U.S. Navy Mantech B2PCOE and the Lead Free Manhattan Project

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Abstract: The mission of the Navy Mantech Benchmarking and Best Practices Center of Excellence (B2PCOE) is to identify, validate, and disseminate best in-class practices, processes, methodologies, systems, and best practice technologies with the end objective of improving the level of competitiveness of the defense industrial base and the affordability of performance of defense platforms and weapons systems. Examples of projects that the B2PCOE is engaged in include shipbuilding manufacturing affordability, energy use, open systems architecture and tool use. An overview of the B2PCOE will be presented with a brief discussion of B2P methodology. A recently completed B2PCOE project, the Lead Free Manhattan Project (LFMP) will be then be discussed more fully. The LFMP was driven by the European Union ROHs directive and the associated WEEE directive, both of which have spurred commercial manufacturers to phase out the use of lead in electronics manufacturing. This has led to a number of critical issues for the Aerospace, Defense and other industries as well as a high degree of uncertainty as to what practices should be used in lead-free electronics manufacturing. The LFMP brought together 15 of the leading experts in the area of lead-free electronics for a focused two-week project. The objective of the project was to develop a report that outlined baseline or best practices in lead-free electronics manufacturing. The purpose of this case study is to describe the background, planning and organization for the project, to describe some of the important aspects of the project from a process point of view and discuss the key factors that led to the development of a high performing team and a successful outcome. Several key factors led to the success of the project. These included clarity of vision, leadership, team selection, effective collaboration, knowledge management, a structured development process and a good technical support system. Future plans for the LFMP will also be discussed.

Keywords: teams, best practices

1. Introduction

The United States Navy has identified Centers of Excellence (COE) in key areas of Science and Technology (S&T). The COEs were established as focal points for the development and transition of new manufacturing processes and equipment in a collaborative environment with industry, academia and the Naval Research Enterprise. The Navy acknowledges the need to conduct benchmarking and identify best practices in order to keep the Department of Defense (DoD), its industry partners, and academia at the leading edge of innovative manufacturing technology so that the affordability and performance of defense platforms and weapon systems can be enhanced. The B2PCOE vision is to be a Navy and Department of Defense resource for sharing best practice standards for mature manufacturing technologies, stable and producible designs, and mature production processes.

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The B2PCOE mission is to identify, validate, and disseminate best in-class practices, processes, methodologies, systems, and best practice technologies with the end objective of improving the level of competitiveness of the defense industrial base and the affordability of performance of defense platforms and weapons systems. Specifically, the role of the B2PCOE is to identify, collect data, validate, and disseminate best practice standards by formally integrating each ManTech Center of Excellence, small businesses, academia, and industry, thus fostering high levels of horizontal communication and collaboration. The B2PCOE maintains strategic partnerships with academic organizations, industry, and government across all technology disciplines that impact Navy and DoD platforms and weapon systems. Ultimately, the objective of the center is to identify practices which, when implemented, will significantly increase affordability and performance of Navy/DoD weapon systems.

The B2PCOE undertakes a variety of projects related to system performance and affordability. Current projects include: Tool Use in Shipbuilding and Related Manufacturing, Energy Use in Shipbuilding, Corrosion Mitigation, and Systems Open Architecture. In each case the B2PCOE seeks to establish and understand benchmarks for practices related to the process or technology and then to seek best practices that can improve affordability and performance in the relevant areas. Each project begins with the selection of a benchmarking team that includes representatives from key stakeholders who are knowledgeable in the technology or process being studied. All team members participate in a Benchmarking and Best Practices training program developed by the B2PCOE. The training program utilizes a model adapted from the Department of the Navy that includes four phases: Plan, Do, Study, Act. Training covers each of these phases in detail and includes issues such as sampling, data collection, data interpretation, avoidance of judgmental biases and the communication and implementation of best practices. Each B2P team develops its own team charter, or working agreement, and develops a benchmarking plan as part of the training. An important part of each plan is an outline of the steps necessary for the successful implementation of the best practice identified.

This paper will discuss a recent B2P project that was somewhat unusual in that it had a large team of experts and was conducted within a short, but intensive, time frame. The Lead Free Manhattan Project, Phase 1 was conducted in April of 2009. The project used the Manhattan Project as a metaphor to underscore the criticality and the urgency of issues related to lead-free electronics manufacturing.

The genesis for the Lead Free Manhattan Project (LFMP) was two European Union directives issued in 2003 banning the use of lead in electronics manufacturing. The directives, which actually went into effect in 2006, spurred commercial manufacturers to phase out the use of lead in electronics manufacturing. For over 50 years manufacturers have used the primary eutectic alloy of 37% lead and 63% tin for soldering in electronic components. Tin-lead, or SnPb solder as it is commonly known, has a number of desirable properties that make it ideal for electronics manufacturing.

It is easy to work with (solderability), relatively inexpensive, has a lower melting point and creates stronger ductible solder joints. Perhaps the most important feature of SnPb is that it essentially eliminates the growth of “tin whiskers”. (see Figure 1). Tin whiskers are singular crystalline structures, or whiskers, that form on tin and can lead to unintended short circuits and metal vapor arcs. Whiskers can also break off creating foreign debris within the component. Any one of these problems can cause the catastrophic failure of a system. Failures due to tin whiskers have been documented in commercial satellites, medical equipment, telecommunications, missile and radar systems, nuclear utilities and computers. Apart from tin-whiskers major problems with the reliability of lead-free alternatives have been observed.

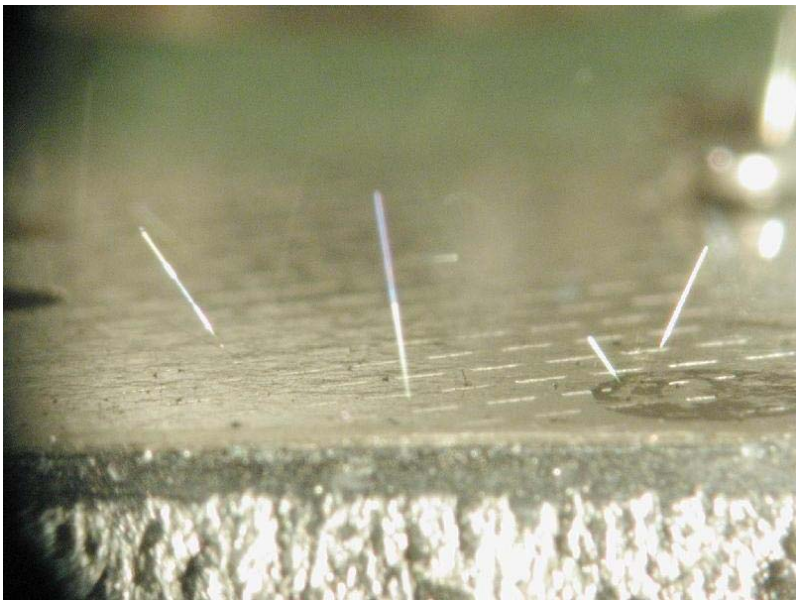


Figure 1. Tin Whiskers

The Lead Free Manhattan Project, Phase 1 brought together 16 of the world's leading subject matter experts (SMEs) in the area of lead-free electronics for a focused two-week project. The objective of the project was to develop a report that outlined baseline or best practices in lead-free electronics across the life-cycle of a product. This case study describes the background, planning and organization for the project discusses the process used and the key factors that led to the development of a high performing team and a successful outcome.

Figure 2 shows an overview of the project flow from the development of the vision to the project outcome, and development of the final report. The project began with an initial vision. Planning took place over several months with consistent communication amongst team leadership via teleconferences during which SME team selection occurred. Once the team was assembled, team building took place and sub-teams were formed. A structured process enabled sub-teams to quickly focus on their task and develop the final report. It should be noted that an important feature of the process was a set of feedback loops that served as a communication link between each of the project steps. For example, the vision was continually refined until the report was completed.

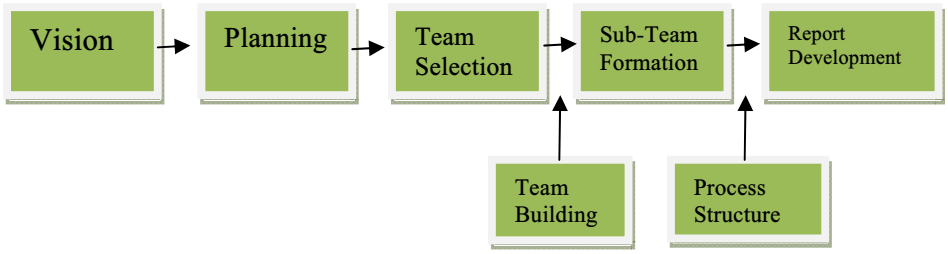


Figure 2. Overview of LFMP Phase 1

2. Developing the Vision for LFMP

Much of the success of Phase 1 of the LFMP project can be attributed to the development of a clear vision. The development of this vision began with two industry leaders posing the question, "wouldn't it be great if we could do something about the lead-free problem? The conversation led to the idea of creating a highly focused project that would bring together the leading experts in lead-free electronics to identify current best practices, develop a roadmap for what needs to be done to address the challenges of lead free electronics and carry out the necessary research and development. A phased approach was planned. Phase 1 would focus on identifying current best practices in lead-free and would identify baseline practices where no best practices existed. Phase 2 would focus on developing a roadmap for the work that needs to be done in research and development. Phase 3 would be a multi-year effort aimed at conducting the R&D necessary to develop reliable and sustainable Pb-free electronics.

The initial vision for the first two phases was stated as follows:

The objective of this effort is to capture industry-wide Pb-free electronics best practices and to develop an integrated industry/government plan to mitigate future risks posed by the worldwide transition to Pb-free electronic products. The scope of this effort will be to assemble leading Subject Matter Experts (SMEs) and have them collectively define the current set of best practices in use to mitigate the risk associated with Pb-free electronics usage in DOD applications and then to develop an action plan to mitigate future risks.

3. Pre-project Planning

Pre-project planning began in February of 2009 with a teleconference that included the conference coordinator, the two co-leaders and the facilitator. It was determined that the LFMP would be a two-week, intense effort that would bring together 16 of the leading SMEs in Pb-free at one location. Teleconferences were held every two weeks until the project start. Topics covered in these meetings included logistics for the conference, outside speakers, the work structure, the facilitation process and the desired outputs. Drafts of a possible structure and schedule were circulated and commented upon and there was an eventual consensus as to how the two weeks would be structured, a detailed schedule, how the work flow would be managed, how issues related to team process would be handled and what the outputs would be.

4. Team selection

A critical step in the process was the selection of the team of SMEs who were to participate in the two-week session. The primary objective of the team selection process was to identify individuals with the best combination of experience, knowledge and expertise in lead-free electronics for the LFMP. Two operational constraints were added. The group should broadly represent the Aerospace Industry and DOD service organizations. A second constraint was that the group should be limited to 16 participants.

The selection began with one of the co-leaders identifying 4 well-known experts in Lead Free Electronics to serve as an advisory panel. Potential SMEs were drawn from industry, academia, government and research organizations. Through emails and teleconferences the advisory panel identified a group of peers with the requisite qualifications. The advisory panel then did a preliminary ranking of the identified individuals. At this point the members of Industry Advisory Board (IAB) of the Navy Mantech Electronics Center of Excellence, seven director-level representatives from industry, were asked to review the list and add or subtract names. Once this list was developed, the IAB and the advisory panel re-ranked the names in an Excel spreadsheet. The ranks from each individual were then sent to the co-leader who aggregated all of the rankings by taking the average rank across all SMEs and IAB members. A consolidated list of 37 SMEs was then prepared and sent back to the IAB for review. Individuals were then invited to participate in the LFMP according to their overall ranking. If an individual could not participate for any reason the next-ranked name on the list was then invited until a total of 16 SMEs had agreed to participate. Although other industry representatives offered to fund the participation of additional SMEs the group size remained at the 16 selected by this process.

5. The Setting and Schedule

Setting

The two-week session was held at the headquarters of the American Competitiveness Institute (ACI) headquarters in Philadelphia. The full team met in a large conference room set up with audio-visual equipment, including a projector and teleconference equipment. The larger group was organized into five sub-teams, each with their own breakout room. Each of the five groups was charged with reporting on one of the following topics: design, testing, reliability, manufacturing and sustainment. For the full-team sessions audio recordings were made via individual microphones assigned to each of the SMEs. In addition, selected video recordings were made during the two weeks.

Schedule and Purpose

Each day began at 8am. A "tag-up" session was held at the end of the day. These sessions were intended to review outstanding issues, problems, questions and lessons learned. Key points were recorded on an easel and posted in the large conference room. The first two days were set aside for introductions and an Industry Forum. The purpose of the Industry Forum was to accommodate a larger group of SMEs who could not be physically present but whose expertise could help to augment the current understanding of issues and solutions for the LFMP team. Day 3 was intended to allow the LFMP team to discuss, synthesize and react to the Industry Forum Speakers as well as provide an opportunity for team interaction and beginning discussion of the vision and objectives of Phase 1.

Days 4 and 5 were set aside for discussion of the deliverable and the initial report outline. At this time, five sub-teams were formed with responsibility for Design, Manufacturing, Testing, Reliability and Sustainment. This structure was elected because it was a logical extension of how products are developed within the DoD framework. Initial outlines were developed and discussed within the team and storyboards were introduced to permit formulation and synthesis of thought before writing draft textual material. On day 6 sub-teams gave overviews of their storyboards and other SMEs provided feedback which encourage convergence to a shared conceptualization of the approach and objectives. Days 7, 8 and 9 were devoted to

writing reports and sections of sub-teams' reports were posted for review and comment. On the final day teams completed their initial drafts and agreed on follow-up activities. The final day ended with a recognition event at which certificates were awarded by the Director of the ONR ManTech Electronics Center. Figure 3 shows the complete day-by-day schedule for the LFMP project.

	Activity
1-2	The project began with welcomes from the B2PCOE Director and a presentation from the ONR U.S. Navy ManTech Director. The co-leaders then provided an overview of the schedule, the project purpose and vision. The notion of best practices was introduced and discussed and a consensus was arrived at for a definition of best practices in Pb-Free electronics. Following a break the Industry Pb-Free Electronics Best Practices Forum began. The forum included presentations on varied issues from experts in Pb-Free Electronics. Most of the presentations were made via teleconferencing using speakerphone and a Web Conferencing platform. Questions and discussions were integrated into the sessions.
3	The full team engaged in a more general discussion of the lessons learned from the outside speakers. Additional presentations were made by members of the team and the team discussed lessons learned.
4	The co-leaders and the team discussed the deliverable and refined the outline for the final reports. Individual SMEs were assigned to five specific teams with responsibility for developing reports in the following areas: Design, Manufacturing, Testing, Reliability and Sustainment. A preliminary outline was provided for each report (See Appendix A). Leaders for each team were assigned. Each team included three SMEs, with the exception of Manufacturing, which had four SMEs. Teams began working in their respective breakout rooms. As a first step, each team refined their initial outline for the deliverable. Outlines were posted on the wall and sub-team leads discussed the outlines and received feedback from the LFMP co-leaders and other SMEs.
5	Teams continued refining outlines and began developing initial storyboards. Teams continued working off-line over the weekend and continued to refine their storyboards.
6	Teams developed an initial set of storyboards and posted them on the wall. Sub-team leads gave an overview of their storyboards and SMEs commented and gave feedback.
7 -9	Draft sections of the report were developed. Written material was posted and made available for feedback by SMEs using post-it notes or in the general session.
10	Teams completed their initial drafts and agreed on follow-up activities over the next two weeks**.** Follow-up activities included completing drafts, editing and feedback on final drafts for the report. The two-week session ended with a recognition event and awarding of certificates to all SMEs.

Figure 3. Schedule

6. Development of Team Norms and Project Culture

Development of team norms was an important enabler to the success of the LFMP. Early in the project, a session was held with the entire team to solicit their input on a "code of conduct" for the two weeks. For purposes of discussion the code of conduct was organized around four categories of team behavior: communication, conflict management, self-management and process review.

- **Communication**
  The team agreed on the following principles.
  - All team member listen attentively to other speakers and allow speakers to finish before speaking
  - If a team member wants to speak he or she must raise their hand and be recognized

- Team members will avoid dominating discussions allow everyone to share in the discussion. A three-minute rule was suggested; e.g., any single speaker who speaks over three minutes will be stopped.
- Leadership will monitor and reinforce these behaviors during the two week period.

- **Conflict Management**
  The team agreed on the following ground rules for managing conflict.
  - Ok to agree to disagree respectfully
  - Respect Minority Opinions
  - Don't avoid tough issues/questions
  - Goal in discussions is to arrive at a win-win resolution
  - In the final analysis debates should be settled by data where possible ("data talks")

- **Self-Management**
  The following rules were agreed upon for self-management of the LFMP team.
  - Three-knock rule: when the team or discussion got off point or involved side conversations the co-leaders or any member could knock three times as a signal that the group should be quiet and listen to the speaker.
  - 3 Minute Soap Box Rule: no speaker should be allowed to speak over 3 minutes.
  - Necessary & sufficient: discussions should last no longer than that which is necessary and sufficient to cover the points.
  - Content over volume: the content of discussions should be emphasized over the volume of the speech.
  - There should be a scribe for each session to record key points and issues for feedback and review
  - Issues that cannot be addressed immediately should be captured in a "parking lot"

- **Process Review**
  - End-of-day tag-up sessions where candid discussions of issues, progress and team comments were permitted and was used to review any team process issues
  - If the process is not working, fix it immediately

7. Artifacts

The LFMP culture was characterized by several artifacts that helped to keep the team focused on their end objectives. Artifacts included a professionally done brochure, initial outlines, LFMP storyboards, and a "baseball bat".

The brochure included an overview of the project and outlined the schedule and agenda. The brochure also included biographical information on each SME.

The storyboards provided an organization structure for the sub-team to assemble their initial ideas and share them with the other SMEs. Storyboards included the following sections: A heading for the module, identifying information for the authors, references, conclusions, recommendations, the current baseline practice, issues, gaps and misperceptions and a space for figures, charts or pictures with captions. As storyboards were prepared they were posted on the wall under the relevant topic and other SMEs could review and post comments.

The baseball bat was a humorous symbol used to "enforce" the ground rules, and to keep the SMEs on track for their primary objective.

8. Benchmarking and Best Practices Review

Early in the project an overview on benchmarking and best practices presented to the team. Standard definitions were presented for best practices and after a thorough discussion the SME team reached a consensus that the term "best practice" did not apply to many areas that were being addressed in the LFMP. Many of these issues lacked sufficient data and experience to make a determination as to whether a practice was best or not. An alternative definition was agreed to as follows: *A process or practice that describes the current state-of-the-art as a baseline against which future improvement can be measured.* It was also agreed that where a baseline practice was a best practice it would be so identified.

9. Project Outcome

Overall, the LFMP team functioned extremely well and was successful in meeting the objectives. Although the schedule was demanding and the task was difficult the sub-teams were all able to produce first drafts by the end of the two week period. Although follow-up work was needed to turn the drafts into a final report, the majority of the work was completed within the two weeks.

10. The Keys to Success

The successful outcome of the LFMP was made possible by seven factors that characterize high performing teams. These included clarity of vision, leadership, team selection, effective collaboration, knowledge management, a structured development process and a good technical support system.

11. Clarity of Vision

The vision for the project was clear and more importantly it was communicated to all team members in several ways. First, the written material sent to team members in advance outlined the objectives of the project. As the team met over the first few days, the vision was discussed, refined and agreed upon by the entire team. Having a clear vision has been shown to predict the success of new product development projects (Lynn & Reilly, 2002) as well as a wide range of other projects (Sobel Lojeski, Reilly & Dominick, 2005).

The team had a common understanding of the vision and was able to achieve what team researchers call a "shared mental model" or shared cognition. This allowed the team to see the entire vision for the project and understand how each of the elements fit together interdependently. This shared mental model was enhanced by frequent feedback from the co-leaders and fellow SMEs and the project progressed. A good example of how the shared mental model was expressed was in the agreement of teams to use a common set of colors for visuals: green for no change, yellow for minor change and red for major change. Researchers have noted that shared mental models (SMMs) improve team effectiveness in several ways. First, SMMs include shared task-specific knowledge which allows team members to take action in a coordinated manner without the need to communicate overtly (e.g., Cannon-Bowers et al., 1993). Second, SMMs allow shared knowledge about task-related processes – for example, teamwork and collaboration (Rentsch and Hall, 1994). Third, SMMS allow team members to understand each other - their preferences, strengths, weaknesses, and tendencies as well as the distribution of expertise in the team (Mathieu et al., 2000) in order to maximize performance. Finally, shared mental models may include shared attitudes and beliefs (Cannon & Edmondson, 2001) which allow team members to arrive at compatible interpretations and understandings of the environment and the context within which they are working. This allows better decisions to be made and also improves team motivation and cohesion (Cannon Bowers & Salas, 2001).

12. Leadership

The two co-leaders contributed to the ultimate success of the project in several important ways. First, they set the vision for the end-product and continually clarified and reinforced the vision so that all team members developed a shared mental model. Secondly, the co-leaders kept the team on task by providing feedback on the schedule and the content of each sub-teams' contributions. Third, the co-leaders participated fully in the process, leading review sessions, contributing knowledge and expertise, helping to integrate the various elements provided by sub-teams and writing sections of the report. Finally, the co-leaders motivated the team through their encouragement, obvious commitment and exemplary behavior.

Research in the new product development area has shown that leader "hands-on" involvement in a major contributor to project success (Lynn & Reilly, 2002).

13. Team selection

The LFMP project recruited the "A Team", a group of the top experts on Pb-Free electronics available. The process used to select these individuals was systematic and incorporated the judgment of a sizable group of knowledgeable senior managers and leaders in the field of electronics. In addition to bringing their experience, knowledge and expertise team members, without exception, also brought a passion and commitment to the issue of Pb-Free electronics manufacturing. This combination of expertise and commitment was an essential combination for success. There was also a social networking element to the team's effectiveness. Prior established relationships with one another through professional groups and meetings allowed team members to move quickly past the initial stages of team development and begin working together effectively quickly. Social networking with experts outside the team also allowed information to be obtained and assimilated though the outside speakers and "lifelines" (experts in a particular area of Pb-Free) that could be called upon for information or advice on specific key issues. As Lynn and Reilly (2002) have noted selecting the "A team" is a critical element of project success. The LFMP definitely had the A team.

14. Knowledge Management

The LFMP was a complex undertaking with a large amount of knowledge and data to be presented, discussed and assimilated. The effective management of knowledge during the two weeks was accomplished in several ways.

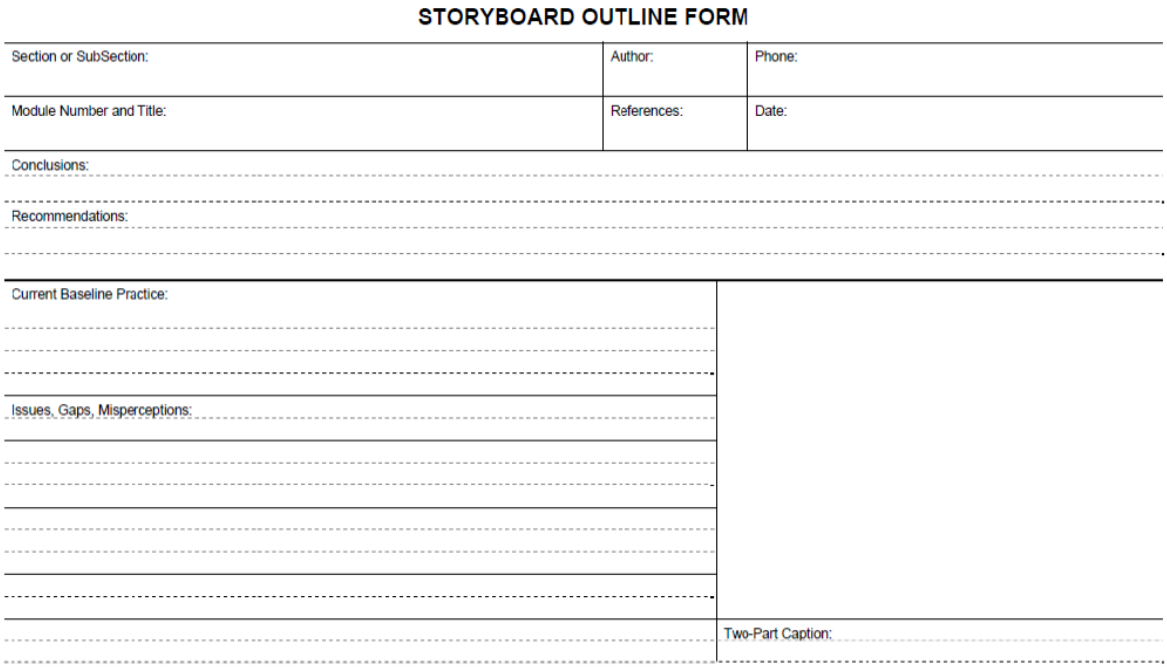
- **Outside Presentations and Review**
  Industry forum presenters were selected to provide useful, and in some cases, provocative information for the SMEs. Following each day of presentations a review session was held to discuss the presentations and highlight what one of the co-leaders called "aha" or "hmm" reactions. That is, were there insights or thought provoking aspects of a particular presentation that might have implications for Pb-free electronics manufacturing? These follow-up sessions were lively and gave SMEs an opportunity to discuss their own views and thoughts on the same topic, to indicate that something new had been learned or to agree that much more data was needed.

- **Tag-up Sessions**
  Tag-up sessions were held at the end of each day to review progress, outstanding technical or team process issues, scheduling issues and any other topics that might come up. These session often included the exchange of information or a discussion of process issues that helped all SMEs to stay

on schedule and understand the perspective that other sub-teams were taking with respect to particular issues.

- **Tacit knowledge exchange**
  Perhaps the most important knowledge that emerged during the two weeks was tacit knowledge. Much of the knowledge about Pb-Free is not codified, but resides with SMEs. This tacit knowledge was exchanged through Industry Forum presentations, SME team discussions, and discussions within and between sub-teams. Nonaka (1998) has developed a concept that he calls *ba*. According to Nonaka, "*ba* can be tbought of as a shared space for emerging relationships. This space can be physical (e.g., office, dispersed business space), virtual (e.g., e-mail, teleconference), mental (e.g., shared experiences, ideas, ideals), or any combination of them. What differentiates *ba* from ordinary human interaction is the concept of knowledge creation. *ba* is a shared space that serves as a foundation for knowledge creation. The shared physical and mental space during the two week LFMP created a *ba*-like space within which new ideas and knowledge were created.

- **Storyboarding and Posting**
  Storyboards provided a concise way of presenting information and allowing the review and comments of all SMEs. Once storyboards were completed actual text and visual material was posted for review and comment and allowed all SMEs to track the progress of each sub-team.



STORYBOARD OUTLINE FORM

Section or SubSection:	Author:	Phone:
Module Number and Title:	References:	Date:
Conclusions:		
Recommendations:		
Current Baseline Practice:		
Issues, Gaps, Misperceptions:		
		Two-Part Caption:

Figure 4. Shows the template for the storyboard.

- **Co-leader Review and Feedback**
  The co-leaders provided continual feedback during the two weeks and added additional thoughts and information. Co-leaders were able to take a broader and integrated perspective by reviewing the progress of all sub-teams and providing feedback to sub-teams and the full SME team in general sessions.

15. Effective Collaboration

As others have noted (e.g., Burke, et al., 2004) a group of experts does not necessarily make a team. The challenge in the LFMP project was to provide the framework and processes for effective collaboration amongst 16 experts from diverse backgrounds. How was this accomplished? The larger team was able to collaborate effectively in the early stages of the project by adhering to the code of conduct and engaging in constructive conflict. Ground rules were generally followed with occasional reminders about hand raising and use of the three-knock rule. Sub-teams also functioned effectively and the sub-teams met with one another to discuss interdependencies and ensure that issues were being handled consistently. Conflict during the sessions was always about the task or the process and never about individuals. As one of the SMEs remarked on the last day of the project "nobody's ego got in the way and nobody came with an agenda". The sub-teams interfaced effectively and helped one another when it was appropriate, even writing specific sections for another sub-team in some cases. One important feature of the LFMP was the co-location for two-weeks of all team members. This provided fertile ground and a contributing environment for the exchange of tacit knowledge between team members that would have been otherwise difficult or impossible without collocation. The use of outlines and storyboarding promoted collaboration as it allowed all sub-teams to understand what was being covered, where there might be overlap, where there were inconsistencies, where there might be a need for cross-team collaboration and where there might be gaps in what was covered. In addition, most team members were housed in the same hotel allowing off line discussions and relationship building that helped the team to continue to work together effectively. This was further enhanced by nighttime teambuilding activities (an evening dinner, a major league baseball game and a dinner cruise) during which the team was able to relax and share some fun time together.

16. Structured Development Process

A structured development process enabled the team to quickly engage in their task within a common framework. The process began with a template for the reports which was then turned into outlines by the sub-teams. Following the development and review of outlines the sub-teams developed storyboards which addressed specific elements of their report. Finally, storyboards were turned into draft reports. As noted, an important element of the process was the posting of material at each step. This allowed feedback, coordination, identification of overlap or other issues that needed to be addressed. One other element of the process that should be mentioned is a hard deadline for completing the drafts imposed by the co-leaders with a well-defined schedule. The deadline served to mobilize and focus the efforts of the team and made

keeping on schedule essential. Specific milestones were used by sub-teams and the co-leaders to monitor progress. The importance of process has been noted in the new product development arena (Lynn, Reilly, Akgun, 2000; Lynn & Reilly, 2002).

17. Supporting Technology

Supporting technology was used to help the team achieve its goals in several ways. First, most outside speakers were not on-site so Web enabling technology and teleconferencing equipment was used to allow speakers to present information and dialogue with the LFMP SMEs. Second, all SMEs had access to the internet which allowed them to search for information and communicate via email to other experts. A local FTP site was set up so that sub-teams, co-leaders and individuals could both upload and download documents as they were prepared. In addition, resource materials were uploaded and resided on the FTP site so that they could be used by SMEs at any time. Breakout rooms had wireless connections and projectors so that sub-teams could share focus on material as it was being developed.

18. Conclusions

The B2P mission to improve performance and affordability includes the consideration of a wide variety of processes and technologies. The LFMP was an unusual B2P project in several respects. It brought together leading experts in a specific area of technolology, it used a structured process and resulted in an end-product in a short time span, hence the analogy to the Manhattan Project. The LFMP Phase 1 is an example of a project that could be replicated for other technical areas. As such, it represents a best practice for bringing together experts to focus on a problem and produce a useful outcome in a short time frame. It is suggested that the seven principles described here – Clarity of Vision, Team Selection, Knowledge Management, Effective Collaboration, Leadership, a Structured Development Process and Supporting Technology – should be followed to ensure a high performing team and a successful project outcome when leading experts are brought together for a focused, collaborative effort. As such, the LFMP can serve as a model for future, highly focused efforts to advance manufacturing technologies and processes.

Acknowledgements

The U.S. Navy Mantech B2PCOE and the Lead Free Manhattan Project

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