recent definition was jointly crafted and adopted by the American, European, and Japanese space agencies to specify that a lesson must meet certain criteria, as follows:

> A lesson learned is a knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure. Successes are also considered sources of lessons learned. A lesson must be *significant* in that it has a real or assumed impact on operations; *valid* in that is factually and technically correct; and *applicable* in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result (Secchi et al. 1999 [as cited in Fosshage 2013]).

The three attributes described above help transform an observation into a lesson identified (rather than a lesson learned, which by definition has been infused into behavior expectations and/or job requirements). The process improvement team found similar recommendations and definitions from other sources during its literature review,[5] and these validated major points in discussions

[5] Of particular note, the *NATO Lessons Learned Handbook* (NATO 2009) and the Center for Army Lessons Learned's *Establishing a lessons Learned Program: Observations, Insights, and Lessons* (CALL 2011).

with internal and external subject experts. Using the *significant*, *valid*, and *applicable* attributes from Secchi et al. (1999) as a guidepost, the team recognized the value in crafting its own lesson examples for the following reasons:

- understanding the difficulty in authoring useful lessons (see the appendix section on Lessons Learned about Understandability of Lessons Statements),
- providing guidance to potential users who would be requested to generate content, and
- validating the proposed lessons learned format.

We realized that it is not easy to craft a well-written lesson description; this difficulty contributes to the volume of poorly written and therefore non-useful lessons documents. A good system will provide training and education about how and why to write (or record) effective lessons or best practice (good practice) descriptions.

The team practiced writing their own lesson descriptions containing fields deemed necessary to provide enough context for a lesson statement to be useful. Their efforts were an improvement over the unstructured descriptions (observations) found in many legacy "lessons learned" documents. Team members used the difficulties they experienced while attempting to write significant, valid, and applicable lessons descriptions to refine the proposed Lessons Capture Form, found in Appendix B: Lesson Description.

Desired Attributes of a Lessons Learned System

Although the process improvement team focused on creating a lessons learned process, we recognized that the process must be aligned with broader knowledge transfer and KM objectives. We identified the following attributes as necessary to an effective lessons learned system.

- Recognition of how people want to use the system
- Recognition of how the system addresses the expectations of SNL major programs management, specifically how it improves existing product realization lifecycle activities
- Ongoing communication/training/marketing about the process and the system, leveraging existing opportunities whenever possible
- Recognition of the difference between observations, lessons identified, and lessons learned (demonstrated by behavior change, requirements change, etc.)
- Methods for collecting lessons
- Knowledge of what constitutes a good lesson statement (lesson documented)
- Deliberate and sufficiently wide dissemination of lessons
- Infusion of lessons learned into requirements
- Existence of a centralized, accessible repository or database—with recognition that it is only a part of an overall system
- Existence of a sustainable (and sustained) archive—with recognition that the major purpose is access and reuse, not storage, and a focus on relative ease of both accessibility and searchability
- Managed workflow built into the system to include analysis, verification, and assessment (metrics)

- Deliberate and ongoing efforts to keep lessons learned activities aligned with each other and with related knowledge transfer and KM initiatives
- Sustained level of resources and support

Comparison of Existing and Desired Lessons Learned Process Attributes

The team then compared the current lessons learned process to the list of six desired process attributes identified in the Desired Attributes of a Lessons Learned Process section: accessibility, usability, consistency, shareability, durability, and understandability. The existing lessons learned process exhibits inefficiences in each attribute. For example:

- Lessons are distributed across multiple organizations with tight access limitations, or access is dependent on knowing whom to ask.
- The process of finding or learning about potentially valuable lessons is time intensive and user-unfriendly.
- There is neither a consistent format nor consistent expectations about the content to be included in a lesson. The team found that many of the legacy lessons documents lack sufficient contextual information.
- Individual initiative is needed to find lessons that might be valuable for a project team. No mechanism currently exists to consistently distribute or share information about specific lessons.
- Lessons tend not to be durable in a practical sense.
- Many lessons documents had inconsistent format, insufficient detail, and lack of context. The potential to understand connections is limited because lessons are stored in multiple unconnected repositories and lack assigned keywords, unifying contexts, or other metadata that could help potential users search for and find related lessons.

Table 2 contrasts the existing lessons learned process to the desired future process. The team assessed alternative approaches against these attributes as well.

Table 2 Comparing Existing and Desired Lessons Learned Process Attributes

Attributes	Existing LL Process	Desired LL Process
Accessible	Multiple organizations Limited Access Metagroups	Major program access
Usable	Brute force Time intensive User unfriendly Used mostly by Quality Engineers	Ease of use Timely User friendly Searchable (document & repository) Used by all major programs
Consistent	Multi-media • Paper archive • Electronic archive Lack of format • Bullets • Text Lack of necessary information	Electronic Formatted Necessary information required

Attributes	Existing LL Process	Desired LL Process
Shareable	Find on own Request access when figure out who controls No distribution required	Available for major program access Distribution required and perhaps automated
Durable	No policy • Sharing, reading, and using not required Individual repositories • Paper archives • Electronic archives • Decentralized Works by heroes	Policy • Sharing expected • Reading and using required • Single corporate-approved repository Process developed to be available, useful, consistent, easy, and timely
Understandable	Lack of format Context not always available No consistency Poor searchability	Structured Context available Consistent Indexed/searchable

ALTERNATIVE APPROACHES

The team's third and fourth objectives were to propose alternative approaches to address existing process inconsistencies and to perform qualitative evaluations of these alternative approaches.

Alternative Methods for Collecting Lessons

The LLPIT identified a number of alternative approaches, many of which are already in use within SNL.

Case Studies: SNL's R&D organization published a document (Daily and Sumpter, 2013) containing case studies that illustrate different aspects of the phases of research. The case studies are well written, with "morals of the story" (lessons) for each. Storytelling is a proven method for passing on knowledge; the collection of case studies is an effort to document the stories in a compelling way.

Document Collections: Documents containing lessons-related observations and sometimes "lessons identified" are located in various department shared drives, SharePoint sites, or other locations both inside and outside of SNL major programs. Sometimes these collections are identified as lessons learned collections and sometimes they co-exist within large sets of department-related documents. These collections contain a wide variety of primarily unstructured documents: formal SAND reports, PowerPoint briefing slides, meeting notes, interview notes, Word documents, text files, and more. It can be difficult to retrieve and synthesize lessons in a meaningful way from these collections.

Although many document collections do contain lessons, they are usually structured so that it is difficult to retrieve and synthesize lessons in a meaningful way and the process of doing so is labor-intensive. It became evident that lessons within these different types of documents are embedded within a narrative (e.g., unstructured) format that makes their reuse difficult. From this activity, the team would later attempt an exercise at proper lesson formatting in order to both understand its difficulty and assist in the development of a lesson taxonomy for the proposed lessons learned system.

Spreadsheet Listings: The team found one example of a spreadsheet used to document lessons, and it created another.

In the former example, an engineering subject matter expert (SME) manually reviewed a selected set of lessons learned documents, identified individual issues or lessons contained in each document, and listed each individual issue or lesson in a spreadsheet, with reference to the source document. The SME also identified high-level subject categories for each. In the latter example, a member of the LLPIT team created a spreadsheet that listed, for each document in the team's collection, the file location, file name, document title, author, date, and major system.

Spreadsheets like these can serve as locators for otherwise poorly documented collections, though these are labor-intensive creations and are hampered by the limitations of other stand-alone documents.

SharePoint/SharePoint with Form: Some departments have set up SharePoint sites to store, organize, and share documents. Often these sites function little differently than do access-controlled shared drives on an SNL server. SharePoint sites can be set up to require use of data entry forms or "lesson templates" as part of the document upload process. Using such forms will introduce a level of consistency not found otherwise, and can improve the ability to search and find relevant documents.

Video Collection: SNL's professional development organization manages a knowledge management streaming assets library. Some of the videos contain information about observations and/or lessons identified in the past although there is currently no easy way for determining which videos contain substantive lessons, nor where in the video that content can be found.

Blogs: One particular SNL organization uses a blog to disseminate lessons-related content. Blog posts can share the storytelling attributes of case studies and are easily accessible. They tend to be ephemeral, however.

Qualitative Evaluations of Alternative Approaches

The various approaches already in use across SNL are similar to general approaches the team found during its review of lessons learned literature and its informal benchmarking efforts. Consequently, we evaluated the various approaches used at SNL against the six desired attributes of a lessons learned process, using team members' personal experiences and comments from other users to reach our conclusions. Table 3 summarizes those conclusions using color-coding: green for approaches that fulfill a desired attribute, yellow for approaches that partially fulfill an attribute, and red for those that do not fulfill an attribute.

Table 3 Alternative Approaches Compared to Desired Attributes

Color-coding: green for approaches that fulfill a desired attribute, yellow for approaches that partially fulfill an attribute, and red for those that do not fulfill an attribute.

Attributes	Case Studies/ Storytelling	Document Collections	Spreadsheet Lists	SharePoint	Database and Web Interface	Video	Blog
Accessible, (easy to find)	Person-to-person is only accessible in the moment; a case studies collection is only accessible if you know about it	Scattered; stove-piped; typically do *not* exist as specific lessons learned collections; only accessible if you know who to ask	One-stop pathfinder to selected lessons, but only accessible to the extent you know about it	Can be a one-stop archive for lessons Typically access controlled; may be restricted by department	Can be a one-stop archive for lessons; The SNL LLDB is accessible to ALL, but collections within it might be restricted by metagroup access	Only accessible to the extent you know about them; many are access controlled	Only accessible to the extent you know about them and blog posts are often ephemeral
Usable (easy to understand, searchable); addresses both inputs and outputs	Stories are compelling; person-to-person stories allow for questions and further exploration	Documents often contain observations, not detailed lessons; unstructured format makes it difficult to synthesize lessons or to draw conclusions about a current situation	Use of standard fields, combined with basic sorting and searching capabilities aids usability; probably better for small collections of lessons	Use of standard input form enhances basic SharePoint search	Database design drives usability; standard fields, taxonomies; etc. aid usability	Currently difficult to search within video to find actual lessons; a labor-intensive effort to tag "clips" is being tested	Limited searchability, depending on blog software
Consistent	SNL's research organization used a consistent format for its published cases but stories are often very individualized	Formal documents within specific major system guidelines have a consistent format, most others do not	Pre-established fields with definitions drive consistency	If form/standard template used	Pre-established fields with definitions drive consistency	Videos created specifically to share lessons learned *could* be consistent if a defined process is followed	Blog content *could* be made consistent, but typically is not
Shareable (easy dissemination to the right people at the right time)	Word of mouth or manual	Manual	Manual	Workflow elements MAY enable easy dissemination	Workflow elements MAY enable easy dissemination	Manual	Blog software *might* contain quick link to email distribution, otherwise manual
Durable	Person-to-person stories fade with time; documented case studies endure longer	Documents endure so long as technology and format are supported	Documents endure so long as technology and format are supported	Documents and related formats endure so long as technology and software are supported	Documents and related formats endure so long as technology and software are supported	Videos endure so long as technology and format are supported	Blog posts are typically ephemeral
Understandable	Stories add context and enhance understanding	Depends on how well-each document is written and reviewed	Depends on how well-written and reviewed each entry is	Depends on how well-written and reviewed each document is; standard entry template will help	Depends on how well-written and reviewed each document is; standard entry template will help	Videos can add context and enhance understanding Lessons are buried in most current videos; time-consuming to find and understand	Depends on how well-written and reviewed each post is
Other issues	Time, effort, and cost to produce well-told stories and case studies	Limited access; limited meta-tagging; inconsistent formats	Limited access; limited meta-tagging;	If to be more than a "shared drive," needs SharePoint expertise; cost	Needs database expertise, maintenance and support; cost	Cost; specialized equipment and expertise	Blog is like an ephemeral email message or case study
Overarching Issue	**None of these tools by itself is a process or a system, and all will fail if not supported by education, leadership, and oversight.**						

RECOMMENDATIONS TO MANAGEMENT

The team's fifth objective was to recommend to management a lessons learned process for prototyping or implementation. We did this in two parts, first making a "tool-agnostic" initial recommendation and then following up with a detailed proposal that included recommended tools.

During this time, the team finalized a lessons learned data capture template and a spreadsheet template to test our data collection assumptions, developed database requirements, created process flow diagrams, and engaged further with the systems engineering teams.

Options for Improving Existing Lessons Learned Process

The team reviewed and discussed its assessment of SNL's existing approach to lessons learned as well as various alternative methods for capturing and communicating lessons compared to the lists of desired attributes.

We recommended that SNL would improve its lessons learned process by:

- centralizing lessons documents, or at least providing a centralized portal/starting point;
- standardizing the content provided in lessons documents;
- infusing lessons learned awareness into major program procedures; and
- assigning oversight.

Centralized Portal or Repository

As previously noted, one challenge in the current SNL lessons learned environment is that observations and identified lessons are not readily available. Person-to-person transfer of knowledge is not always documented and documented lessons are "stove piped" in decentralized repositories with limited access and no centralized starting point.

The team concluded that, at a minimum, SNL must make it easier for its engineers and other staff to locate lessons-related documents. This could be done by identifying all such documents and creating a centralized portal that would point to existing collections, or by pulling relevant documents into a centralized repository.

Initially this might need to be implemented for newly generated observations and identified lessons. Additional resources would be needed to bring legacy documents and other artifacts, or records about those artifacts, into a central location.

Standardized Content

Another opportunity for improvement in the current environment is that documented lessons exist in a variety of non-standard formats with inconsistent content, making them difficult to interpret. They are usually unstructured making it difficult to retrieve and synthesize lessons in a meaningful way and to do so would be labor intensive. Lessons within these different types of documents are embedded within a narrative (e.g., unstructured) format that makes their reuse difficult.

The team proved this to itself when members of the team each reviewed one or more legacy documents in an effort to identify the essential lesson or lessons contained in each and to understand the context for those lessons. It proved to be much more difficult than we had anticipated. The exercise helped us understand the importance of proper lesson formatting and assisted us in developing a taxonomy for the proposed lessons learned system.

The hands-on (and humbling) efforts to write lessons learned statements, our efforts to read as many of the legacy lessons documents as possible, and our struggles to understand what those documents were trying to convey informed our discussions about what makes a good (i.e., usable, actionable) lesson. We concluded that there are four essential components to a good lessons statement and a number of highly desirable components (discussed further in the Lesson Capture Form section). Major programs staff would benefit by being consistently able to find this kind of information in every lessons-related document.

This could be accomplished by some combination of training and by frequently reminding staff about the importance of including the specified types of information, by having lessons-related documentation reviewed with these criteria in mind, and/or by creating templates that called for the needed information.

Infusion

A proper lesson learned is an implemented solution that leads to improved performance or changed behavior. For a lesson to become learned it needs support along the way. It must become known (disseminated, explained, and taught) and its recommended (and vetted) solutions must be infused into behavior expectations and job requirements.

SNL RPPs, which guide project teams through each phase of a product realization lifecycle, represent an existing mechanism for documenting lessons learned-related requirements. However, one more of the identified inefficiencies in the current SNL lessons learned environment is that RPPs could better support lessons learned approaches. Currently the documented process is fragmented, there is little or no reference to reviewing legacy lessons learned, and there is little consistency across RPPs.

The team engaged with SNL's systems engineering organization and management to recommend related revisions to RPPs; this continued as a parallel effort. It should be noted that some RPPs have subsequently been revised and there is an active RPSS Architecture redesign effort underway. Guidelines for using the proposed lesson format have been created and should be incorporated into the RPSS.

We believe that lessons learned awareness should be infused much more broadly, into other guidance documents such as design guides, engineering documents, orientation sessions, and training offerings across the board, as examples. The lessons learned process must be designed to effectively infuse lessons learned into other SNL processes.

Oversight

Much of what the team observed and learned during its exploration of lessons learned approaches pointed to the need for oversight and hands-on SME involvement.

For example, APQC (2010) encourages governance processes and clearly defined roles, and calls for facilitators at key points. Carnes and Breslau (2002) state that "…effective knowledge management systems may begin as grassroots emergent systems, but eventually require a formal systems analysis that identifies roles and responsibilities…" Hinze et al. (2012) identifies a lesson validation process that incorporates both a gatekeeper review and SME review. NATO (2011) calls for project management BPs to be used for improving the effectiveness of staffing a lessons learned process.

Moreover, in the early, successful days of the SNL ES&H (subsequently corporate) LLDB, one full-time coordinator managed the lessons learned process. Anecdotal evidence indicates the corporate LLDB and overall process were both weakened when the full-time coordinator retired and was not replaced.

The team concluded that effective lessons learned processes and systems require a combination of education, training, leadership, and oversight; any given tool for capturing lessons will fail without those components. Also important is SME involvement, to include a process owner, SMEs from across major program areas of responsibility, and/or the engagement of management.

Detailed Proposals

Process Flow

The team developed notional but detailed lessons learned process flow diagrams as a way to understand the relationships and interdependencies of the various roles and steps in a lessons learned system. The flow diagrams can be found in Appendix D: Proposed Lessons Learned Process Flows, and are listed here.

- The user accesses the lessons learned database (LLDB). This assumes permission of some kind will be needed to access lessons documents from SNL major programs.
- The database administrator manages the database. This identifies tasks assigned to this role; it is not a true process flow.
- The analyst generates metrics or special reports. This assumes that the database developer will build in reporting capabilities.
- The user submits or modifies lessons learned input form.
- The control board (CB) reviews and makes decision on proposed lessons learned entry. This assumes that all entries will be reviewed by a board or panel, process owner, proprietary data reviewer, or designated SME.
- New lessons reviewed for proprietary information.
- The LLDB distributes new lessons learned. This assumes a method for interested users to self-identify as well as for distribution lists to be created and maintained.
- The CB or management infuses lessons into requirements, guidance, and training documents as appropriate.
- The user searches existing lessons learned.

We color coded activities to help distinguish the individual roles (Figure 2).

- Green, CB, is a decision making position that controls the content of lessons learned accepted into the LLDB and recommends how lessons learned can be infused into SNL work practices.
- White, User.
- Purple, LLDB.
- Pink, Proprietary Review.
- Yellow, Analyst.
- Orange, LLDB Administrator.

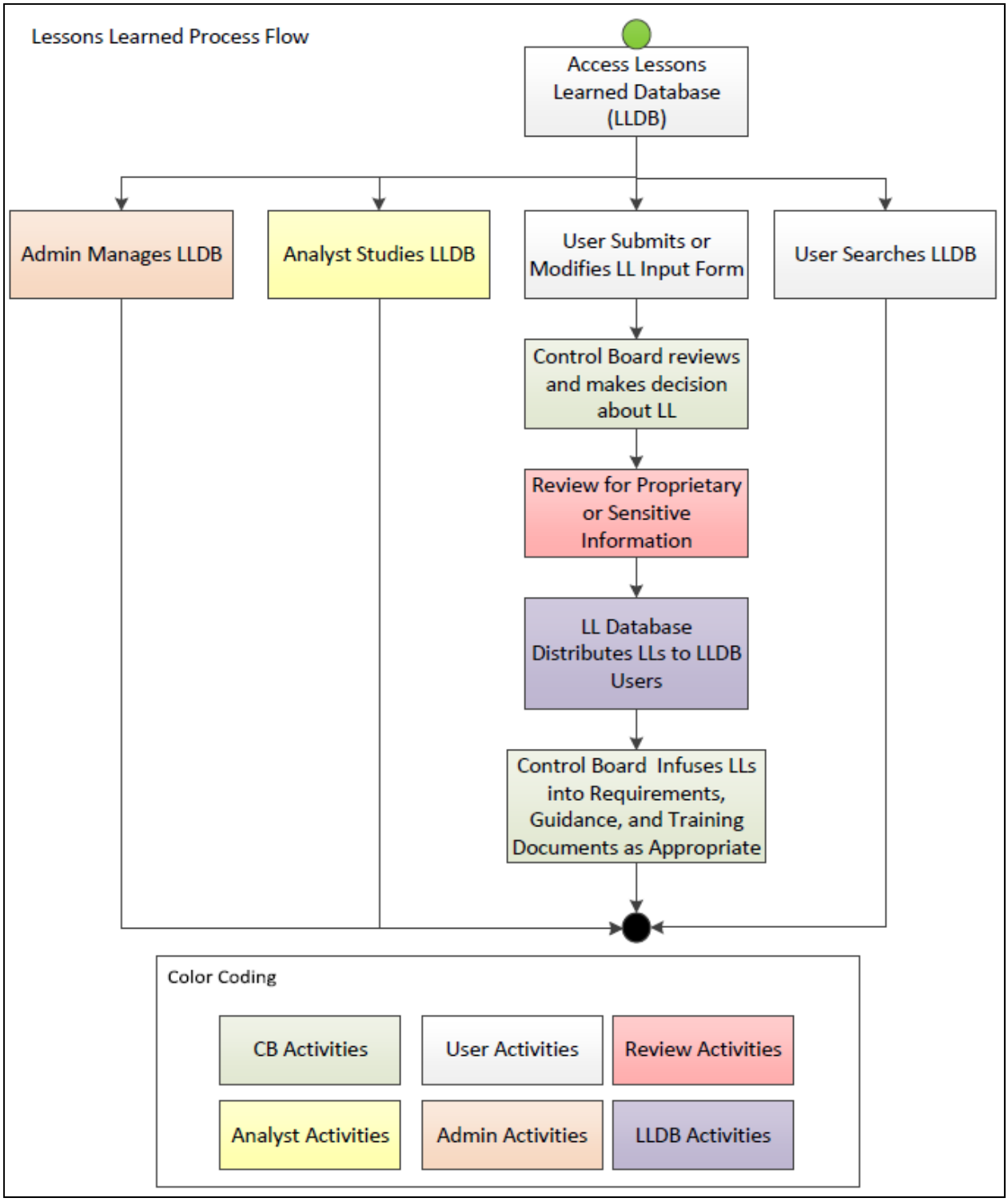

Figure 2. Lessons Learned Process Flow Overview

Archive/Database Requirements

The team had recommended development of a centralized archive. Based on its evaluation of alternative approaches compared to desired attributes (see Table 3) the team determined that some form of structured database or SharePoint site would deliver more of the desired attributes than other alternative approaches to collecting lessons learned.

We spent much time reviewing the literature and examining features of existing databases and portals such as the SNL corporate LLDB, the NASA JPL website portal, and others in advance of compiling a detailed check sheet of "database requirements." These requirements became a basis for us seeking estimates from six internal and external developers. A copy of the checksheet is attached as Appendix C: Database Requirements Check sheet and its major sections are summarized here.

1.0 General Information – This section provided information about purpose, system overview, points of contact, the audience, the users, and other related information.

2.0 Content – This section provided information about type of content/format, repositories, access and version control, the data entry process, archive needs, and related information.

3.0 Search – This section addressed searchable content types, desired advanced search capabilities, keyword search, taxonomy and metadata, ability to browse and to provide feedback and comments, and the needed ability to print and save retrieved results.

4.0 System Attributes – In this case, the word "system" was used to mean the database system; this section addressed the need for the database design to facilitate knowledge collection, storage, dissemination, and reuse**.**

5.0 Lesson Attributes – Although this was not really a database issue, the team wanted to ensure the database designers were aware of this related set of attributes.

6.0 Other – This section covered such topics as user interface, online forms, workflow, interactions with other databases, metrics reporting, and more.

The checksheet provided three pages of detail, but still there were questions from developers. One of our many lessons learned is that it is important to devote time working through requirements in detail, but equally important to recognize that just as much time will need to be spent around the table with a development team to be sure everyone is on the same page with definitions and meaning.

Database Options

We investigated the following tools:

- A commercial-off-the-shelf (COTS) tool for configuration management (CM) and product lifecycle management and is available on the SNL networks. It is used in document management, parts management, test management, and inventory management applications. For example, one major program uses this tool for document workflow control prior to publishing documents to SharePoint. It was built on Microsoft.NET framework, operates on Microsoft Windows servers with a Windows 7 client operating system, utilizes Microsoft SQL Server as a database engine, and meets HTML, JavaScript, HTTP/HTTPS, SQL, and XML standards.

- A commercially available enterprise risk management tool used at SNL has already incorporated a lessons learned application as part of the department's risk management process, using the LLPIT's lesson capture form as a model. The risk management tool is built on Microsoft.NET framework and couples to Oracle or Microsoft SQL databases. It has a web services-based application programming interface that provides integration with Microsoft, Oracle, Deltek, and SAP.

- The **Sandia corporate lessons learned database** and web portal has existed since roughly 2002. It was modeled on an earlier database developed 20 years ago by SNL's ES&H organization. In recent years, the database was expanded for use across all SNL policy areas, with spotty success. Nonetheless, the process team had explored the existing corporate database (SQL Server), web interface, and supporting processes during its scan of the internal and external environment, and found it to be a useful model with potential for usage by SNL major programs.

- A **custom database application** can be developed to meet specific LLDB needs. One particular department, at the request of the lessons learned process team, proposed to design and develop a database and document storage application using the Microsoft.NET Framework and SQL. The proposal was for a three-phase rollout, and the design would meet all of the LL process team's database requirements, with flexibility for future revisions. This was also the most costly option, when considering all three phases, and would have required SNL major programs to invest in a stand-alone system, with full responsibility for maintaining and supporting the system.

- A **SharePoint** site, based on a Microsoft-developed platform that integrates intranet applications, content management, and document management/information sharing components was also considered because of its wide use at SNL. The team was advised that SharePoint does not have the programming flexibility of Microsoft.NET Framework (proposed by the custom application option) nor is it a heavy-duty SQL database such as the corporate LLDB. In addition, the out-of-the-box version would not meet the team's requirements for data entry, workflow, and robust search. However, developers would be able to enhance the basic version with the addition of lesson entry forms, workflow management options, and moderately robust search options, making SharePoint a workable option.

The team's analysis focused on the estimated cost to implement each system and on developer responses to the requirements checklist. After reviewing the resulting responses, the capabilities of each tool, and the estimated costs, the team determined that a SQL database or SharePoint site offered the best alternatives for a robust lessons learned "engine."

The benefits to leveraging the corporate effort for SNL major programs included an existing but improved database structure, shared development and maintenance costs, and use of a centralized SNL starting point, from which major program users could be directed to major program lessons.

The team recommended that SNL major programs pursue the opportunity to leverage the corporate LLDB solution (depicted by green in Table 4's decision column), with SharePoint

(also in green) as a backup option if the corporate database was unable to meet schedule, performance, or cost requirements.

Lesson Capture Form

A good lesson is accessible, timely, and has context. It also contains categories of content similar to all other lessons learned documents, to ensure future users are able to find and understand the essential message.

The team had to balance user desire for quick and easy content creation and retrieval with usability requirements for sufficient detail. Without sufficient detail, future users would not have enough context to decide how or if a given lesson statement might apply to their immediate situation.

As shown in Figure 3, we identified 18 fields, 4 of which were deemed required for all lessons learned documents as users would be required to complete those fields. The remaining 14 fields were deemed highly desired; it was the team's recommendation that users be encouraged to provide the information requested in those fields and that SME reviewers add content to those fields if necessary.

A. Required fields

Your name

Suggest a title for your lesson learned or best practice

Tell us what happened

What did you learn from what happened?

Based on extensive review & discussion:

4 required fields
7 optional (but desired) fields
7 additional fields for SME input

B. Optional Fields

What would you recommend to others?

Suggest some Keywords

What documents, if any, capture the information in this lesson?

What is your role? (Dropdown menu)

Project or Program (Dropdown menu)

Level of assembly

Lifecycle Phase (Dropdown menu)

C. To be completed by Reviewers

Subject matter expert reviewer name, comments, and date

Review Panel Analysis

Likelihood of making the mistake again

Potential consequence if mistake occurs again

Has this been institutionalized (list any reference documents)

Key questions

Taxonomy (Dropdown menu)

Figure 3. Lessons Capture Form

The team chose these fields after an extensive review of the literature for best practices, a review of the legacy lessons learned documents, our “test case” efforts to capture essential data from existing documents, and much discussion within the team and with Human Factors and other extended team members. All sources support the conclusion that the more detail that is missing from a lesson statement the less usable the lesson will be in the future. Appendix B: Lesson Description contains detailed descriptions of these fields.

To be usable, a collection of lessons learned statements or documents must be easily searchable. Almost all of the LLDBs that the team investigated, including SNL’s corporate LLDB, allowed users to browse or search lessons by standard subject categories (taxonomy terms). This feature enhances full-text and keyword search capability because appropriately identified taxonomy terms pull together related documents, regardless of the words contained in the lesson description.

Taxonomy

We saw taxonomy terms as one of the desired elements of a good lesson, and deemed them important enough to ask the SME reviewers to take responsibility for identifying these terms.

To identify suitable taxonomy terms for a major program audience, we asked ourselves how that group of people would want to use the data and what subject categories would make sense to SNL engineers. The team identified 10 major categories and 168 related terms, which it proposes be added as a drop-down menu item to an electronic lesson capture form.

Board of Experts

The team concluded that an effective lessons learned process and system requires oversight as well as SME involvement. We recommended that SNL major programs identify a lessons learned process owner, identify a panel of SMEs from across major program areas of responsibility (i.e., systems engineering, legacy and life extension programs, components, quality, reliability, safety, production, surveillance, etc.), and engage management in the process.

As envisioned by the team, the lessons learned process owner would be an experienced technical professional with an understanding of systems engineering who would own the process, engage SMEs and management when needed, liaise with internal and external lessons learned efforts, oversee training and communication, and generally sustain a successful lessons learned system. The technical nature of the lessons descriptions we surveyed led us to conclude that an administrative professional or someone lacking a strong background in SNL major programs would be unsuited as the LL owner.

SMEs representing all technical areas of a major program could be assembled as needed to review and assess the relevance and completeness of lessons submitted to the system and to add detail to selected lesson content fields. They could also serve as informal champions and disseminators of lessons learned content. They might also form a pool of future lessons learned process owners.

Existing management of major programs would ensure that applicable lessons are infused into appropriate requirements, guidance, and training, and that the lessons learned system is afforded the attention and resources it needs.

Final Recommendations

As the team fleshed out the details of its initial recommendations, made in March 2014, it became clear we had overlooked some essential aspects. Specifically, we recognized the value of engaging experienced SMEs in the ongoing lessons learned process and we recognized the need to expand the concept of infusion beyond just RPPs, although those were a good start.

Our final specific recommendations to management were that SNL should:

- Leverage SNL's corporate LLDB, working to ensure major program-specific needs could be met.
- Consider SharePoint as an alternative, if the corporate database is not able to meet major program needs.
- Create a new full-time lessons learned process owner position as a principal or distinguished-level technical professional.
- Utilize the process owner and a hybrid of an on-call panel of SMEs or a lessons learned advisory board and the major programs as an overall CB.
- Make initial modifications to RPPs to facilitate not just the creation, but also the use of lessons learned.
- Infuse lessons learned awareness not just into requirements documents but also into documents, other procedures, and training programs.
- Create a recommended structure for consistency in capturing attributes consistent with the desired attributes mentioned above.
- Consider and investigate additional options and sources of information.

Leverage Corporate Lessons Learned Database

As stated in the section titled "Centralized Portal or Repository," the team concluded that, at a minimum, SNL must make it easier for its engineers and other staff to locate lessons-related documents. This could be accomplished by identifying all such documents and creating a centralized portal that would point to existing collections, or by pulling relevant electronic and print documents into a centralized repository.

The team recommended that SNL begin by pursuing the opportunity to leverage the corporate LLDB solution to capture and disseminate lessons and best (or good) practices going forward, with SharePoint as a backup option if the corporate database was unable to meet schedule, performance, or cost requirements. It will also be essential to develop a plan for adding useful legacy lessons documents to the database and/or otherwise making them more easily accessible.

Create a Process Owner and Control Board

Experience with SNL's ES&H and corporate lessons learned portal indicates that *someone* must own the lessons learned process and have primary responsibility for managing and coordinating the lessons learned process.

Process Owner

The lessons learned process owner would have the essential role of building a sustainable organizational system in which lessons are truly learned. He or she would need to recognize and

meet the challenges inherent in creating and sustaining the needed culture for that to happen and have the support needed to address those challenges. The process owner, working with a CB or board of experts would be responsible for the following duties:

- owning the lessons learned process and building a stable process;
- recommending or performing lessons learned process improvements;
- recognizing and recommending infusion opportunities;
- identifying SMEs to evaluate lessons identified or to otherwise support the process (broad experience across disciplines and major programs)
- coordinating SME or "board of experts" interactions/reviews;
- ensuring lessons are submitted as expected;
- ensuring lesson consistency, accuracy, and completeness;
- ensuring dissemination;
- ensuring lessons learned reports, briefings, and other documents are archived per the process;
- identifying appropriate metrics and monitoring them;
- recommending or performing lessons learned analyses;
- recommending or performing lessons learned process improvements;
- overseeing training and communication on lessons learned and process;
- engaging major programs as needed;
- engaging with other internal and external entities on lessons learned;
- interacting with the database administrators; and
- integrating with NNSA Systems Engineering and Integration (NA-18).

In the absence of a process owner, SNL management would need to decide how these duties would be accomplished.

Desired Skills

The candidates should have broad and significant technical experience within SNL major programs, possess systems engineering knowledge, have a knowledge of and interest in principles of continuous improvement, lessons learned, and KM, and be a distinguished-level staff member.

Options for Owning and Governing the Lessons Learned System

The first option utilizes a full-time process owner. The LLPIT believes it will be very difficult to implement a successful lessons learned system without full-time attention, particularly in the years leading up to a steady state.

As a second option, there could be an interim half-time process owner to explore and recommend the right approach; perhaps a senior technical staff person with a passion for continuous improvement approaches who wants to build a stable process.

The third option establishes a panel with a coordinator. The panel members would be SMEs from Systems Engineering, Legacy Systems, Life Extension Programs, Components, Quality, Reliability, Safety, Production, and/or Surveillance (as appropriate) with an additional SME on lessons learned or KM processes and methodologies. Note here that the panel members would be

doing the required work (cost equivalent to a half- or full-time or more, but split across departments). A final option is to employ some combination of the preceding options, for example, two half-time people with different responsibilities.

Facilitate Utilization of Lessons Identified

For the most part engineers are on their own to find lessons that might be valuable to their efforts. The team found little evidence of concerted efforts to distribute or share information about specific lessons or the archives in which they are located.

Lessons tend not to be durable in a practical sense. Whether due to an inability to find documented lessons, having to sift through too much information, difficulty interpreting the lessons, or a disinclination to use them, lessons of the past are lost and must be relearned.

As previously stated, a true lesson learned is an implemented solution that leads to improved performance or changed behavior. For a lesson to become learned it needs support along the way. It must become known (disseminated, explained, and taught) and its recommended (and vetted) solutions must be infused into behavior expectations and job requirements, for example, by being institutionalized in RPPs or other guiding documents.

Investigate Additional Options

The LLPIT identified some additional options for increasing the impact of a lessons learned system, but determined it would be best for the implementation team to identify additional options as needed after it had time to assess results of initial efforts. For example, we recognized that videos or other similar media could be better utilized to reinforce how lessons are identified, communicated, and learned. We also noted that attention to the development and implementation of a successful lessons learned effort would be increased by escalating the effort to a corporate milestone.

A lessons learned system fits into the broader context of organizational knowledge transfer and KM efforts. Within SNL major programs, lessons learned initiatives must be integrated into the overall learning system, which spans such efforts as knowledge preservation activities and the training curriculum.

This report summarizes the recommendations of the LLPIT for a lessons learned process and, to an extent, a lessons learned system that addresses human behavior, incorporates education and training, and fits into the broader context of knowledge transfer and KM efforts and learning initiatives. The recommendations are being transitioned to an implementation team, responsible for taking the research and examples provided in this report and developing the path forward to implementing an effective lessons learned and knowledge capture system.

In business and industry at large, the role of CKO or chief learning officer (CLO) was created to ensure executive leadership focus on KM strategies and to ensure these efforts are sustained. Use of the role has ebbed and flowed over the past 15 years, but there is some indication of a moderate relationship between the presence of organization-wide KM systems, including the appointment of executive level officers, and organizational effectiveness and revenue (Harlow, 2014).

No such CKO position currently exists at SNL, but the LLPIT suggests that SNL major programs could consider elevating attention to its lessons learned system and broader KM efforts by identifying a Chief Knowledge Officer. The CKO should be expected to:

- Be responsible for managing intellectual capital and the stewardship of KM practices in an organization
- Be an organizational leader, responsible for ensuring that the organization maximizes the value it achieves through "knowledge"
- Ensure that the company profits from the effective use of knowledge resources, which may include employees, processes, and intellectual property; the CKO can help an organization maximize the ROI on those investments
- Lead further development and use of KM, especially with the aid of information technology resources, as enablers for mission success
- Be responsible for knowledge and unstructured information and managing those assets

The team's recommendations about the role of the lessons learned process owner were influenced, in part, by the role of NASA JPL's CKO and by descriptions of CKO qualifications and roles,[6] for the following reasons:

- *Knowledge is a basic economic resource*. The modern era is characterized by rapid change and uncertainty, and new knowledge is constantly created that must be consistently disseminated throughout the organization and embodied in its technologies and products. Technology companies typically have a greater investment in intellectual capital than in physical capital such as buildings and machinery.
- *Companies are not good at managing knowledge*. They often undervalue the creation and capture of knowledge, lose or give away what they possess, deter or inhibit knowledge sharing, and underinvest in both using and reusing the knowledge.

These KM shortcomings are especially true of tacit or unarticulated knowledge:

- That which is more personal, experiential, context specific, and hard to formalize
- Is difficult to communicate or share with others
- Is generally in the heads of individuals and teams

The LLPIT offers these recommendations, summarized in Figure 4, to the SNL lessons learned implementation team as a guide to a durable lessons learned process and system.

[6] See, for example, Michael Earl's and Ian Scott's "What is a Chief Knowledge Officer," *Sloan Management Review*, Vol. 30, no. 2, 1999. http://sloanreview.mit.edu/article/what-is-a-chief-knowledge-officer/

- Leverage SNL's corporate LLDB, working with the owning organization to ensure program-specific needs can be met.
- Consider SharePoint as an alternative, if the corporate database is not able to meet program needs.
- Create a new full-time SNL lessons learned process owner position as a principal- or distinguished-level technical professional.
- Utilize the process owner and a hybrid of an on-call panel of SMEs or a lessons learned advisory board and the major programs as an overall CB.
- Make initial modifications to RPPs to facilitate not just the creation, but also the use of lessons learned.
- Infuse lessons learned awareness not just into requirements documents but also into documents, other procedures, and training programs.
- Create a recommended structure for consistency in capturing attributes consistent with the desired attributes mentioned above.
- Consider and investigate additional options and sources of information.

Figure 4. Final Recommendations, July 2014

PATH FORWARD

The team's sixth and seventh objectives were to gain concurrence on a path forward for the SNL lessons learned process and to transition the effort to an implementation team. As of the end of FY2014:

- Management approved the proposal to leverage the corporate LLDB.
- The LLPIT briefed SNL management at a lessons learned kaizen event and engaged with the lead department for the corporate LLDB upgrade project. We shared our database requirements checklist and other documents with the corporate database project lead, who began incorporating aspects of the work into the proposed upgrade design. Developer cost estimates should be available in early 2015.
- Management resonated with the concept of a board but was unconvinced that a full-time process owner was needed and asked the team to consider whether the responsibilities could be effectively handled in some other way. Members of the LLPIT accepted responsibility to work with the incoming implementation team to consider and propose alternatives, which have been summarized in the section titled "Create a Process Owner and Control Board."
- Changes were considered for the initial selected set of RPPs.
- The LLPIT worked with SNL management to identify a lessons learned implementation team that will report to program management, implement recommendations, investigate other options, and socialize the SNL lessons learned process proposal with a wider audience.

Figure 5 presents the proposed tasks of the implementation team.

FY15 Implementation Phase	FY16-17 Launch Phase	FY18+ Steady State (fully infused process)
• Pilot Process (database, training, RPPs, infusion, etc.) • Incorporate Study Group Recommendations • Gather Stakeholders & SMEs	• Refine Working Process • Incorporate Past LLs • Re-engage Stakeholders & SMEs • Identify Inclusion of LLs into Corporate KM Processes • Document Process	• Manage and Evaluate Process • Re-engage Stakeholders & SMEs • Maintain as Active KM Process
Level of Effort: Database Designer (~xx)	Level of Effort: Database Admin. (<0.10)	Level of Effort: Database Admin. (<0.10)
Level of Effort: Project Team (tbd) LL Position (tbd)	Level of Effort: Project Team (tbd) LL Position (tbd) Advisory Panel/Board (tbd)	Level of Effort: LL Position (tbd) Advisory Panel/Board (tbd)

Figure 5. Proposed Path Forward FY15 through FY18

IN SUMMARY

The purpose of a lessons learned system is to enable people in an organization to learn from past experiences, good and bad, to make better decisions in the present and the future.

In this report, the LLPIT provided recommendations on a path forward for a future lessons learned implementation team. This path forward considered a lessons learned environment that encompassed not only the lessons learned process and lessons learned system, but also addressed human behavior, incorporates education and training, and fit into the broader context of organizational knowledge transfer and KM efforts and of SNL learning initiatives. Lessons learned initiatives must be integrated into the overall SNL learning system, which spans such efforts as knowledge preservation activities and the SNL training curriculum.

Although the team did not address KM in depth, we believe it represents a major challenge for SNL. The related lessons learned environment describes the tools and practices whereby information about experiences (lessons or good practices) is collected, verified, stored, disseminated, retrieved for reuse, and assessed for its ability to positively affect organizational goals.

We investigated the lessons learned literature and government websites, and we interacted with NASA JPL to understand their experience and recommendations for a successful lessons learned process and system. Our study found that the documented lessons themselves must contain sufficient applicable information to make them actionable. Lessons learned process attributes were identified and incorporated into the team's consideration of related process and system approaches.

We recommended a LLDB based on the corporate LLDB platform, a consistent format for lessons descriptions codified by a template, a search-enhancing taxonomy, a lessons learned process flow, a technical lessons learned process owner, and a board that aids with lesson maturation and infusion. Management approved the recommendation to pursue leveraging the corporate LLDB platform. An implementation team will further determine the lessons learned process and how best to incorporate recommendations around process owner and board involvement and interactions.

The lessons learned system is part of a larger SNL organizational system that is accountable to internal and external forces and that addresses risk management, quality assurance, and KM, all of which incorporate aspects of lessons learned.

DEFINITIONS

Best Practice	A positive example of work processes with the potential to be the basis for significant operational improvements or cost savings.
Good Practice	A practice that has been proven to work well and produce good results, and is therefore recommended as a model. It is a successful experience, which has been tested and validated, in the broad sense, which has been repeated and deserves to be shared so that a greater number of people can adopt it.[7] (This is typically what is meant by the phrase "best practice" as well.)
Knowledge Management	Knowledge management is the name of a concept in which an enterprise consciously and comprehensively gathers, organizes, shares, and analyzes its knowledge in terms of resources, documents, and people skills.[8]
Lesson Identified	An observation that has been subjected to additional analysis to identify such things as potential future consequences or impact, possible root causes, and/or appropriate remedial or corrective action.
Lesson Learned	An implemented solution that leads to improved performance or changed behavior. For a lesson to become learned it needs support along the way. It must become known (disseminated, explained, and taught) and its recommended (and vetted) solutions must be infused into behavior expectations and job requirements.
Observation	A basic description of an operating experience, either a problem or a success. The experience has been identified and documented in some way as an issue for improvement or a potential best practice.

[7] As defined by the Food and Agriculture Organization of the United Nations, in contrast to a "best practice", which it states may imply that no further improvements are possible. http://www.fao.org/docrep/017/ap784e/ap784e.pdf
[8] http://searchdomino.techtarget.com/definition/knowledge-management.

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APPENDIX A: ANNOTATED BIBLIOGRAPHY

Following is a bibliography of articles, book chapters, conference papers, and other documents that address various aspects of lessons learned systems. The bibliography is presented in two sections.

Section One sorts the by keyword with each keyword followed by a bibliographic list of the relevant documents. **Section Two** sorts the content by title with a list of keywords and an abstract provided for each document.

Section One: Keywords

Artificial Intelligence (1)

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Attributes (6)

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Section Two: Titles

A framework and findings for learning based project reviews

Kotnour, Tim and Catherine Vergopia. "A framework and findings for learning based project reviews." In *PICMET 2007, Portland International Center for Management of Engineering and Technology*, 2074-79: IEEE, 2007.

KEYWORDS: Best Practices, Processes, Project Reviews

ABSTRACT: The authors' research focuses on developing best practices for "learning-based program/project reviews" that provide real-time routine opportunities to create, capture, share, and apply both tacit and explicit knowledge throughout a project life-cycle, not just during a "lessons learned" session at the end of the project. They highlight tools used for various types of reviews but acknowledge that most do not focus on "across project" reviews or understanding of organizational wide issues.

A learning framework for project management

Kotnour, Tim. "A learning framework for project management." *Project Management Journal.* 30 (1999): 32-38.

KEYWORDS: Processes, Project Reviews

ABSTRACT: This paper develops a framework for project management and learning processes using the plan-do-study-act (PDSA) cycle. The "act" step is the use of lessons learned on the next project,

during the planning phase. Both inter-project and intra-project learning cycles are examined. The paper suggests that 1) the use of lessons learned can be conducted throughout a project lifecycle, not just at the end of the project, and 2) the learning process can break down at any stage of the PDSA cycle. It offers a set of questions to guide learning; answering the questions helps the project team develop lessons learned.

A practical solution for incorporating lessons learned

Nicol, Alan. "A practical solution for incorporating lessons learned." *Manufacturing.net*, http://www.manufacturing.net/articles/2011/12/a-practical-solution-for-incorporating-lessons-learned.

KEYWORDS: Collection/Sources, Communication, Databases and Websites, Pitfalls

ABSTRACT: The author asserts that lessons learned databases tend to be cumbersome, messy, and difficult to use effectively. They may be useful for maintaining an historical record of lessons learned, he states, but for actionability he proposes that short, real-time, actionable notes be added to the product development roadmap or checklist. Communication and discussion would occur at regular reviews such as design reviews or gate reviews.

A software engineering lessons learned repository

Harrison, Warren. "A software engineering lessons learned repository." In *Software Engineering Workshop, 2002. Proceedings. 27th Annual NASA Goddard/IEEE Software Engineering Workshop*, 139-43: IEEE, 2002.

KEYWORDS: Characteristics, Communication, Data Fields, Databases and Websites, Dissemination, Processes, Project Reviews

ABSTRACT: The author believes post-project reviews (PPRs) can collect very good lessons learned, but the information contained in those lessons must be easy to extract or it will not be used. The paper highlights the characteristics of a good lessons learned (it is based on behavior or results that actually occurred, it is applicable to other situations - not too general but not too specific, and it is valid- both factually and technically correct.) It identifies high-level processes or activities (collection, storage & maintenance, and retrieval & distribution.) It also highlights the importance of being able to access the information contained in reports or other lessons learned documents by various topics, based on what the user needs. It also describes, at a high level, a web-based lessons learned repository, some of the data fields, and some of the lessons learned about the archive.

Accident data for the semantic web

Benner Jr., Ludwig. "Accident data for the semantic web." *Safety Science.* 50 (2012): 1431-37.

KEYWORDS: Databases and Websites, Dissemination, Pitfalls

ABSTRACT: With a focus on accident data and safety, the paper's premise is that current lessons learned systems do not maximize learning. The paper summarizes some current lessons learned practices and impediments to learning. Underlying impediments to learning are summarized as: 1) perception of end-users' data needs limits the data made available, 2) the use of natural language, with its wide range of vocabulary, syntax, meaning, etc., impedes manual analysis and machine analysis, 3) software obsolescence, 4) liability concerns, and 5) other impediments. There is a

need to refocus on behavior data needed by users and on behavioral inputs and outputs during investigations.

Active case-based reasoning for lessons delivery system

Weber, Rosina, David W. Aha, Karl Branting, J. Robert Lucas, and Irma Becerra-Fernandez. "Active case-based reasoning for lessons delivery system." In *FLAIRS Conference*, 170-74, 2000.

KEYWORDS: Communication, Data Fields, Lessons Learned Statements/Descriptions, Knowledge Management, Processes, Systems

ABSTRACT: The paper states that exploiting lessons learned is a key knowledge management task, but that most lessons learned systems are passive, stand-alone systems, whereas practical knowledge management systems should be active. By this the authors mean a repository that alerts the decision maker as needed in the context of the decision-making process. The paper introduces a general architecture for such an approach, based on military planning systems. The paper also identifies the most useful text fields for retrieving lessons, as found in the military Joint After-Action Reporting System (JAARS). Those fields are: keywords, task name, observation (concise summary of the context and lesson), discussion (multi-paragraph description), lesson learned (concise summary of the lesson), and recommended action (brief summary of how to interpret the lesson in future contexts.)

Air Force lessons learned program

USAF. *Air Force lessons learned program*. Air Force Instruction 90-1601, 2010.

KEYWORDS: U.S. Air Force, Collection/Sources, Data Fields, Dissemination, Processes

ABSTRACT: This publication implements Air Force Policy Directive (AFPD) 90-16, Air Force Studies, Analyses, Assessments and Lessons Learned. It provides guidance for the Air Force Lessons Learned Program (AFL2P) to include developing standards for major activities under the Air Force Lessons Process (AFLP). It covers all activities associated with lessons learned support.

An empirical comparison study of the effect of chief knowledge management officers and knowledge management systems on innovation and financial outcomes

Harlow Harold. "An empirical comparison study of the effect of chief knowledge management officers and knowledge management systems on innovation and financial outcomes." In *Proceedings of the 15th European Conference on Knowledge Management: ECKM2014*, October 2014.

KEYWORDS: Knowledge Management

ABSTRACT: This paper reports on the results of an empirical study of the relationship of knowledge management executives' presence at firms and the knowledge management system maturity level at those firms to firm performance.

Assessing propensity to learn from safety-related events

Drupsteen, Linda and Jean-Luc Wybo. "Assessing propensity to learn from safety-related events." *Safety Science*. 71, no. 2015 (2014): 28-38.

KEYWORDS: Organizational Behavior

ABSTRACT: The authors attempted to identify a set of indicators that would determine an organization's propensity (inclination) to learn, positing that an organization with a high propensity to learn is an organization that is very likely to learn from an event or operating experience. They hypothesize that an organization with a propensity to learn has a propensity to perform each of the steps in a learning process, that members of that organization have a propensity to share information throughout the learning process, that the members have a positive attitude toward learning, and that if the organizational conditions for learning exist within an organization, the propensity for learning from experience is higher than if those conditions do not exist.

Assuring that lessons learned critical to mission success get used

Oberhettinger, David. "Assuring that lessons learned critical to mission success get used." In *2012 IEEE Aerospace Conference*, 2012.

KEYWORDS: Communication, Dissemination, Lessons about Lessons Learned, NASA, Processes

ABSTRACT: In the face of evidence that NASA programs and projects were failing to apply lessons learned despite the longstanding existence of an established process for documenting and disseminating the lessons, NASA's Jet Propulsion Laboratory (JPL) implemented a three-pronged approach to assure that NASA lessons learned get used by JPL spaceflight projects:

1. Targeted distribution - technical discipline experts best suited to take preventive action receive newly published entries in the lessons learned system
2. Project self-assessment - JPL subject matter expert (SME) is assigned each new lesson learned entry to determine applicability, assess potential impact, evaluate project compliance, and propose a course of action
3. Lessons learned infusion - lessons learned entries are cross-referenced to specific paragraphs in JPL's two mandatory core engineering standards AND lessons are forwarded to the JPL line organization for appropriate action at the discretion of the process owner

Attributes of a good lessons learned

U.S. Department of Energy (DOE). “Attributes of a good lessons learned.” Produced by the U.S. Department of Energy Operating Experience Committee, May 6, 2009.

KEYWORDS: Attributes

ABSTRACT: This document outlines the attributes to look for in a good lessons learned (or "lessons identified") document, and those attributes to avoid.

Avoiding common pitfalls in lessons learned processes that support decisions with significant risks

Rogers, Edward W., Robin L. Dillon, and Catherine H. Tinsley. "Avoiding common pitfalls in lessons learned processes that support decisions with significant risks." In *Aerospace Conference, 2007*, 1-7: IEEE, 2007.

KEYWORDS: Dissemination, Lessons about Lessons Learned, Metrics, NASA, Pitfalls, Processes

ABSTRACT: This paper identifies common pitfalls in three steps of the process: collecting lessons learned, managing lessons learned systems (storage), and applying lessons learned appropriately (dissemination). The paper describes how these "lessons about lessons learned" were applied at the NASA Goddard Space Flight Center. A high-level process flow diagram is included. Of

particular note is the admonishment that what hurts lessons learned application is the expectation that the system will provide people with *answers* rather than help them formulate *questions* to figure out how to solve their own problems.

Building a better lessons learned program

Miller, Charles F. and W.F. Steinke. *Building a better lessons learned program*. Idaho National Engineering and Environmental Laboratory, 2002.

KEYWORDS: Attributes, Case Studies, Communication, Data Fields, Lessons about Lessons Learned, Pitfalls, Processes, Systems

ABSTRACT: The report provides a case study of change to a lessons learned system over a two-year period, in response to a fatal accident at Idaho National Engineering and Environmental Laboratory (then INEEL, now INL, Idaho National Laboratory.) The report identifies problems encountered and efforts to solve the problems.

Categorizing intelligent lessons learned systems

Weber, Rosina, David W. Aha, and Irma Becerra-Fernandez. "Categorizing intelligent lessons learned systems." In *Intelligent Lessons Learned Systems: Papers from the AAAI 2000 Workshop*, 63-67, 2000.

KEYWORDS: Communication, Knowledge Management, Processes, Systems

ABSTRACT: The authors propose a two-step categorization method to support the design of intelligent lessons learned systems. Such systems may be needed because, the authors state, interviews with multiple members of lessons learned centers indicated that existing lessons learned systems, although well-intentioned, are rarely used. The paper states that addressing these categorizations can help identify an adequate design methodology for intelligent lessons learned systems, though no such design methodology is described in this paper.

CDC unified process practices guide: Lessons learned

CDC. *CDC unified process practices guide: Lessons learned*, edited by Centers for Disease Control and Prevention, 2006.

KEYWORDS: Best Practices, Processes, Systems

ABSTRACT: This CDC handout, and a related set of documents linked from the handout, provides a lessons learned process overview for project teams at the CDC. It touches on requirements, best practices, activities, and key terms. Referenced in the handout, with links provided, are several related documents - a project lesson learned log template, a checklist for effective project lessons learned, and a post-project survey template.

Common taxonomy fuels a learning engine

Johnston, John M. *Common taxonomy fuels a learning engine*. BAE Systems, 2008. presentation slideset.

KEYWORDS: CMMI, Metrics, Taxonomies

ABSTRACT: This set of briefing slides describes the connection among risks, issues, and lessons learned, and the value of a common taxonomy. It suggests the need for flexibility in categories, with opportunity for user input, and the ability to add or delete categories over time.

Considerations for implementing an organizational lessons learned process

Fosshage, Erik. *Considerations for implementing an organizational lessons learned process*. SAND2013-3671. Albuquerque, NM: Sandia National Laboratories, 2013.

KEYWORDS: Attributes, Bibliography, Pitfalls, Processes

ABSTRACT: This report reviews the literature on lessons learned (LL) and synthesizes findings for the following topics: Lessons learned definitions, causes of LL system failure, relationship of LL and "the learning organization," integrating LL into organizational processes, proposed system attributes and next steps. A high-level U.S. DOE lessons learned process flow diagram is included.

Criteria for lessons learned (LL)

Cowles, Thomas R. *Criteria for lessons learned (LL), 4th annual CMMI technology conference and user group*. Raytheon unpublished presentation slideset, 2004.

KEYWORDS: CMMI, Pitfalls, Processes

ABSTRACT: This set of presentation slides examines criteria for a lessons learned process within the context of the CMMI (Capability Maturation Model Integration) model, and identifies lessons learned references in the CMMI. It also defines elements in a generic lessons learned process: collection, verification, storage, dissemination, reuse and OID (organizational innovation and deployment) identification.

Cutting the cost of not knowing: Lessons learned systems people really use

APQC. *Cutting the cost of not knowing: Lessons learned systems people really use*. edited by American Productivity and Quality Center, 2010.

KEYWORDS: Best Practices, Center for Army Lessons Learned (CALL), Lessons about Lessons Learned

ABSTRACT: This document provides a high-level summary of a 2009 APQC collaborative research study to investigate the reasons that cause many organizations that successfully capture lessons learned to still struggle with actually learning from them and applying them. The summary identifies best practices as gleaned from three best-practice organizations that participated in the study: CALL, ARDEC, and Credit Suisse.

Developing a systemic lessons learned knowledge model for organisational learning through projects

Duffield, Stephen and S. Jonathan Whitty. "Developing a systemic lessons learned knowledge model for organisational learning through projects." *International Journal of Project Management*, 2014 (in press.)

KEYWORDS: Communication, Dissemination, Processes

ABSTRACT: The authors state that in practice, organizational learning from projects rarely happens, and when it does, it fails to deliver the intended results. However, based on the successes of some organizations, the authors developed a conceptual model (SYLLK) adapted from Reason's Swiss cheese model, to enable project organizations to conceptualize how they learn from past project experiences and distribute successful project know-how across an organizational network of elements such as individual learning, culture, social, technology, process and infrastructure. They show how the SYLLK model can influence the identification, dissemination, and application of project management lessons learned.

Development of a methodology for lessons learned practice: From post-project learning to continuous process-based learning

Chirumalla, Koteshwar. *Development of a methodology for lessons learned practice: From post-project learning to continuous process-based learning.* Doctoral Thesis, Lulea University of Technology, 2013.

KEYWORDS: Best Practices, Bibliography, Case Studies, Pitfalls, Processes

ABSTRACT: The author used data from three case studies to show that effective lessons learned (LL) practices require a continuous approach with a standard format, and identifies eleven functional requirements for overcoming outlined barriers (pitfalls) and improving processes. Based on analysis of the functional requirements, the author proposes a methodology for representing LL in a standardized format together with guidelines, using videos and storytelling as enabling media.

Establishing a lessons learned program

CALL. *Establishing a lessons learned program.* No. 11-33. Fort Leavenworth, KS: Center for Army Lessons Learned, 2011.

KEYWORDS: Best Practices, Center for Army Lessons Learned (CALL), Dissemination, Lessons Learned Statements/Descriptions, Metrics, Organizational Behavior, Processes, Collection/Sources, Storage

ABSTRACT: This handbook was developed as a "how-to guide" for other organizations interested in developing or refining their own lessons learned programs. Its three chapters describe and discuss the purpose of a lessons learned program, the functions of a lessons learned program, and the organizational considerations involved when establishing a lessons learned program. Lessons learned programs can be and should be crafted to meet the unique needs of the organization, but they should have at least six functions: collect (sources for lessons learned), analyze, share (disseminating information), archive (databases & websites; workflow), resolve (address issues), and assess (metrics). Each function is discussed.

Implementing knowledge sharing systems and establishing a culture to share lessons learned within a multidisciplinary company enhancing effective knowledge transfer

Hinze, Iris, Phil Perry, George T. Jacob, and Wade V. Wise. "Implementing knowledge sharing systems and establishing a culture to share lessons learned within a multidisciplinary company enhancing effective knowledge transfer." In *SPE Annual Technical Conference and Exhibition*, 1659-67: Society of Petroleum Engineers, 2012.

KEYWORDS: Databases and Websites, Dissemination, Knowledge Management, Processes, Systems

ABSTRACT: The authors describe how an oilfield services company developed and expanded tools to enable cross-disciplinary teams to capture, share, and reuse validated knowledge. They also describe how employees were engaged in the process through managerial support, user roles, training, professional development, systems integration, communications, surveys, etc.

Intelligent lessons learned systems

Weber, Rosina, David W. Aha, and Irma Becerra-Fernandez. "Intelligent lessons learned systems." *Expert Systems with Applications.* 17 (2001): 17-34.

KEYWORDS: Artificial Intelligence, Collection/Sources, Communication, Decision Support Dissemination, Knowledge Management, Lessons Learned Statements, Processes, Systems

ABSTRACT: This journal article follows the conference paper from the AAAI 2000 workshop. It describes again a two-step categorization method to support the design of intelligent lessons learned systems. Such systems may be needed because, the authors state, interviews with multiple members of lessons learned centers indicated that existing LL systems are rarely used. The article then highlights barriers, as found in existing lessons learned systems, to creating the kinds of representations needed by artificial intelligence (AI) approaches. It suggests three issues to resolve when designing LL systems, and provides examples.

ITS Taxonomy: Taxonomy of intelligent transportation systems applications

DOT. *ITS Taxonomy: Taxonomy of intelligent transportation systems applications*. edited by U.S. Department of Transportation, 2012.

KEYWORDS: Taxonomies, U.S. Department of Transportation (DOT)

ABSTRACT: The Taxonomy is the classification scheme used to categorize system costs summaries. The figure contained in the PDF file depicts the categories used within the "Browse System Costs By Application" section of the Costs Database. [summary from the its.dot.gov website] This document is included as a sample taxonomy.

Knowledge management (KM) processes in organizations: Theoretical foundations and practice

McInerney, Claire R. and Michael E.D. Koenig. *Knowledge management (KM) processes in organizations: Theoretical foundations and practice*. Morgan & Claypool, 2011.

KEYWORDS: Knowledge Management, Processes, Taxonomies

ABSTRACT: This document traces the evolution of KM in organizations, summarizing the most influential research and literature in the field. It also presents an overview of selected common and current practices in knowledge management, including the relationship between knowledge management and decision making, with the intention of making a case for KM as a series of processes and not necessarily a manipulation of things (from authors' abstract). Some key points: the importance of frameworks for classifying information (e.g. APQC's Process Classification Framework is used by some); the importance taxonomies and of assigning index terms, tagging, or metadata to all "knowledge objects"; importance of providing sufficient context for the information to be used appropriately; importance of criteria for such things as: who "vets" the lessons learned as worthwhile, who monitors the system, and how and when are lessons archived and/or deleted from the database.

Knowledge reuse in action: the case of CALL

Chua, Alton Y.K., Wing Lam, and Shaheen Majid. "Knowledge reuse in action: the case of CALL." *Journal of Information Science.* 32, no. 3 (2006): 251-60.

KEYWORDS: Attributes, Case Studies, Center for Army Lessons Learned (CALL), Knowledge Management, Processes, Search Tools

ABSTRACT: Using the Center for Army Lessons Learned as a "case study" (albeit one based solely on literature review rather than actual contact), the authors investigate how the process of knowledge reuse can be implemented and sustained. It briefly describes relevant steps in the process. With regard to "search", the CALL database uses two indexing schemes. The first is structural indexing based on keywords, attributes of the learning events, and an army-wide coding scheme of conditions, tasks, and standards. The second is a process-based indexing scheme developed on the organizational processes and functions mapped in an army-wide handbook.

Learning from risks: A tool for post-project risk assessment

Dikmen, I., M.T. Birgonul, C. Anac, J.H.M. Tah, and G. Aouad. "Learning from risks: A tool for post-project risk assessment." *Automation in Construction.* 18, no. 1 (2008): 42-50.

KEYWORDS: Case Studies, Databases and Websites, Pitfalls, Risk Management

ABSTRACT: The authors hypothesize that a learning-based approach to risk management may remove some of the bottlenecks observed in risk management applications in practice. They developed a database system, using Microsoft Access, to facilitate learning from risks in construction companies. Features, benefits, and some pitfalls of the database tool are described.

Lesson write-up guide, version 3.1

Kabir, Firoz and Brian Philips. *Lesson write-up guide, version 3.1*. edited by U.S. Department of Transportation ITS Joint Program Office, 2008.

KEYWORDS: Characteristics, Data Fields, Lessons Learned Statements/Descriptions, Taxonomies, U.S. Department of Transportation (DOT)

ABSTRACT: This document provides guidance on how to write up and submit lessons learned to the U.S. Department of transportation, Intelligent Transportation Systems lessons learned database. Lesson write-up samples, a template, and definitions are provided. Appendix A provides a taxonomy of the major categories and their related subcategories.

Lessons learned about lessons learned

Wellman, Jerry. "Lessons learned about lessons learned." *Organizational Development Journal.* 25, no. 3 (2007): 65-72.

KEYWORDS: Human Factors, Lessons about Lessons Learned, Organizational Behavior, Pitfalls, Processes

ABSTRACT: The article describes the strengths, shortcomings, and interactions of the four ways that organizations capture what they have learned: culture, old pros, archives, and process.

Lessons learned and best practices database user manual

LBL. *Lessons learned and best practices database user manual*. Ernest Orlando Lawrence Berkeley National Laboratory, 2007.

KEYWORDS: Communication, Data Fields, Databases and Websites, Dissemination
Lessons Learned Statements/Descriptions, Processes

ABSTRACT: This document is a 2007 user manual for the Lawrence Berkeley Laboratory lessons learned and best practices database. It provides descriptions of all data input fields, and itself is an example of user-oriented communication tool.

Lessons learned system for Kentucky transportation projects

Goodrum, Paul M., Mohammed F. Yasin, and Donn E. Hancher. *Lessons learned system for Kentucky transportation projects.* KTC-03-25/SPR-262-03-1F. Lexington, KY: Kentucky Transportation Research Center, University of Kentucky, 2003.

KEYWORDS: Data Fields, Databases and Websites, Lessons about Lessons Learned, Processes, Systems

ABSTRACT: Describes the development of a centralized web-based lessons learned system for the Kentucky Transportation Cabinet. Three database platforms were considered: MS Access, MySQL, and Oracle. MS Access was chosen because of compatibility with existing software and an already existing related database. The report recommends relatively straightforward processes; more complex flows may provide more intensive learning opportunities but require so many resources they often fail. The report also recommends three types of users, with different levels of access: end users, gatekeepers, and database administrators.

Lessons learned: Improving performance through organizational learning

Carnes, W. Earl and Bruce Breslau. "Lessons learned: Improving performance through organizational learning." In *Human Factors and Power Plants, 2002. Proceedings of the 2002 IEEE 7th Conference*, 2-23, 2002.

KEYWORDS: Communication, IEEE Working Group 5.5, Knowledge Management, Lessons about Lessons Learned, Organizational Behavior, U.S. Department of Energy (DOE)

ABSTRACT: This paper describes the history and status of the DOE lessons learned program, including identification of communication methods, metrics, and "lessons learned about lessons learned." Reportedly, IEEE Working Group 5.5 was using the DOE lessons learned experience to craft an IEEE standard on the key attributes of effective lessons learned programs for nuclear facilities.

Lessons learned: It's the right thing to do

Sidell, Sue Ann. "Lessons learned: It's the right thing to do." In *American Society for Quality Control (ASQC) 47th Annual Quality Congress*, 1993.

KEYWORDS: Communication, Dissemination, Processes

ABSTRACT: This 20-year old paper describes an electronic lessons learned system developed at Martin Marietta Energy Systems (predecessor of Lockheed Martin.) The paper provides a glimpse at an early use of automation to capture and disseminate lessons learned. A high-level process flow is provided.

Lessons learning system attributes: An analysis

Benner Jr., Ludwig and William Carey. "Lessons learning system attributes: An analysis." In *Draft Proceedings of the 36th ESReDA Seminar,* 2009.

KEYWORDS: Attributes, Characteristics, Processes, Systems

ABSTRACT: The authors distinguish between accident investigation-oriented lessons learned systems and knowledge management-oriented systems; their research focused on an investigation-based lessons learned system. They identify the attributes of lessons learned *systems* (rather than the attributes of a lessons learned database or individual record.) The paper identifies inefficiencies of current lessons learned system attributes. It also identifies thirteen desired system attributes categories from a user perspective and thirteen desired system attributes from a developer perspective.

Mooers' law: In and out of context

Austin, Brice. "Mooers' law: In and out of context." *Journal of the American Society for Information Science and Technology,* 52, no. 8 (2001): 607-09.

KEYWORDS: Characteristics, Human Behavior

ABSTRACT: In 1959 Calvin Mooers set forth a "contradictory principle" of the new field of information retrieval systems; Mooers' Law states “an information retrieval system will tend not to be used whenever it is more painful and troublesome for a customer to have information than for him not to have it.” In this 2001 article, the author puts the law in context and offers three expansions on Mooers' law. For developers of lessons learned systems, the "lessons" may be: the systems must not add pain to the process of obtaining information; the usefulness and "actionability" of the lessons learned information is equally or more important than system design; an understanding of human behavior should underlie all decisions.

NASA policy directive 7120.6 - Knowledge policy on programs and projects

NASA. "NASA policy directive 7120.6 - Knowledge policy on programs and projects." 2013.

KEYWORDS: Knowledge Management, NASA

ABSTRACT: This November 2013 NASA Policy Directive updated one titled "NASA Lessons Learned Process" (March 2005, also numbered NPD 7120.6) with a new title (Knowledge Policy on Programs and Projects) and focuses on overarching knowledge management requirements. Lessons learned are one aspect of knowledge-sharing efforts, as identified in this policy document.

NASA: Better mechanisms needed for sharing lessons learned

GAO. *NASA: Better mechanisms needed for sharing lessons learned.* GAO-02-195. Washington, DC: U.S. General Accounting Office, 2002.

KEYWORDS: Best Practices, NASA, Pitfalls, Processes, Storage, Systems

ABSTRACT: The GAO reports that NASA defines a lesson learned as knowledge or understanding gained by experience. The experience may be positive, such as a successful test or mission, or negative, such as a mishap or failure. A lesson must be significant in that it has a real or assumed impact on operations; valid in that it is factually correct; and applicable in that it identifies a specific design, process, or decision that reduces or eliminates the potential for failures and mishaps, or reinforces a positive result. The principal source NASA has established for the agency-wide collection and sharing of lessons is the LLIS, a Web-based lessons database that managers are required to review on an ongoing basis. In addition, NASA uses training, program reviews, and periodic revisions to agency policies and guidelines to communicate lessons. Several NASA centers and key programs also maintain lessons learned systems. Despite the process and procedures, GAO notes there is no assurance that lessons are being applied toward the success of future missions. The report points to pitfalls and highlights best practices for overcoming resistance.

On the Implications of Lessons Learned Use for Lessons Learned Content

Buttler, Tanja and Stephen Lukosch. "On the implications of lessons learned use for lessons learned content." In *13th International Conference on Knowledge Management and Knowledge Technologies, i-KNOW 2013*. Graz, Austria: Association for Computing Machinery (ACM), 2013.

KEYWORDS: Characteristics, Organizational Behavior, Processes

ABSTRACT: This article investigates how lessons learned are used in organizations and what implications the use has for their content. Inadequate content can prevent or hinder the use of lessons learned.

Retaining knowledge after an engineer leaves

Goossens, Paul. "Retaining knowledge after an engineer leaves." *R&D Magazine* (2014). Published electronically June 4, 2014. http://www.rdmag.com/articles/2014/06/retaining-knowledge-after-engineer-leaves.

KEYWORDS: General

ABSTRACT: This article raises a question worth asking - "If a senior engineer left an organization suddenly, how many hours would it take for the engineering team to fully take over his projects, confident that they understand not only the designs, but why those designs are the way they are?" The article does not address lessons learned, although one driver for the development of lessons learned programs is to retain knowledge. This article promotes a tool that helps engineers capture and retain key assumptions in the early stages of a design process.

Sharing lessons learned in the Department of Energy

Bickford, John C. "Sharing lessons learned in the Department of Energy." In *Intelligent Lessons Learned Systems: Papers from the AAAI Workshop*, 5-8, 2000.

KEYWORDS: Dissemination, Human Behavior, Pitfalls, Processes, U.S. Department of Energy (DOE)

ABSTRACT: This paper describes how the DOE developed processes and tools for sharing lessons learned. It also proposes the need for "intelligent searching" via text mining-like applications, however offers no examples of such applications. A high-level U.S. DOE lessons learned process flow diagram is included.

The DOE corporate lessons learned program

DOE. *The DOE corporate lessons learned program.* DOE-STD-7501-99. 1999.

KEYWORDS: Processes, Taxonomies, U.S. Department of Energy (DOE)

ABSTRACT: This is a technical standard that provides a framework for the DOE corporate lessons learned program. Although the standard provides specific guidance for DOE managers and staff, much of the information and guidance could be adapted for other organizations in general. Appendices offer a data entry template, a list of lessons learned categories (taxonomy of terms useful for searching or browsing the database), a high-level process flow, and a sample program assessment guide.

The NATO lessons learned handbook, 2nd edition

NATO. *The NATO lessons learned handbook, 2nd edition*. NATO Joint Analysis and Lessons Learned Center, 2011.

KEYWORDS: Attributes, Best Practices, Collection/Sources, Communication, Data Fields, Databases and Websites, Dissemination, Lessons about Lessons Learned, Lessons Learned Statements/Descriptions, Processes, Systems

ABSTRACT: This handbook provides a detailed overview of the NATO lessons learned system. It differentiates "observations," "lessons identified," and "lessons learned." It covers the following topics in separate chapters: gathering observations, converting observations to lessons identified, creating lessons learned, including the role of leaders, sharing the lessons learned, and additional topics. A lesson template and examples of "lessons identified" are provided.

The work-around culture: Unintended consequences of organizational heroes - executive summary

Tucker, Anita. "*The work-around culture: Unintended consequences of organizational heroes - executive summary*." edited by Harvard Business School, 2010.

KEYWORDS: Human Behavior, Organizational Behavior, Pitfalls

ABSTRACT: In this executive summary of a faculty research symposium, the author reports her research into "work-around cultures" (or hero cultures) at hospitals, resulting in short-term fixes rather than systemic problem solving. Although the research is focused on hospitals, it is applicable to other settings, especially service settings.

Understanding the lessons-learned process

Kotnour, Tim and Harold Kurstedt. "Understanding the lessons-learned process." *International Journal of Cognitive Ergonomics.* 4, no. 4 (2000): 311-30.

KEYWORDS: Knowledge Management, Lessons Learned Statements, Processes

ABSTRACT: The authors conducted an experiment is to understand the effect of lessons-learned design parameters on the development and use of a lesson learned. They concluded that formal lessons learned produce a higher quality lesson learned and that formal lessons learned have a greater effect on decision quality than informal lessons learned. The authors identify both formal and informal questions to ask when developing a lessons learned statement; a later section identifies several questions to help determine how and why a lesson learned was used, or why it was not.

Using hydrogen safety best practices and learning from safety events

Weiner, Steven C., Linda L. Fassbender, and Kathleen A. Quick. "Using hydrogen safety best practices and learning from safety events." *International Journal of Hydrogen Energy* 36, no. 3 (2011): 2729-35.

KEYWORDS: Databases and Websites, Taxonomies, U.S. Department of Energy (DOE)

ABSTRACT: This article describes the Hydrogen Safety Best Practices website maintained by Pacific Northwest National Laboratory and Los Alamos National Laboratory with funding from the DOE. The Incident Reporting section of this website contains a link to a related H2Incidents Lessons Learned website (see http://h2incidents.org/). The H2Incidents site provides an example of a web-based user interface, to include a browsable taxonomy and a basic search function.

Weapon quality policy

NNSA. *Weapon quality policy*. 2013.

KEYWORDS: U.S. Department of Energy (DOE), NNSA Policy Letter

ABSTRACT: Subsection 3.13 (a.) (vii.) of the “Corrective Action” section requires a process to capture and communicate lessons learned for effective use in preventing problems and making improvements.

APPENDIX B: LESSON DESCRIPTION

The following form and related descriptions are notional only. The set was developed to describe the kinds of information the team feels will help ensure a lesson description will be useful.

Recommended Lesson Capture Form

A. Required fields

Your name (Auto generated from the system?)

Suggest a title for your lesson learned or best practice Text field

Tell us what happened. Text field (long) [allow for uploaded images and attachments]

What did you learn from what happened? Text field (long)

B. Optional Fields

What would you recommend to others? Text field (long)

Suggest some Keywords. Text field (each will need to be searched separately)

What documents, if any, capture the information in this lesson? Text field

What is your role? Dropdown menu

Project or Program. Dropdown menu

Level of assembly. Text field

Lifecycle Phase Dropdown menu

C. To Be Completed by Reviewers

Subject matter expert reviewer name, comments, and date. (This may be more than one field. Part of workflow, with auto-generated option to select reviewers?)

Review Panel Analysis. Text field

Likelihood of making the mistake again. Text field

Potential consequence if mistake occurs again. Text field

Has this been institutionalized (reference specific organizational documents, as applicable) Text field

Key questions. Text field.

Taxonomy. Dropdown menu

D. Auto-generated Fields/Other

Peer Review
Manager Review
Proprietary Review
Submission Date
Submitting Organization
Unique Lesson Identifier
Contact Search [default = person logged in]
Contact Details
Manager Search
Manager Details [default = manager of designated contact]

Specific Target Audience (optional) – by name, organization number, or metagroup. Workflow
Save button (with ability to return to it later); Workflow
Save and Submit for Peer Review Button; Workflow
Save and Submit for Review [or other title, to reflect manager review as well?]; Workflow

Recommended Field Descriptions

A. Required Fields

Your Name
Auto-generated or enter your name or the name of the person who wrote the lesson.

Suggest a title for your lesson learned or best practice
Short, descriptive title that will help the reader quickly determine relevance.

Tell us what happened
Tell the story. What happened? Brief discussion that provides the reader with enough background information to understand what was experienced and whether or how it might happen to them or their project. [Will allow for images, videos, and attachments]

What did you learn from what happened?
What did you or your team learn from the experience? There might be more than one lesson learned or best practice to highlight.

B. Optional Fields

What would you recommend to others?
List or describe actions taken and/or actions recommended to help others prevent similar problems or to achieve similar good results.

Suggest some keywords (key concepts or phrases)
Add words or phrases that you think will help the reader search for and find the lesson.

What documents, if any, capture the information in this lesson?
Links to additional references that might help the reader understand the lesson, experience, analysis, or action taken.

What is your role?
Select from the drop-down list of roles.

☐ Project Lead	☐ Purchased Product Engineer	☐ System Evaluation Engineer (SEE)
☐ Project Lead Manager	☐ Process Engineer	☐ Principal Investigator
☐ Component Engineer	☐ Product Engineer	☐ Other – link to optional text box
☐ Subsystem Engineer	☐ Quality Engineer	
☐ System Engineer	☐ Reliability Engineer	

System

From the drop-down list, select the name of the system this lesson occurred in, or select “SNL corporate policy or process,” or “other.”

☐ Program 1	☐Non-active systems, retired or not fielded	☐Other– link to optional text box
☐ Program 2	☐SNL corporate policy or process	
☐ Program 3		

Level of assembly

Identify the applicable level of assembly, if appropriate for this lesson learned or best practice.

Lifecycle

Use a drop-down list to select the stage of the lifecycle in which this lesson occurred

C. To be completed by reviewers

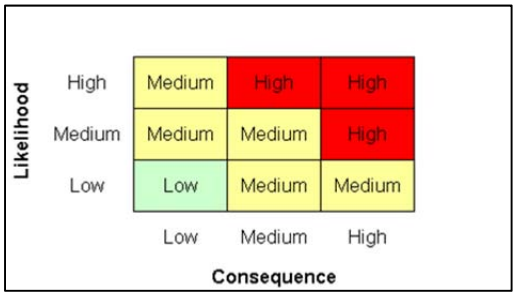
Subject matter expert reviewer name, comments, and date

Each lessons learned entry will be routed to a review panel or reviewer for validation. The review panel or reviewer will describe the outcome of their review in this section.

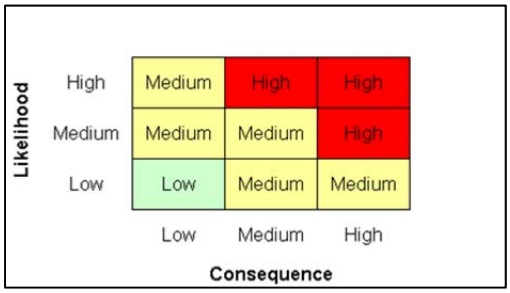
Review panel analysis

Each lessons learned entry will be routed to a review panel for validation. The review panel will describe the outcome of their review in this section.

Likelihood of making the mistake again



Potential consequence if the mistake occurs again



Has this been institutionalized (reference specific organizational documents, as applicable)

Identify all instances of the lesson or best practice having been infused into requirements documents, design guides, general engineering documents, or other sources of performance expectations.

Key questions
Key questions you believe should be asked and answered by project teams, reviewers, and others. (Note – may be tailored to each lesson learned.) Some examples of key questions include:

- Could this situation apply to your project?
- Are you already implementing the recommendations on your project?
- How is your situation different from the above?
- Do you agree or disagree with the lesson? Or the recommendations?
- What conditions make this lesson or these recommendations not valid?

Taxonomy
Select from among the predefined list of controlled terms, which are sorted into major categories. Use as many terms as needed.

APPENDIX C: DATABASE REQUIREMENTS CHECK SHEET

REQUIREMENT	DESCRIPTION	COMMENTS
1.0 GENERAL INFORMATION		
Purpose:	To provide a robust application for capturing, collecting, disseminating, sharing, and facilitating the use of lessons learned and the integration of lessons learned into existing processes.	
Additional System Overview:	Probably hosted on corporate server with strict access controls to the LLDB and related documents and reports.	Originally, we specified "hosted on major program server" but that is a costly option.
Points of Contact: POCs that may be needed by the user for informational and troubleshooting purposes.	<deleted.	
Audience:	All major program staff and managers; Possible others (internal to SNL)	
Users: Who will be entering data? Who will be retrieving data?	Major program staff or managers; Possible other SNL staff or managers	
Other:	Ideally, web interface would recognize and format for mobile as well as desktop access.	
2.0 CONTENT		
Type of Content/Format:	Content from online data entry form Reports or other related documents, stored separately Ability to upload images Ability to upload videos Ability to upload documents and link to other documents	
Repositories? Stored where?		
Access Control Needed?	Yes	
Version Control Needed?	Maybe	
Approval Process Needed?	Yes – approval process before content is published to the lessons learned system; Maybe also access approval	Will need to add "publish" step to the process flow, unless it is currently reflected as the "Archive lessons learned" step.
Data Entry Process	Online form – some auto-generated fields; some dropdown menus; some text only fields For fields with dropdown menus: 1.Ability to select as many as needed 2. add a text box to explain "other" selections 3. Add "easy buttons" to allow users to recommend additions to dropdown menu items See appendix 1 for list of fields There needs to be e-mail confirmation of user entry	
Archive Old Content?	Yes	
	Note – consider how the content might be disseminated externally – verbally, in email discussion, other – are there system controls?	

Cont.

REQUIREMENT	DESCRIPTION	COMMENTS
3.0 SEARCH		
Search What Content?	Ability to search across all records; all data entry fields; and related repositories. Default to search active (?) Option to search inactive or "all"	
Advanced Search?	Yes. Desired: Boolean search Phrase searching Ability to search multiple fields Ability to search across all fields Ability to search *within* results or to narrow results by selected fields	
Keyword Search?	Yes – keywords must be searchable as separate entries Keywords will be user-generated	
Taxonomy and Metadata?	Yes – needs to be searchable Desired – easy means for users to request the addition of a taxonomy term	
Browse?	Yes – ability to browse by selected fields	
Feedback/Comments	Yes – user ability to comment on lessons they have retrieved. Desired - Comments editable by administrators? Desired - Comments stay with the record?	
Print/Save?	Yes – must be able to print and or copy and save retrieved results.	
What search engines work well with the system under review?		Seeking developer response to this question.
4.0 SYSTEM ATTRIBUTES		
	Must facilitate knowledge collection, storage, dissemination, and reuse	
	Searchability Timely availability Simplicity Supports assimilability or infusion Performance metrics Accessibility Targeted distribution/dissemination from within system Scalability Other …	
5.0 LESSON ATTRIBUTES		
	Content reviewed for relevance Minimal signal/noise ratio Standard format or standard content fields Other …	

Cont.

REQUIREMENT	DESCRIPTION	COMMENTS
6.0 OTHER		
User Interface	Webpage-like interface	
Online Forms	Yes – data entry form 1. Required fields must appear first – may not proceed to subsequent steps unless required fields have content 2. Optional Fields 3. Reviewer fields 4. Auto-generated fields	
Workflow: Describe. Monitored?	Yes there will need to be workflows 1. Peer review or review team review 2. Manager or Proprietary review 3. Manager review (might be part of proprietary review) 4. Oversight process to ensure each step is handled in a timely way 5. Loop closed to publish the content 6. Dissemination to selected audiences Note: consider R&A workflows (formal and programmatic) as a model	See draft process flow diagrams.
Information Life Cycle?		
Interactions with Other Databases?	Yes – SNL HR or other Also – ability to browse and link from personal and shared drives	Note – if commercial tool / software licensing is an issue, this could be expensive.
Change Control?		
Other	Metrics: system metrics and lesson assimilation metrics – need to be defined. Reports – reporting capability desired. Need to define what kind of reports. Need upfront caution not to input proprietary information. Suggested: a yes/no checkbox to answer a question like “Is any aspect of the actual lesson proprietary?” If YES – a dialog box would open advising the user to summarize the lesson in non-sensitive terms; also, a “flag” should attach to the record for reviewers and others. Note – need some way to ensure the proprietary version of such a lesson is captured appropriately.	

APPENDIX D: PROPOSED LESSONS LEARNED PROCESS FLOWS

The following process flow diagrams are notional only. The team drafted these diagrams as a preliminary aid in understanding how various people would access and use the database. These diagrams or others like them would need to be refined in workflow-related discussions with database designers, to ensure that gaps and inconsistencies are identified and addressed.

User Accesses Lessons Learned Database

Figure 6 shows the proposed process flow for accessing the LLDB. The process assumes that all users that apply for access provide a reason and preferences. The reasons for access could range from standard usage needs, CB processing, proprietary data review, or analysts' work. Metagroups can control access to forms that only certain members can edit. Preferences, input into the user profile, are based on the taxonomy. The preferences could be set to specify what types of lessons learned entries to automatically email to a user, or they could be set to the default of all lessons learned entries being sent.

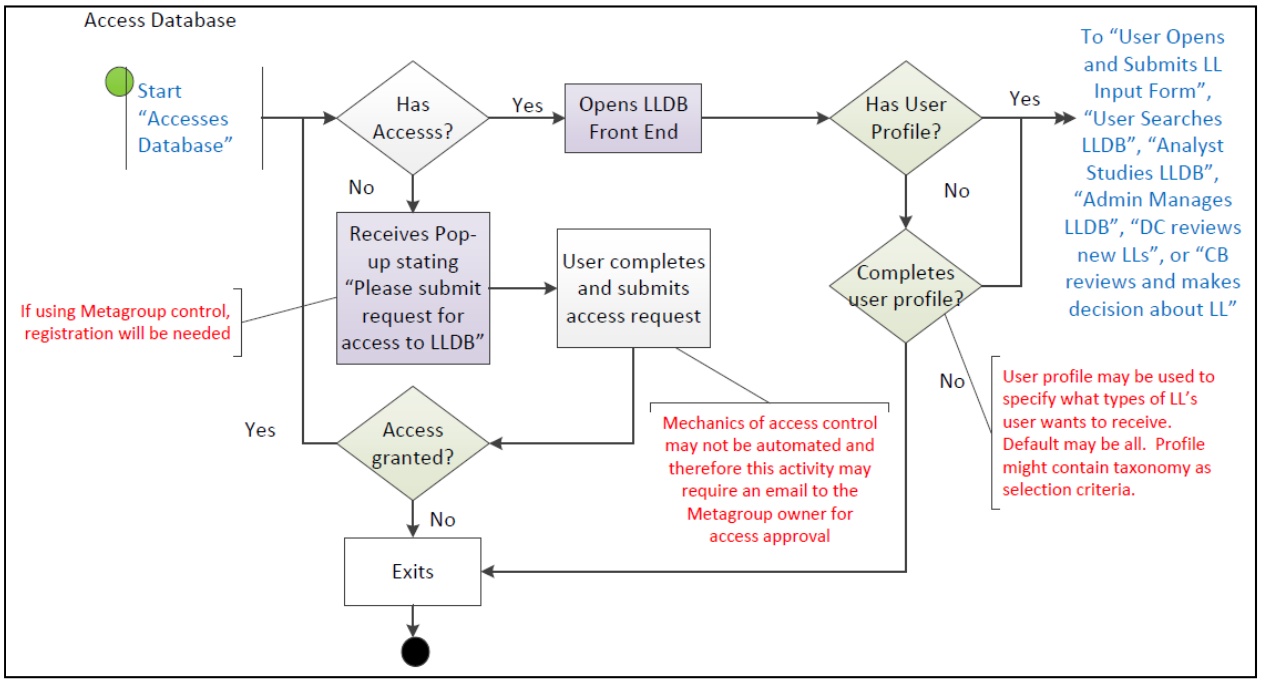


Figure 6. Proposed Process Flow for Accessing Lessons Learned Database

Administrator Manages Lessons Learned Database

There is no true process flow for the LLDB Administrator, as any of the tasks assigned to this role may be needed in any particular order. The tasks are depicted in Figure 7.

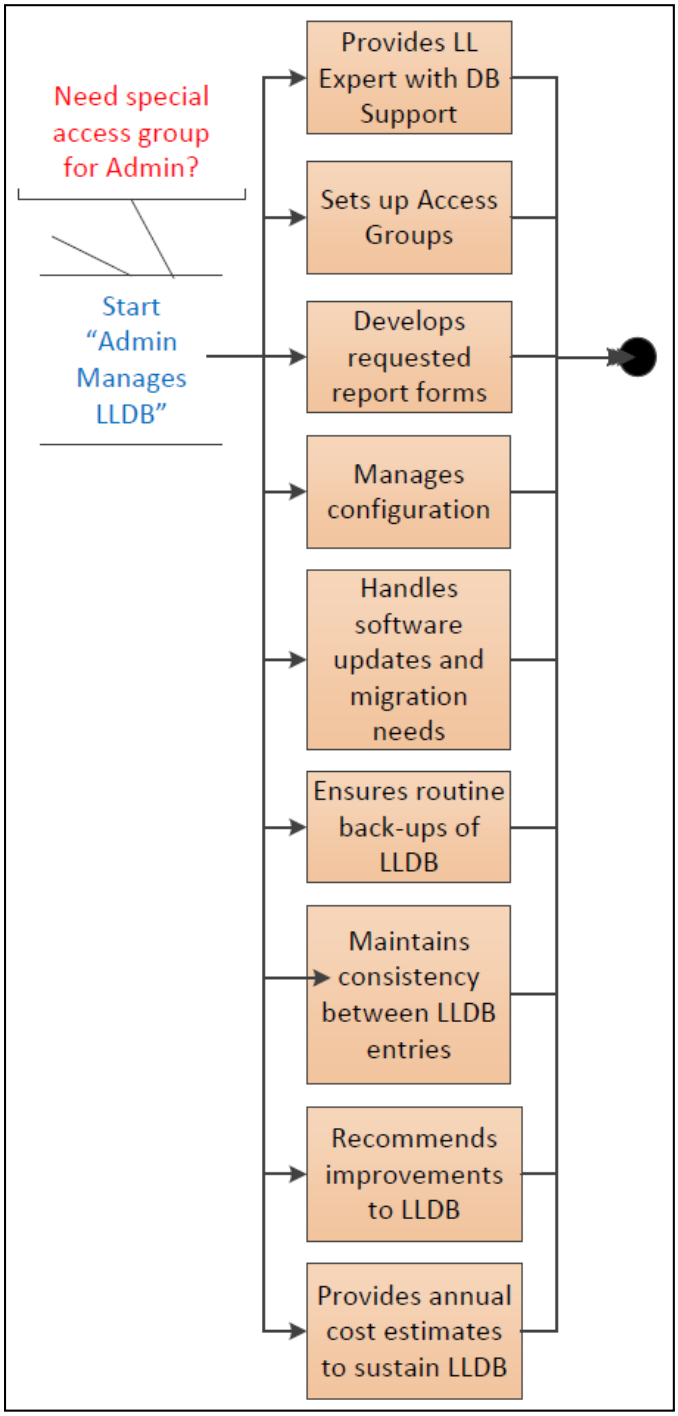


Figure 7. Lessons Learned Database Administrator Tasks

Analyst Studies Lessons Learned Database

An LLDB analyst needs to:

- Generate reports specific to project or program needs; for example, a report on product qualification lessons learned entries.
- Study entry trends to determine if recurring themes exist and should be collected into a meta-lesson or flagged for focused attention by the major programs.
- Capture metrics on LLDB usage.
- Capture metrics on lessons learned entries in general.

The limited view of the process flow for the analyst activities is shown in Figure 8.

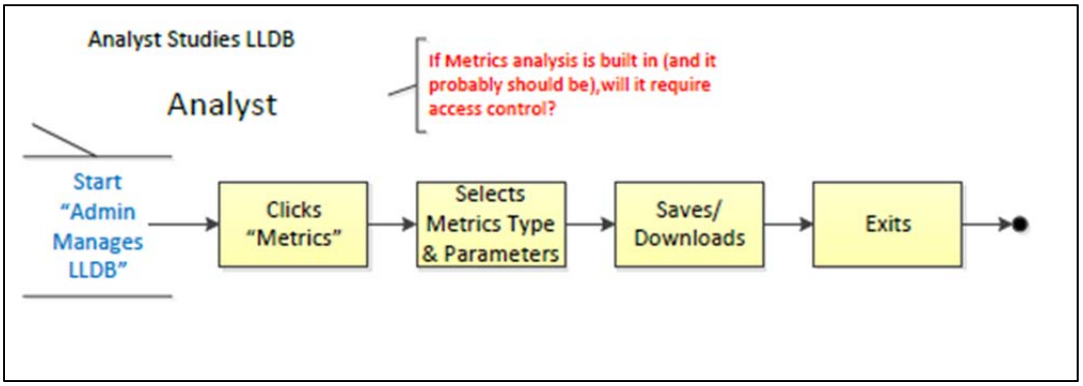


Figure 8. Analyst Process Flow for Metric Studies

The report generation task may require database programming. Figure 9 shows the process.

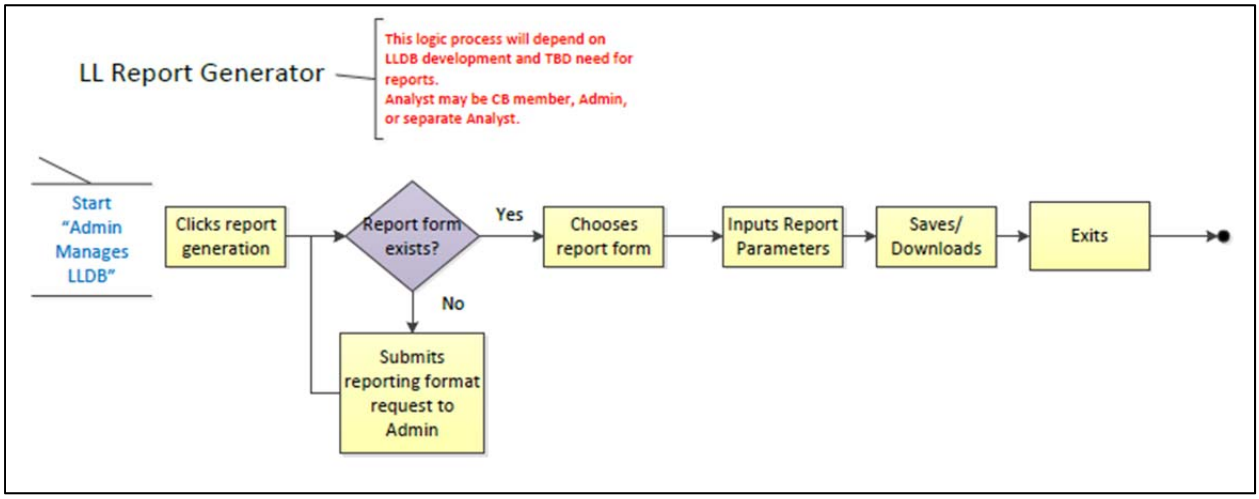


Figure 9. Report Generation Process Flow

User Submits or Modifies Lessons Learned Input Form

On accessing the LLDB, the user can enter a new lessons learned observation or modify an existing lessons learned entry if he or she is the author. The LLDB will be able to present the user with a list of the user's lessons learned entries that are pending acceptance by the CB.

The desire to have an non-sensitive version of the LLDB necessitates the cautioning of users against entering proprietary information. If the user is to submit a proprietary lessons learned entry, a Proprietary LLDB that mimics the non-sensitive LLDB will exist. The user is to input a non-sensitive "crumb" or "bread trail" for others to follow to the Proprietary LLDB.

The user enters the information into the lessons learned form and submits the lessons learned entry. If necessary, the entry can be saved for future modification.

All newly submitted lessons learned entries would reside in the "New" region of the LLDB. They are not available for others to see.

The user will receive an automatically generated email confirming submission (Figure 10).

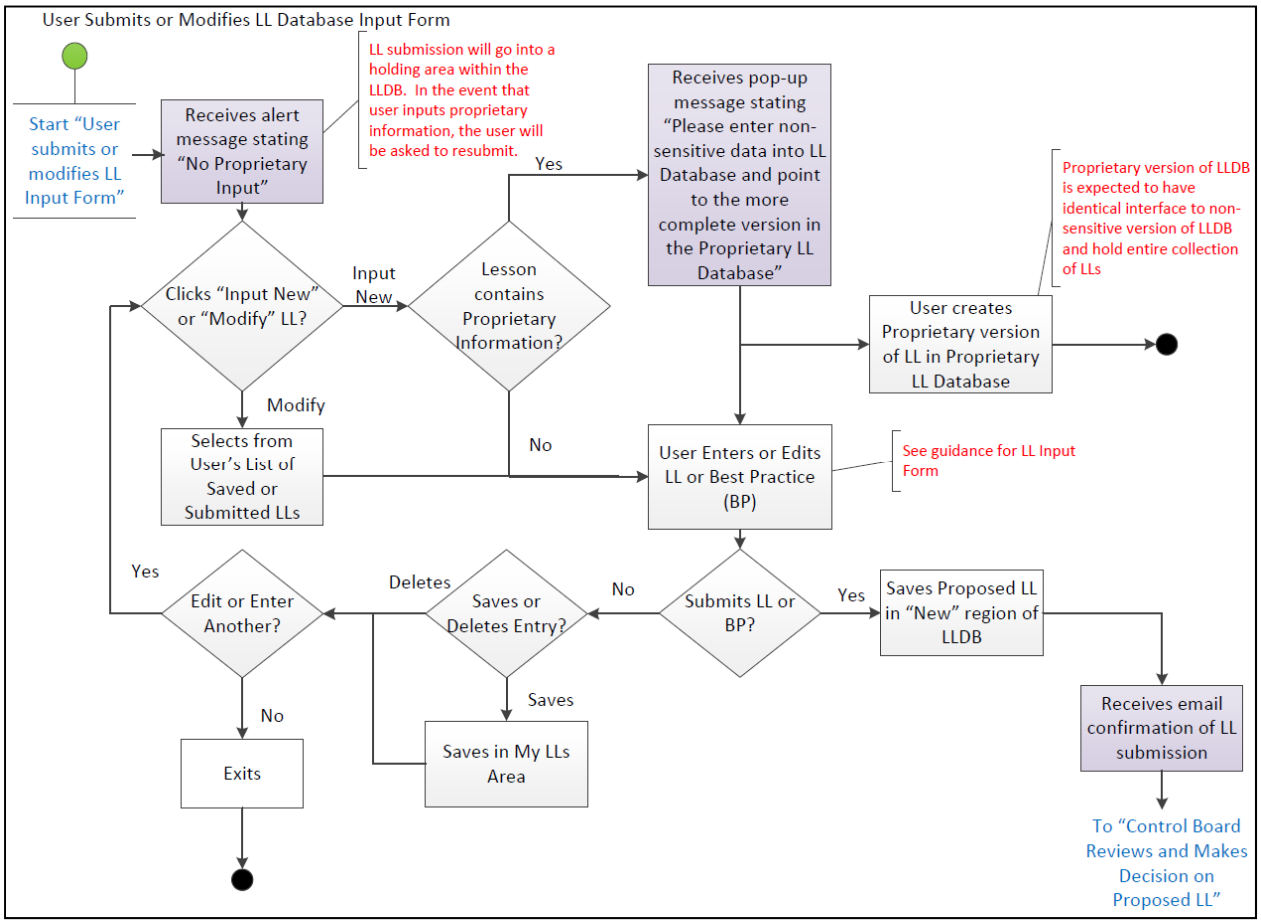


Figure 10. Lessons Learned Submission Process Flow

Control Board Reviews and Makes Decision on Proposed Lesson Learned

The CB plays a key role in the lessons learned process, such that CB members must be authorized via a special metagroup that enables editing of fields in newly submitted lessons learned forms and authorization to enter fields of the lessons learned form that the user cannot access (Figure 11).

The CB opens a lessons learned entry in the "New" section of the LLDB to review for approval. If more information is needed from the user, the CB must direct the lessons learned entry back to the user. If the CB chooses to process and accept the lessons learned entry, it can complete all fields. The lesson learned is flagged for final proprietary review as subsequent processing may have changed its sensitivity status. Once the lesson learned has passed final proprietary review it can be activated or submitted for additional approval, as needed.

If the CB considers the lesson learned entry a repeat of an existing entry or not sufficient to process as a lesson learned for the broader major program community, the entry is moved to the "Non-Active" region of the LLDB.

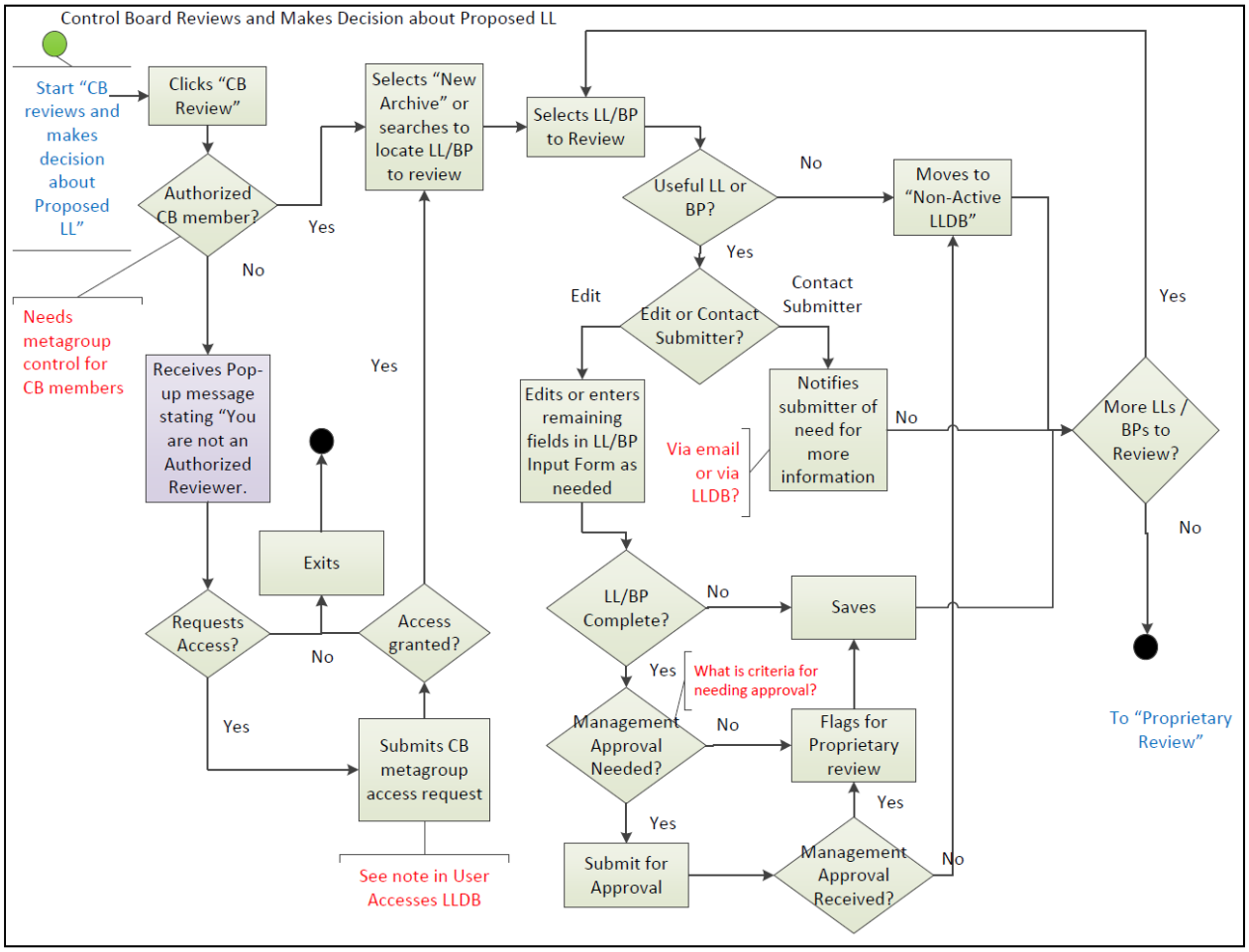


Figure 11. Control Board Process Flow

Proprietary Review of New Lessons Learned

The proprietary review process, shown in Figure 12, requires LLDB entry to "New" region of the LLDB and must allow the proprietary reviewer to officially mark an entry as reviewed. If the reviewer encounters a proprietary entry, he or she will notify the submitter and request re-work.

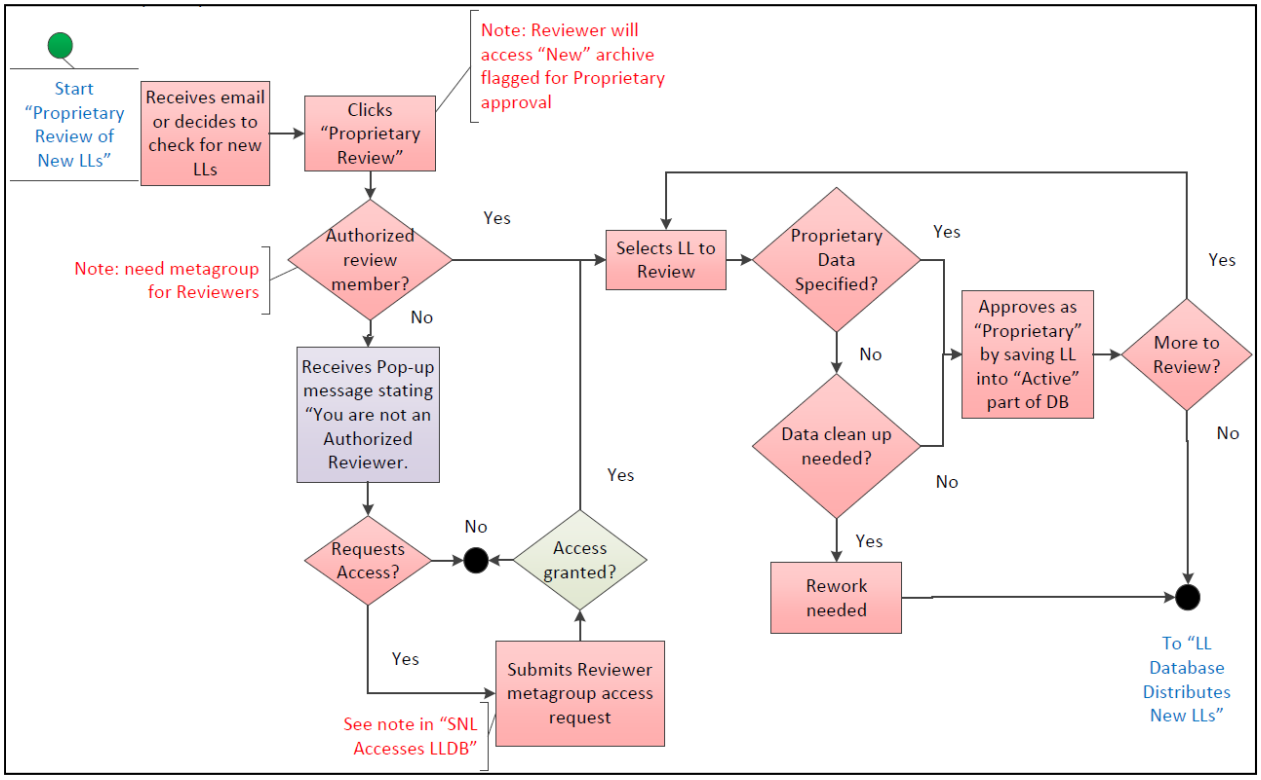


Figure 12. Proprietary Review Process Flow

Lessons Learned Database Distributes New Lessons Learned

On final approval and transfer of a new lessons learned entry from the “New” region to the “Active” region of the LLDB, the system automatically sends emails to the distribution list. Newly active lessons learned entries could be sent to everyone or sent only to those whose preferences match some set of the entry. The system flags that the lessons learned statement has been broadcasted to the user base. The process flow is shown in Figure 13.

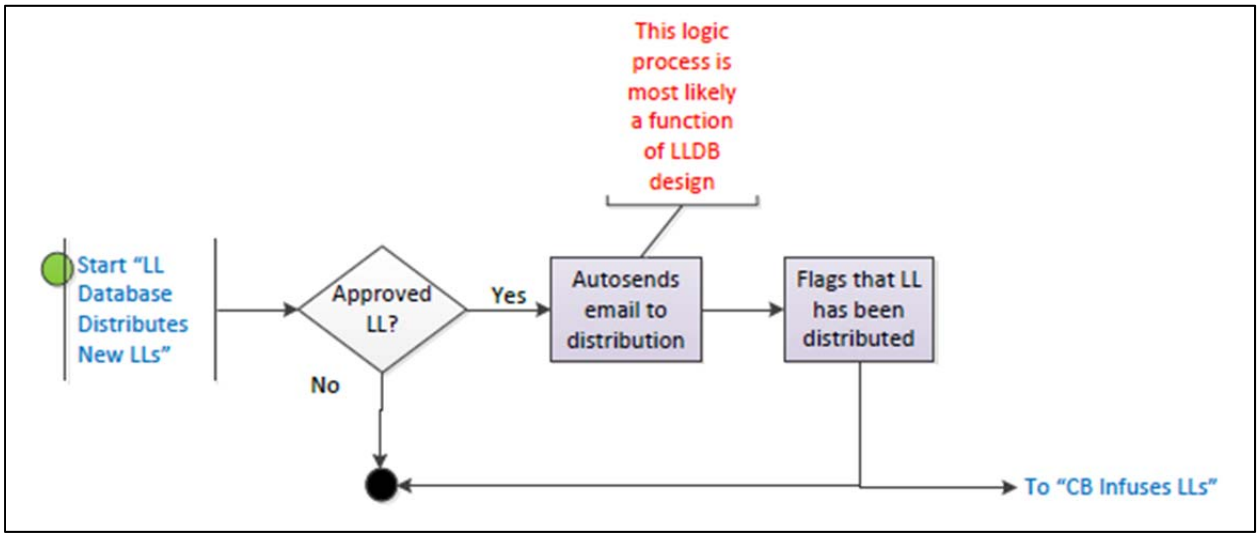


Figure 13. Lessons Learned Database Distributes New Lessons Learned Process Flow

Control Board Infuses into Requirements, Guidance, and Training Documents as Appropriate

The CB, with help from the major programs as needed, determines how widespread given lessons might be and considers options for infusing those lessons into requirements, guidance, and/or training documents. If the lesson learned is inserted into work practices, it is then considered a BP (or "good practice") and this designation is made to its entry in the LLDB. The entry is then searchable as a BP. The process flow is depicted in Figure 14.

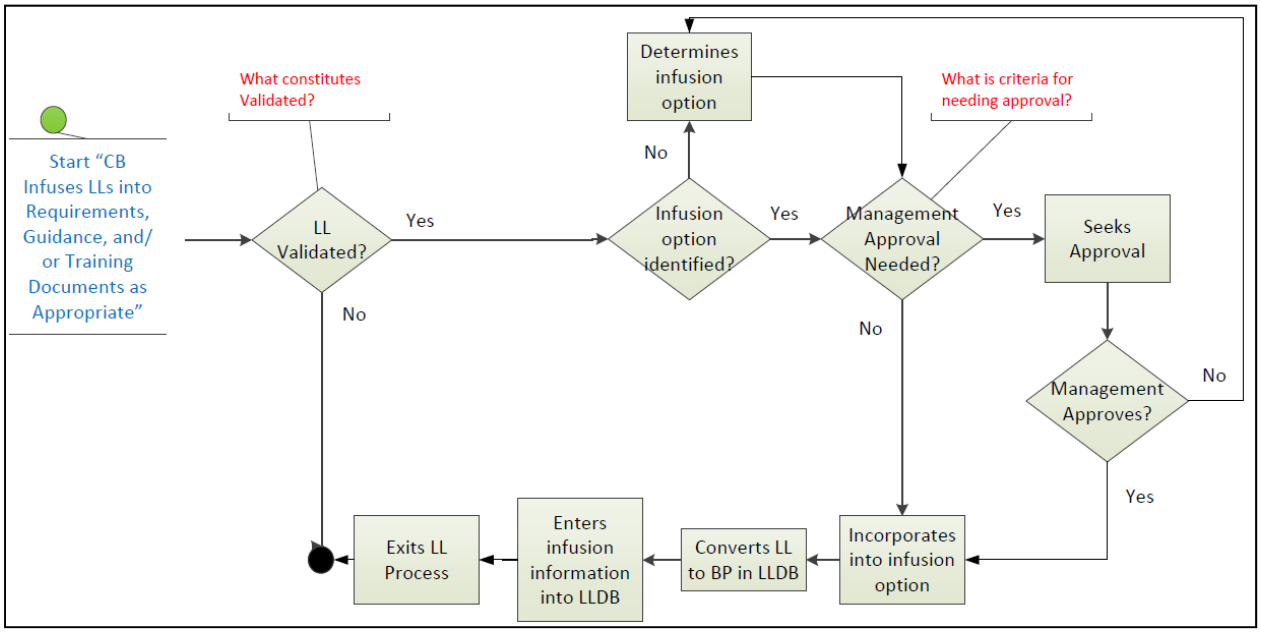


Figure 14. Control Board Infuses Lessons Learned Process Flow

User Searches Existing Lessons Learned

The user can search in a variety of options including looking only at “New lessons learned entries” since the last time the user accessed the LLDB, browse lessons learned entries based on most popular or other designations or on his or her submissions, or search for entries by selecting taxonomy terms (Figure 15). All searches default to the “Active” portion of the LLDB. The “Non-Active” region of the LLDB is available for searching but only if the user chooses to include Non-Active lessons learned entries.

The user can rate lessons learned entries or enter feedback. Ratings may be “Useful” or “Not Useful” or other options set during implementation of the LLDB.

If the user selects multiple lessons learned entries, the LLDB can accommodate but must warn the user that individual entries in the LLDB are non-sensitive. Multiple lessons learned entries could be saved to a file or printed. The user is responsible for any aggregation issue.

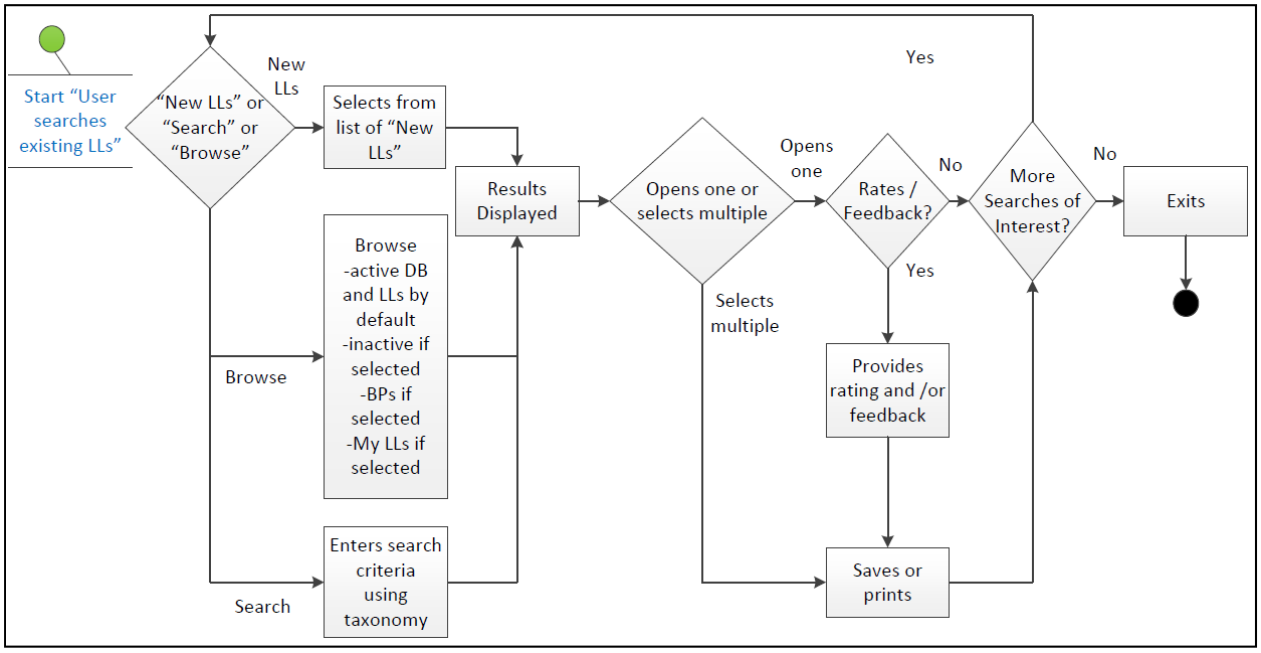


Figure 15. User Searches Existing Lessons Learned Process Flow

APPENDIX E: LESSONS LEARNED ABOUT LESSONS LEARNED

Lessons from the Literature

As reflected in the annotated bibliography (Appendix A to this report), a number of useful "lessons learned about lessons learned" are found in the literature. Here we highlight some of those.

In *Cutting the Cost of Not Knowing: Lessons Learned Systems People Really Use*, APQC identifies the following best practices related to lessons learned systems.

- Determine the strategic objectives of the lessons learned process
- Align the lessons learned approach with process excellence methodologies
- Create governance processes and clearly defined roles
- Integrate the lessons learned approach into core processes
- Leverage facilitators at key points
- Make captured lessons easily accessible
- Review and publish lessons in a timely manner
- Encourage participation in the lessons learned approach

In "Lessons Learned: Improving Performance through Organizational Learning," Carnes and Breslau identify eight "lessons learned about lessons learned" during the DOE's initial efforts to implement a lessons learned program.

- Senior management ownership and accountability is essential for implementing a lessons learned program that provides value.
- Incentives must be developed to effect a culture change so that the organization actively seeks to identify lessons, learn from them and share with others.
- Metrics are difficult but essential. Measurements that have organizational value should focus on reuse of lessons for tangible benefits.
- Organizational processes must be re-engineered to make identification and use of lessons part of the normal business processes.
- Care must be taken to provide the context in which lessons are learned. Context is essential for communicating applicability and potential value of the lesson beyond the initial circumstance in which the lesson was identified.
- The value of a lesson is a function of the quality of analysis. An event report by itself does not constitute a lesson.
- Multi-media should be used to communicate lessons. Communicating the full context and implications of lessons may require multiple levels of detail.
- Effective knowledge management systems may begin as grassroots emergent systems, but eventually require a formal systems analysis that identifies roles and responsibilities, information sources, lessons generators, lessons users, validators, communication networks and communication media type.

The team took these and other lessons about lessons learned into account as it considered options for SNL major programs.

Lessons Observed by the SNL Lessons Learned Team

Team members made a number of observations about the challenges and opportunities facing SNL as it strives to improve its lessons learned process and system.

- It is really difficult to write useful lessons learned statements
- Metrics are important but difficult to define
- We overlooked the need to socialize the project beyond program management (although that can still be done during the early "implementation" stage)
- Usage of lessons learned could be a challenge
- Commitment of senior management without funding is insufficient
- Sharing of lessons learned across programs needs to be addressed
- Buy-in for LLDB will require continued socialization and demonstration of usefulness—this is not a one-year project
- When a team is tasked to "develop a lessons learned process", it is not unusual for it to drive straight to designing a database and collecting lessons learned to populate it. However, as the literature indicates, it is important to first evaluate what is needed in the context of the larger existing organizational system *and* to take time to learn what intended end users need and what they will use *before* designing a system.
- It is important to devote time working through requirements in detail, but recognize that just as much time will need to be spent around the table with a development team to be sure everyone is on the same page with definitions and meaning.
- Don't forget "human factors" – "how are people going to want to use the system?"
- There is no consensus on the right lessons learned environment for SNL. The right lessons learned environment is a compromise among competing objectives – it must be affordable; it must be user friendly for both data entry and data access; it must be accurate and complete and provide the proper context; it must be sustainable. Perhaps the best solution is a standard basic model that allows some flexibility for individual units.
- A lot of people want a lessons learned enterprise, but few are willing to pay the price in dollars and time to obtain it, much less sustain it.
- We were adversely impacted by the lack of identification and engagement of a corporate lessons learned champion. If we went away, who would stand up and say that we are missed?
- It is easy to migrate to a place of a capability looking for an application as opposed to a customer need looking for a solution. Instead, stay focused on the customers and their requirements. Who at the executive level champions a lessons learned environment as a corporate milestone and provides the resources to meet identified deliverables?
- There would be value in understanding what the relative value is between an effective lessons learned environment (whatever that looks like) and the effective utilization of experienced SMEs as peer reviewers (recognizing that it is becoming more and more difficult to engage retirees as peer reviewers with SNL's evolving procurement rules). The right answer would appear to be an effective balance of the two. But, how do you determine the balance, or even address the relationship between the two (such as capturing experiences from peer reviews as input to the lessons learned database)?
- It is nearly impossible to quantify the cost savings associated with problem avoidance through the effective use of lessons learned. What is the return on investment for

incorporating lessons learned into our work processes? It is easy to quantify the cost, but the return on investment is elusive, leading folks to want to invest elsewhere where the return is more apparent. It is sort of like the cost of quality or the cost of safety.

- At a very basic level, there are probably some inexpensive (though incomplete) steps that could be taken. Simple things like "lessons learned" key words or phrases in a title for documents containing lessons learned to aid in even today's search environment. Having ongoing projects record lessons learned as the project evolves and not attempting to identify all of them at the end of the project. Having a standard approach in how lessons learned get written down. Having an expectation that projects will BEGIN with a survey of lessons learned (this too is being realized today through evolving RPPs).
- We have an RPP on peer review. Why do we not have an RPP on lessons learned?

Related Comments and Advice from SNL Managers

- There is too much "low hanging fruit" lesson material that is not captured
- URs and SFIs are also a good source of lessons
- Lessons learned should be injected into existing normative references (if they exist), such as design guides or RPPs, rather than creating new ones
- Generally agree – we do not communicate or learn from our lessons
- There are islands of information that don't talk to each other, because it is nobody's job to connect these islands
- Documenting lessons should not be onerous
- Documenting lessons should be mandatory, and part of everyone's job description
- The universe that we would like to grow, my job; the universe that we would like to shrink, everything that prevents me from doing my job, especially defects; lessons should specifically address this universe
- There are multiple time scales that people seem to want to merge, but they shouldn't be merged:
    - You cannot learn lessons over really long time frames (like kids and dogs, they cannot make the association over the course of months or years)
    - The lesson timeframe needs to be the right grain size, and applicable to the shortest timeframes possible (days or weeks)
- Need to frame lessons as a time/cost savings for *me personally*; frame the argument as a return on investment
- Lessons should help the progression from tacit knowledge to implicit knowledge to explicit knowledge

Lessons Learned about Understandability of Lessons Statements

As a demonstration of inefficiency experienced by staff responsible for collecting and utilizing lessons identified or learned, our team took select legacy lessons learned documents, tried to extract lessons, and experienced the following results:

- Not all team members had adequate subject matter expertise to comprehend the lessons, such that the lessons were lost on them. This would likely be true of potential future readers.
- Insufficient context was available with the documented lesson such that the applicability of the lesson could not be determined.

- Multiple understandings were arrived at for some documented lessons such that uncertainty existed as to the true lesson to be learned.
- The benefit (impact or consequence) of the lesson was not portrayed clearly, making it difficult to appreciate the value of the lesson.
- The timeframe over which the lessons applied were only sometimes documented (i.e., certain lifecycle phases only) such that the importance or applicability over the major program lifecycle could not be understood.

These and related issues gave LLPIT members a greater appreciation for the importance of consistent, standardized, well-written lessons statements.

Sandia National Laboratories