Combining MMOWGLI Social Media Brainstorming with Lexical Link Analysis (LLA) to Strengthen the DoD Acquisition Process

30 September 2013

by

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MMOWGLI (Massive Multiplayer Online Wargame Leveraging the Internet) sponsored by the Office of Naval Research, is an online game platform designed to elicit collective intelligence from an engaged pool of world-wide players. In the past the Naval Postgraduate School hosted a series of successful games including piracyMMOWGLI (2011), energyMMOWGLI (2012) and biiMMOWGLI(2013) which built the critical mass of players needed to find creative solutions to real-life, difficult business problems such as piracy, energy and business innovation initiatives (bii). NPS also leveraged MMOWGLI with the analytic framework of Lexical Link Analysis (LLA) to link the game data to the concepts documented in two business processes (i.e. improve DoD energy efficiency and improve future open systems architecture [OSA] strategy). We demonstrated the synergy of using both tools to gain faster viability of new ideas to improve the acquisition process, and sorted the idea cards that might be good candidates for further investigation. We then determined that the majority of Navy programs are affected by (or critically dependent on) energy issues but goals and terms are handled inconsistently. It is evident that MMOWGLI together with LLA is an important tool for comparing and considering innovative ideas using social media games to improve acquisition processes.
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Abstract

MMOWGLI (Massive Multiplayer Online Wargame Leveraging the Internet), sponsored by the Office of Naval Research, is an online game platform designed to elicit collective intelligence from an engaged pool of world-wide players. In the past, the Naval Postgraduate School hosted a series of successful games including piracyMMOWGLI (2011), energyMMOWGLI (2012) and biiMMOWGLI(2013) which built the critical mass of players needed to find creative solutions to real-life, difficult business problems such as piracy, energy and business innovation initiatives (bii). NPS also leveraged MMOWGLI with the analytic framework of Lexical Link Analysis (LLA) to link the game data to the concepts documented in two business processes (i.e. improve DoD energy efficiency and improve future open systems architecture [OSA] strategy). We demonstrated the synergy of using both tools to gain faster viability of new ideas to improve the acquisition process, and sorted the idea cards that might be good candidates for further investigation. We then determined that the majority of Navy programs are affected by (or critically dependent on) energy issues, but goals and terms are handled inconsistently. It is evident that MMOWGLI together with LLA is an important tool for comparing and considering innovative ideas using social media games to improve acquisition processes.

Keywords: Massive Multiplayer Online Wargame Leveraging the Internet, MMOWGLI, Collective Intelligence, Brainstorming Social Media, Match Matrix, Idea Cards, Action Plans, Open Systems Architecture, OSA Strategy, Lexical Link Analysis, LLA, Text Mining, Data Mining, Program Elements, Unstructured Data, Data-Driven, Acquisition Process
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Disclaimer: The views represented in this report are those of the author and do not reflect the official policy position of the Navy, the Department of Defense, or the federal government.
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Combining MMOWGLI Social Media Brainstorming With Lexical Link Analysis to Strengthen the DoD Acquisition Process

Background

Massive multiplayer online wargame leveraging the internet (MMOWGLI), sponsored by the Office of Naval Research (ONR), is an online game platform designed to elicit collective intelligence from an engaged pool of world-wide players, thus invoking a fresh approach to gather data from a targeted community via crowd sourcing. The Naval Postgraduate School (NPS) is the primary developer of this game software. In the past, NPS hosted a series of successful games including piracyMMOWGLI (2011-present, ongoing), energyMMOWGLI (May 2012) and biiMMOWGLI (business innovation initiative MMOWGLI, July 2013) which built the critical mass of players needed to find creative solutions to real-life, difficult problems such as piracy and energy. These games were hosted by the NPS Modeling Virtual Environments and Simulation (MOVES) Institute.

We leveraged MMOWGLI game output in this effort, to elicit collective intelligence from the acquisition communities for two business processes:

1. Improve Department of Defense (DoD) energy efficiency: Studies evaluating the DoD’s energy use have been conducted by the Institute for Defense Analyses, the Defense Science Board Energy Security Task Force, and JASON (an independent scientific advisory group). All three studies suggest that DoD energy inefficiency is a significant liability, a constraint on operations and a force-protection challenge. More specifically, all three studies led to two consistently held requirements to improve DoD energy efficiency: (1) By reducing energy demand, one may provide operational forces greater flexibility and reduce their dependency on logistics infrastructure, and (2) the DoD’s current requirements and acquisition processes to value the technologies with the potential to improve energy efficiency (DoD Energy Inefficiency, 2012).

2. Improve open systems architecture (OSA) strategy: The assistant secretary for research development and acquisition (ASN RDA) authorized a new naval OSA strategy in November 2012 to reduce the total ownership cost of systems, encourage innovation, and more rapidly deliver needed capabilities to the warfighter. This strategy
specifically challenges the naval acquisition workforce to institute measures to improve competition, eliminate redundant developments, and coordinate program activities that promote the reuse of tactical products across sea and air platforms. The acquisition organization is tasked to implement the strategy, however, success will require substantial changes in the Navy’s business practices, organizational structures, and resource planning.

In concert with the updated strategy, Deputy Assistant Secretary of the Navy (DASN) – Research, Development, Testing & Evaluation (RDT&E) created a business innovation initiative (BII) to search for ways to overcome the inertia many of our programs of record (PoR’s) suffer today. Mr. Sean Stackley (as cited in Guertin, Womble, & Bruhns, 2013), the ASN RDA said in a recent article:

“The value of an innovation initiative is to explore what business-relationship changes are needed to open up competition; incentivize better contractor performance; increase access to innovative products and services from a wider array of sources; decrease time to field new capabilities; and achieve lower acquisition and life-cycle costs while sustaining fair industry profitability.” (page 667).

The biMMOWGLI game using LLA is one of the ways to achieve these goals. LLA enables the graphic depiction and quantitative analysis of the captured MMOWGLI data, as explained in detail in the business innovation initiative MMOWGLI games chapter. We reveal the new knowledge discovered by those participating in this game and the ideas arising from the data linked – or not linked – to other ideas, or perhaps specific guiding documents. We are thus able to show relevance, gaps, and consistency, between all analyzed data. This has great ramifications by revealing how guidance documents may be missing certain innovations, or how they might show acceptance within the community. We show these graphic depictions, and their supporting match matrices in later chapters and in the appendices.

In the past year, we applied the methodology to link the two MMOWGLI games to the concepts documented in the two business processes. The goal of this research is to provide an innovative platform that can be deployed quickly to mobilize the intellectual capacities of the research and professional acquisition communities to provide innovation and creative ideas to address the challenges and difficulties in the two business processes. We also compare new game data with the most recent acquisition data and measure the impacts of the game data on the current state of the policies and practices in a broad range of DoD acquisition programs.
Methodology

MMOWGLI Game

The game is built using a unique, open source, software adaptation of the Institute for the Future (IFTF)-designed game to simulate a real-world “brainstorm.” A player needs to register with a required game ID and email; the last name, first name and other personal identification information (PII) are not required.

The game starts with an explanation of the situation and allows a player to “Play an Idea” or “Take Action.” Players can then choose to input an idea or participate in the discussion of an existing idea in the categories of “Innovate” and “Defend.” The discussion can be in one of five categories: expand—build on this idea to amplify the impact; counter—challenge this idea; adapt—take this idea in a different direction; or explore—something missing. Or players can ask a question, as shown in Figure 1. In the end, the system gathers collective intelligence that resides in tree-structured, color-coded sets of ideas and discussions in text format as shown in Figure 2. If an idea and its associated discussion have merit, which is determined in the combination of the player’s score and the Game Master’s recommendation, it is taken into a separate “Take Action” board for further planning and deliberation.

Figure 1. Categories of Ideas Based on the Styles of Responses
The MMOWGLI platform is suitable for tackling a broad range of challenges for national security, multiple stakeholders, and small or large communities (e.g. corporations and research communities like the acquisition system communities). It is a configurable innovation platform that can be adapted to any scenario.

**Lexical Link Analysis (LLA)**

As in military operations, where the term *situational awareness* is coined, we note that our efforts can inform awareness of analyzed data, in a unique way, that help improve a decision-makers’ understanding or awareness of the data’s content. We therefore define awareness as the cognitive interface between decision makers and a complex system, expressed in a range of terms or features, or specific vocabulary or lexicon, to describe the attributes and surrounding environment of the system. Specifically, LLA is a form of text mining in which word meanings represented in lexical terms (e.g., word pairs) can be represented as if they are in a community of a word network.

Link analysis “discovers” and displays a network of word pairs. These word pair networks are characterized by one-, two-, or three-word themes. Figure 3 shows a visualization of common lexical links shared between Systems 1 and 2, shown in the red box. A system, or a corpus, can be a collection of documents for an actual physical system (e.g., OSA strategies, ideas in a MMOWGLI game or simply a category of information). A node in in Figure 3 represents a word in a corpus and a link or edge represents a word pair. A word pair is a bi-gram (Manning & Schütze, 1999) word pair extracted from the corpus. Within the field of computational linguistics, an $n$-gram is a sequence of $n$ items matched certain probabilistic patterns from a given text. Size 2 of $n$-gram is a bi-gram. In Figure 3, each color of a link refers to the collection of words, lexicon or features that belongs to a cluster which describes a concept or theme. In overlapping areas, nodes are lexically linked. Unlinked, outer vectors (outside the red box) indicate unique system features.
Figure 4 shows the information from three categories can be compared and Figure 5 shows the information from two time periods that can be compared. What is unique here is that LLA constructs these linkages via intelligent agent technology using social network grouping methods.

The closeness of the systems in comparison can be examined visually or using the quadratic assignment procedure (QAP; Hubert & Schultz, 1976 [e.g., in UCINET]; Borgatti, Everett, & Freeman, 2002) to compute the correlation of two sets of lexical terms from two systems and analyze the structural differences in the two systems as shown in Figure 6.

![Figure 3. Comparing Two Systems Using LLA](image)

![Figure 4. Comparing Three Categories](image)

![Figure 5. Comparing Two Time Periods](image)
Figure 6. QAP Correlation via UCINET

Figure 7 shows a visualization of LLA with connected keywords or concepts as clusters, groups or themes. Words are linked as word pairs that appear next to each other in the original documents. Different colors indicate different clusters of word groups. They were produced using a social network community detection method (Girvan & Newman, 2002) where words are connected, as shown in a single color, as if they are in a social community. The algorithm clusters the words into communities based on the word pair links (edges) among the words. Traditional clustering methods typically use hierarchical clustering method (Székely & Rizzo, 2005) where edges with strong weights progressing towards the weakest ones are gradually included into the clusters. Instead, in the Girvan & Newman method, the communities are detected by progressively removing edges that are least central. For example, betweenness, defined as the number of shortest paths between pairs of nodes that run through a node (Freeman, 1977), has been studied in the past as a measure of the centrality of nodes in networks. The edges connecting communities will have high edge betweenness. By removing these edges, the groups are separated from one another and so the underlying community structure of the network is revealed. As a result, a word center is formed around a word node connected with a list of other words in word pairs. For instance, Figure 8 shows a detailed view of a theme or word group in Figure 7. The center words are “analysis, research, approach.” In this example, we use three-word such as “analysis, research, approach” to label such a group, where the top-three words are these with the highest total degree of centralities (Freeman, 1979; Wasserman & Faust, 1994).
Figure 7. Word and Term of Themes Discovered and Shown in Colored Groups
Figure 8.  A Detailed View of a Theme or Word Group From Figure 7

The detailed steps of LLA processing include the following steps:

**Step 1:** Select word pairs based on the following bi-gram parameters:
- The probability threshold for one word next to another word in a word pair
- The minimum frequency for each individual word

**Step 2:** Apply a social network community finding algorithm, i.e. Newman community detection method (Girvan & Newman 2002) to group the word pairs into themes. A theme includes a cluster of lexical word pairs connected to each other.

**Step 3:** Compute a “weight,” or an importance measure, for a theme.

**Step 4:** Sort theme weights by time, and study the distributions of the themes by time.

The outputs of LLA, include lexical network visualizations such as the ones in Figure 3, 4, 5, 6, 7, and 8, radar visualization, and matrix visualization (Zhao, Gallup, & MacKinnon, 2010). The word pair groups or themes as shown Figure 7 and 8, are further divided into three types according to the weights in Step 3:
- Popular (P): themes containing the highest number of mutually connected word pairs. The themes represent the main topics in a
corpus at the time. The theme represented in Figure 8 is an example of a popular theme.

- Emerging (E): themes containing the medium number of mutually connected word pairs, these themes may grow to be popular over time.
- Anomalous (A): themes containing the lowest number of mutually connected word pairs. These themes may be off-topics compared to other themes and may be interesting for further investigation.

**Business Problems That LLA Addresses**

As a text analysis tool, LLA typically addresses the business problems of discovering themes and topics in the unstructured documents and sorting the importance of the themes accordingly. Current methods, for example, internet search methods of ranking pages, require established hyperlinks, citation networks or other forms of crowd-sourced collective intelligence. LLA is especially useful for the data without hyperlinks and citation networks, for example, large-scale government internal documents. Furthermore, current methods typically rank the importance of the information based on their popularity. Instead, we found that in many business applications, it is useful to rank information based on emerging importance or anomalousness.

Current research of social network analysis mostly focuses on people or organizations of direct associations regardless of the contents linked. The so-called study of centrality (Girvan & Newman, 2002; Freeman, 1979) has been a focal point for the social network structure study. Finding the centrality of a network lends insight into the various roles and groupings such as the connectors (e.g., mavens, leaders, bridges, isolated nodes), the clusters (and who is in them), the network core, and its periphery (Orgnet, 2011).

One of the core innovations of LLA is to analyze the content (e.g., documents and social media communications) created by social entities (e.g., people or organizations), therefore create alternative networks, i.e. semantic networks, to the traditional social networks. The resulting networks from LLA examine both social and semantic networks in terms of the organizations and people involved in the important themes, and how semantic networks might suggest improved potential collaborations and predict future outcomes.

**Implementation Details**

In the past year, we continued our efforts at the Naval Postgraduate School (NPS) by using collaborative learning agents (CLAs; QI, 2009) and expanded to other tools, including AutoMap (Center for Computational Analysis of Social and Organizational Systems [CASOS], 2009) for improved visualizations. Results from
these efforts arose from leveraging intelligent agent technology via an educational license with Quantum Intelligence, Inc. CLA is a computer-based learning agent, or agent collaboration, capable of ingesting and processing data sources.

We have been generating visualizations including a lexical network visualization using various open source tools. We began by using the Organizational Risk Assessment (ORA; CASOS, 2009) tool and expanded to other tools. For example, in the past year, we developed 3D network views using Pajek (Batagelj, Mrvar, & Zaveršnik, 2011) and X3D (Reid 2011, Brutzman 2008, Web3D 2013). We also developed our visualizations radar view and match matrix view (Zhao, Gallup, & MacKinnon, 2010).

LLA uses a computer-based learning agent called CLA (QI, 2009) to employ an unsupervised learning process that separates patterns and anomalies. Unsupervised agent learning is implemented by indexing each set of documents separately and in parallel using multiple learning agents. The unsupervised agents are used because the learning data for supervised agents are expensive to obtain. Multiple agents can work collaboratively and in parallel. We set up a cluster utilizing Linux servers in the NPS High Performance Computing Center (HPC) to handle the large-scale data and secure environment in the NPS Secure Technology Battle Laboratory (STBL).

Relations to Other Methods

The LLA approach is more properly related to latent semantic analysis (LSA) (Dumais, Furnas, Landauer, & Deerwester, 1988) and probabilistic latent semantic analysis (PLSA; Hofmann, 2000). In the LSA approach, a term-document matrix is the starting point for analysis. The elements of the term-document or feature-object (term as feature and document as object) matrix are the occurrences of each word in a particular document, i.e. \[ A = [a_{ij}] \], where \( a_{ij} \) denotes the frequency in which term \( j \) occurs in document \( i \). The term-document matrix is usually sparse. LSA uses singular value decomposition (SVD) to reduce the dimensionality of the term-document matrix. SVD cannot be applied to the cases where the vocabulary (the unique number of terms) in the document collection is large, for example, the number of unique terms in the DoD’s acquisition documentation approach the large value that would make SVD inapplicable. LSA has been widely used to improve information indexing, search/retrieval and text categorization.

A recent development related to this method is called latent Dirichlet allocation (LDA; Blei, Ng, & Jordan, 2003), which is a generative probabilistic model of a corpus. In LDA, a document is considered to be composed of a collection of words—a “bag of words,” where word order and grammar are not considered important. The basic idea is that documents are represented as random mixtures
over latent topics, where each topic is characterized by a statistical distribution (Dirichlet distribution) over the corpus.

Our theme generation from LLA is different than LDA, in which a collection of lexical terms are connected to each other semantically, as if they are in a social community, and social network grouping methods are used to group the words, and unlike LSA, our method is easily scaled to analyze a large vocabulary and is generalizable to any sequential data.

LLA is further related to tools such as PageRank (Brin & Page 1998; PageRank, 2013), Automap (CASOS, 2009), AlchemyAPI (AI, 2013), Semantica (SR, 2013) for entity extraction, text analysis and sentiment analysis, WordNet (Miller, 1995), and Apache Lucene (ASF, 2013), OpenNLP (ASF, 2013), and Mahout (ASF, 2013), with the best of each incorporated in LLA.

**Anticipated Benefits**

Our LLA method provides candidate solutions to meet the critical analytic needs of the acquisition research. The key advantage is to provide an innovative near real-time self-awareness system to transfer diversified data services into strategic decision-making knowledge, specifically through:

- **Automation**: High correlation of LLA results—with the link analysis done by human analysts—makes it possible to save human power and improve responsiveness. Automation is achieved via computer program or software agents to perform LLA frequently— and in near real-time.

- **Discovery**: LLA discovers and displays a network of word pairs. These word pair networks are characterized by one, two or three word themes. The weight of each theme is determined based on its frequency of occurrence. It may also discover blind spots of human analysis that are caused by the overwhelming data for human analysts to consider.

- **Validation**: LLA may provide different perspectives of links. In the acquisition context, links discovered by human analysts may emphasize component and part connections that do not necessarily reflect content overlaps. Consequently, it can provide improved results in terms of trust, quality of association discovery; can help to break through different levels of the *taxonomy of ignorance* (Denby & Gammack, 1999), reach across organizational boundaries, and help to improve organizational reach.
Other Use Cases

In this section we discuss other recent research efforts where LLA has been implemented to uncover meaning and depict Big Data to its users.

Discover New Knowledge Using Open Social Media Data Sources

There is a critical need for Defense Intelligence Agency (DIA) to discover new sources of information from public domains, e.g. from various social media platforms, and then link them with intelligence collected for other intelligence applications. We demonstrated how LLA can be applied to publically available social media data which might be relevant to intelligence applications. We develop a specific persona archetype and to analyze all available data derived from social media.

Identification of NATO Capability Requirements

We applied LLA to analyze the documents that support the current process to identify NATO capability and force requirements from the current process and supporting documents to help determine who the stakeholders are, i.e. US and Allied organizations involved in the current process, in an effort to improve EUCOM visibility and recommend new collaborations toward "Smart Defense."


The US DoD acquisition process is extremely complex, where key processes must work in concert to deliver the capabilities required by the warfighters. Each process produces a large amount of data in an unstructured manner. There has been a critical need for automation, validation, and discovery to help acquisition professionals, decision makers and researchers to reveal the interrelationships among the data elements and business processes. We applied LLA to extract the links, compare the trends and discover previously unknown patterns from data of three armed-services (Army, Navy and Air Force) over the past ten years.

Multi-Agency Radiological Responses Plan and Exercise

Every year, US DHS spends large amounts of money to conduct training, exercises and simulations to prepare for emergency responses. These exercises often involve processes such as planning, organizing, directing, and monitoring activities and collaborations of multi-agencies. The activities generate large amounts of unstructured data for sensemaking. LLA was used for summarizing themes, concepts and discovering the order of the importance of the events.
Naval Recruiting

Facebook, Twitter, and many other social networking sites offer virtual environments for meeting possible candidates that could fit service entry profiles. Sponsored by the Navy Recruiting Command, the goal of this project was to collect and match large-scale Facebook public fan and group profiles with Navy-enlisted and officer-rating documents to improve future Navy Recruiting and advertising efforts.

Navy Chief of Information (CHINFO) (Zhao, Gallup, & MacKinnon, 2011a)

The case study involved the 2006 U.S. Coast Guard Live Fire case, when the Coast Guard planned a live fire training program in the Great Lakes area in Michigan. 980 public comments and 200 pages of public meeting transcripts, linking all associated comments, and then generating semantic networks over time by stakeholder groups. We leveraged LLA to determine how strategic communications of CHINFO proliferate through various open sources.

APAN Network and Haiti Operation Data Analysis (Zhao, MacKinnon, & Gallup, 2012b)

In the aftermath of the Haiti earthquake, U.S. military and civil organizations provided rapid and extensive relief operations. LLA was used to analyze trends in interagency synergy from data collected from these social media platforms such as Twitter, Facebook, news-feed Web sites, official PDF briefing documents, situation reports, forums and blogs from the HAITI HA/DR Community of Interest (COI) on the All Partners Access Network (APAN).

Defense Analysis

Collecting data in the area of human intelligence (HUMINT), we performed a feasibility study from approximately 1500 reports. Each report represented a separate event including post-blast information, and after-action reports from the Combined Explosives Exploitation Cell (CEXC) and data from other reporting tools used in Iraq and Afghanistan war activities as target development, civil affairs, psychological operations, engagement, or indirect fires. Our efforts demonstrated the capability to reconstruct social networks of people, places, and events, as well as to reveal trends and perhaps predict future events.

In summary, LLA discovers and displays these networks of word pairs from large-scale unstructured data. It can be installed as a search and knowledge management tool for scoring and ranking interesting information and for visualizing and reporting correlations among categories and layers of information including social, meta-data and semantic links. This effort then presents the decision maker with previously unavailable and emerging patterns and themes, as well as
unprecedented levels of analysis, thus reducing the workload and overcoming the blind spots of human analysts and providing potential automation. For example, for the recent MMOWGLI games, LLA was leveraged to identify potentially interesting information from idea card, link it, then recommend them for action plans for Game Masters.

Figure 9 shows a MMOWGLI game’s content and attributes can be processed into the inputs (i.e., meta_data.txt and a directory of text files) to LLA.

Figure 10(a) shows word pair clusters using Newman community finding algorithm (Girvan & Newman, 2002) from the 1st iteration. Figure 10(b) selected
lexical terms linked to the most central nodes, for example, “fuel, shipboard, liquid” from the 2nd Iteration.

Figure 10. Iterations of the Two Steps LLA Steps Used to Group Word Pairs Into Themes

At present, LLA computer code is not available to the public and is proprietary in nature. Dr. Zhao is the originator of the software code which was used in support
of numerous government projects as explained above. Future efforts might include an exportable version of LLA.

**Research Results**

We applied LLA to three MMOWGLI games, specifically:

- **energyMMOWGLI** (May 2012): 560 players, ~5000 idea cards and 68 action plans
- **biiMMOWGLI** Round 1 (January 2013): 892 idea cards, 11 action plans
- **biiMMOWGLI** Round 2 (July 2013): 2674 idea cards, 15 action plans

From these games, data was gathered and analyzed by LLA to show the correlation and linkage between numerous ideas and revealed the resulting themes as discussed below.

**Energy Game**

In the **energyMMOWGLI** game, LLA was used to analyze the collected data (idea cards and action plans) retrieved from the following links:


The LLA was performed through the following process:

- **Prepare acquisition data.** Collate key terms and goal statements of current acquisition programs within the congressional budget processes for use by the LLA methodology
- **Perform link analysis and correlation.** Compare the already-collected **energyMMOWGLI** results to determine action plan relevance on a program-by-program basis

As shown in Figure 11, our goal was to demonstrate the feasibility of the social media **energyMMOWGLI** game as an innovation platform that could generate valuable and unexpected contributions and solutions for improved DoD energy efficiency through the acquisition process, by linking current acquisition programs with the **energyMMOWGLI** game using LLA. We achieved this objective by performing the tasks described previously and detailed in the next section.
Prepare Acquisition Data

The goal here is to collate key terms from the current acquisition program in the congressional budget process. The congressional budget process documents e.g. Program Elements [PEs] from http://www.dtic.mil/descriptivesum/ were used in this task. This source is the accurate and authoritative high level of artifacts the DoD RDT&E process. We had analyzed part of these documents in the past (Gallup, MacKinnon, Zhao, Robey & Odell, 2009; Zhao, Gallup & MacKinnon, 2010,2011a,2011b,2011c,2012a,2012b,2013) in detail using the LLA method jointly with other measures such as cost, schedule, and performance. Specifically, we collected the following most recent (2013) PEs for this project:

Perform Analysis and Correlation

We linked the energyMMOWGLI data, specifically, 38 action plans to the 224 Navy PEs to evaluate the current Navy programs relevant to the game data. Figure 12 illustrates the results of this process in a relevance and correlation matrix.

![Phase I Project: Program Relevance/Correlation Matrix of MMOWGLI Game Plans – Comparison of Key Terms from Both Sources](image)

**Figure 12. Phase I Relevance Matrix**

Figure 13(a) shows the actual match matrix sorted with Navy PEs (row) that match the energyMMOWGLI game data (column) based on the LLA score. Figure 13(b) shows a detailed and enlarged part of Figure 13(a). An LLA score for a PE is the total number of LLA word pairs that were matched with the game action plans.
The top five most relevant PEs from Figure 7:

- PE 0603724N: Navy Energy Program
- PE 0601153N: Defense Research Sciences
- PE 0602123N: Force Protection Applied Res
- PE 0603573N: Advanced Surface Machinery Sys
- PE 0206624M: Marine Corps Comb Services Supt

In the actual visualization of the matrix, one is able to click on the online link for the top one (PE 0603724N in Figure 13, red box) leads to the online page of the “Navy Energy Program,” which is an overall PE specifically focusing on Navy energy issues as shown in Figure 14. This validates that the LLA extracted the relevant keywords from the game data.
The matrix in Figure 13 also shows a holistic picture of the current acquisition programs in connection with situations in which DoD is energy inefficient. Directly looking into the match matrix, as illustrated in Figure 13, can be overwhelming. For that, we applied LLA to discover the themes and divide a single match matrix into many match matrices with different themes as shown in Figure 15. For our research, a theme is a network or community of word pairs that are related to each other. To discover themes, we first applied LLA to compute word pair clusters using the Newman community finding algorithm, in which equal word pairs are treated as if in a community (Girvan & Newman, 2002). Then we select lexical terms linked to the most central nodes. For example the red nodes in Figure 16 are the most central nodes: environmental, ship and effective. The red links are the word pairs shared by both sources (i.e., PEs and MMOWGLI game action plans), the yellow links are the word pairs unique to the game data, and the green links are those unique to the PEs.
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Figure 15. Theme Discovered for Navy 2013 PEs Documents and Energy MMOWGLI Data, Sorted According to Overlapping Word Pairs From the Two Sources
A separate matrix can be constructed for each theme including the links of PEs and action plans with the word pairs that only belongs to the theme. In Figure 16, the correlation matrix for Theme 395(E) labeled as “environmental, ship & effective,” has the highest number of matched word pairs. The matched PEs are sorted according to the number of lexical terms matched with action plans. For
example, the top matched PE is “0603724N_PB_2013,” titled “Navy Energy Program,” which indicates that this is a current Navy program dedicated to energy. We used this matrix to determine where opportunities reside in the current process to include energy-related elements. As is shown in Figure 17(a), two concepts, “energy efficient” (red area enlarged in Figure 17[b]) and “ship design” (green area enlarged in Figure 17[c]) are dominant in this theme. They are dominant since four (action 17, 8, 18, 5 in Figure 17[b]) and two (action 9 and 6 in Figure 17[c]) out of 38 action plans contain word pairs “energy efficient” and “ship design” respectively. This seems to suggest that “energy efficient” may have to work with the concept “ship design.” However, among the 12 PEs that mention “ship design”, only one mentions “energy efficient.” (i.e., the top row in Figure 17[c], corresponding to PE 0603724N_PB_2013 -- the Navy Energy Program). This indicates there is a gap, or a DoD energy inefficiency area, and therefore, an opportunity to emphasize the concept “energy efficient” in all the PEs related to the concept “ship design.”
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(a)

(b)
Following the same analysis, Appendix A lists more gap and opportunity areas discovered by LLA.

**Business Innovation Initiative (BII) MMOWGLI Game**

**Round 1**

*biiMMOWGLI* game Round 1 was performed from January 14, 2013 to January 15, 2013. In Round 1, LLA was used to identify potentially interesting information from idea cards and action plans, link them to existing business documents and show their interrelation to domain experts. We performed two separate post-game data analyses.

- Idea cards (892) and action plans (11) were compared to the proposed OSA strategy (four pages) considered by players
- Idea cards (892) and action plans (11) were compared to the OSA contract guidebook (158 pages) familiar to most players

In Round 1, the LLA data analysis discovered the following:
• Ideas and draft action plans expressed in bi game, by anonymous players, showed strong consistency with the concepts in the Program Manager’s Contract Guidebook

• Metrics indicate the draft OSA strategy triggered new and innovative ideas

• Metrics did not indicate that the OSA strategy was risky, controversial, impossible to implement etc.

LLA also discovered eight main or popular themes, reflecting common interest of the players, using the following keywords:

• Multiple support and components
• Common data, data model
• Component reuse, OSA
• Open system and business
• Systems architecture, current systems
• Specific price and fee
• Existing reusable programs
• Engineering, government and community

We also found that innovative ideas, i.e. gaps between the game data and the OSA strategy document, in the following areas (themes) listed below:

• Small and shared
• Developed and built faster
• Critical definition
• Specific price and fee
• Sponsors change and risk
• Changing requirements
• Interoperability and interfaces

Figure 18 shows one example theme detailed from the comparison of game data with the OSA strategy document. Red nodes show the top three word hubs with the most links (or, most central). Yellow word pairs are unique to action plans, green word pairs are unique to idea cards, and blue word pairs are unique to the OSA strategy document. Red word pairs are found in more than two sources.
More background and summary for Round 1 of *biiMMOWGLI* can also be found in (Guertin, Womble, & Bruhns, 2013; Zhao, Brutzman, & MacKinnon, 2013).

**Round 2**

Round 2 of the *biiMMOWGLI* game was conducted between from July 15, 2013, to July 31, 2013. There were 2674 idea cards and 15 action plans generated.

In Round 2, we applied LLA to answer the business question we started to answer in Round 1: specifically, how might the MMOWGLI game data be used to improve future OSA strategy? We also aimed to answer the following related questions:

- What ideas discussed in the game matched with the OSA strategy documents?
How can the related and matched ideas be used in a way that is useful for future OSA strategies?

To answer these questions in detail, in Round 2, we focused on using LLA to produce match matrices that are linked to the new OSA strategy document. We then divided the outputs of LLA into three types as shown in Figure 19:

- **Popularity (P) themes**: themes containing the highest number of mutually connected word pairs. These themes represent the main topics in a corpus at the time.
- **Emerging (E) themes**: themes containing the medium number of mutually connected word pairs. These themes may grow to become popular over time as we show later in the examples.
- **Anomaly (A) themes**: themes containing the lowest number of mutually connected word pairs. These themes may be off-topics compared to other topics and may be interesting for further investigation.

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<td>Projects</td>
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<tr>
<td>NLI</td>
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<td>120</td>
<td>BAIZED,FUNCTION,TREATMENT</td>
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<td>12,2</td>
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<td>120</td>
<td>OFFICE,STAFF,DEPARTMENT</td>
<td>Projects</td>
<td>12,2</td>
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</tbody>
</table>

**Figure 19. Themes of Popularity (P), Emerging (E) and Anomaly (A) Discovered Using LLA in the Round 2 Idea Cards**
Figure 20 shows the detail for the theme centered around “Existing, Future, Innovation.” It shows the contrast between what is only in the OSA strategy document (green) and what is only in the game idea cards only (yellow). It also shows overlap (red) in these two data sources.

Figure 20 shows the detail for the theme centered around “Existing, Future, Innovation.” It shows the contrast between what is only in the OSA strategy document (green) and what is only in the game idea cards only (yellow). It also shows overlap (red) in these two data sources.

Figure 20. Theme Centered Around “Existing, Future, Innovation”

From Figure 20, we see that the game generated many new concepts (yellow links) centered on the theme. These new concepts (for example, “leveraging existing,” “OSA innovation,” “incentivize innovation,” and “future supportability,” etc.) can be used to improve the future OSA strategy document. Appendix B lists the top themes in Figure 19.

Figure 21 shows a match matrix for the idea cards in the biiMMOWGLI Round 2 matched with the OSA strategy document, where the matched word pairs belong to the category “Popularity.” This category includes the concepts that are common knowledge to the acquisition community.

In Figure 21, clicking the link “open standards” opens the LLA search results shown in Figure 22, which identify the idea cards and the OSA strategy containing...
the word pair “open standards.” One can see the cards enrich the concept “open standards” in the OSA strategy with related concepts such as “giant loyalty” (card 2547), “future roadmap” (card 1062), “common playing field” (card 1739) and “open APIs” (card 2612).

Figure 21. A Match Matrix for the biIMOWGLI Game Round 2 Cards Matched With the OSA Strategy Document Using Popularity Word Pairs
Similarly, in Figure 23, clicking the link “life cycle” reveals the LLA search results shown in Figure 24, and identifies the cards and the OSA strategy containing the word pair “life cycle”. Additionally, the idea cards from the game enrich the concept by providing linked meanings such as “life cycle” in the OSA strategy with related concepts such as “operational scenario,” “SE development” (card 2255), “sustainment cost,” “business models” (card 2300), “automatic maintenance,” “infrastructure support” (card 2467 marked as “super interesting” by an analyst),
“system design” (card 2481,2308), “infrastructure costs” (card 2308) and “prohibit contracts” (card 1223).

Figure 23. A Match Matrix for the biiMMOWGLI Game Round 2 Cards Matched With the OSA Strategy Document Using Emerging Word Pairs
Figure 24. LLA Search Results for “Cycle Life”

In Figure 23, clicking on the link on “cost savings” reveals the LLA search results shown in Figure 25, and identifies the ideas cards and the OSA Strategy containing the word pair “cost savings”. In this instance, the idea cards enrich the concept “cost savings” in the OSA strategy with related concepts such as “cost
influence, incentive plans (card 1232), evaluation criteria, CPARS review, future RFPS (card 1601), source selection (card 1467), actual cost, FOSS software, software licenses, contract execution (card 1484), program funds, cost realized, expanded funds (card 1495), etc.

Figure 25. LLA Search Results for “Savings Cost”
In Figure 26, clicking the link “data models” reveals the LLA search results shown in Figure 27 and identifies the cards and the OSA strategy containing the word pair “data models”. These idea cards enrich the concept “data models” in the OSA strategy with related concepts such as “develops subsystems,” “open data” (card 959), “achieve interoperability” (card 1854), “interoperable data,” “monolithic data” (card 1757), “exist models,” and “data streams” (card 1626).

Figure 26. A Match Matrix for the biMMOWGLI Game Round 2 Cards Matched With the OSA Strategy Document Using ‘Anomaly’ Word Pairs
We show here that a match matrix from LLA sorts out the most interesting idea cards that match the business processes such as the ones documented in the OSA strategy document in the biMMOWGLI game. LLA provides drill-down and search capabilities to show how the concepts and ideas are presented in the original context and how related ideas enrich the ones in the links.

The linked and enriched concepts can be used as the bases to apply the collective intelligence generated from the brainstorming MMOWGLI game data to improve the existing business processes. For example, some of these concepts were included in the action plans: incentive (actions 15 and 16 about rewards and action plan 21 about profitability), life cycle and cost savings (action 28, action 21 profitability), and OSA acquisition (action 29).
The idea cards data also suggests that there could be additional topics for in-depth discussions which were not included in the current action plans. Examples include the following:

- Open standards and data models;
- Meaningful metrics, OSA metrics and program metrics; and
- Consolidated product lines based on open standards, TRF level and TRF attributes

**Conclusions**

We demonstrated the use of the MMOWGLI social media brainstorming platform and LLA as a combined collective intelligence platform to gather consensus. We identified new concepts reflected in the LLA word pairs that can be linked to critical variables and elements in these business processes (bii).

We used match matrices for each individual theme found through LLA to identify word pairs and used these word pairs to identify opportunities in the current processes. For example, we found that the great majority of Navy programs are affected by (or even critically dependent on) energy issues, but showed that goals and even terms are handled inconsistently. Without imposing significant operational burdens and vulnerabilities, innovative “energy efficiency” ideas from the social media game might be quickly and naturally implemented into the current processes that drive force structures, combat operations, logistics, and acquisition decisions. We identified these gaps and opportunities, which are listed Appendix A.

LLA sorts and prioritizes idea cards that might be good candidates to engage MMOWGLI action plans. For example, in the biiMMOWGLI game, themes discovered using LLA should be used in future MMOWGLI games to guide the action plans. As shown in Figure 28, the themes are sorted according to their relevance to the OSA strategy document: relevance defined as the percentage of the number of word pairs in the OSA strategy over the total number of word pairs (e.g. 12/71=16.9% in the first row). The last column in Figure 28 shows if the current action plans in the bii game cover a theme. As seen, some themes are covered; however, many themes can be discussion topics for future action plans or can be the basis of seed questions for future games.

Also in Figure 28, the themes with higher relevance to OSA strategy indicate consensus between the thoughts of the acquisition community and current OSA strategy. Conversely, the themes with lower relevance to OSA strategy indicate gaps between the thoughts of the acquisition community and current OSA strategy. The gap areas were discussed more in the current game than the consensus areas. Figure 28 can be used to improve the future game or OSA strategy.
We demonstrated that MMOWGLI together with LLA can be used as an important tool throughout the longer lifecycle of the acquisition process to incorporate collective intelligence from the brainstorming social media such as energyMMOWGLI and biiMMOWGLI games into improve DoD acquisition processes.

<table>
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<th>Theme Id</th>
<th>All Sources</th>
<th>MMOWGLI Ideas</th>
<th>OSA Strategy</th>
<th>Theme Keywords</th>
<th>Overlap</th>
<th>Relevance to OSA Strategy</th>
<th>Relevance to Action Plans</th>
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<td>1(C)</td>
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<td>58</td>
<td>12</td>
<td>REVIEW,AQ, PROCESSES</td>
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<td>0</td>
<td>PEOPLE, SOLUTIONS, CONTRACTING</td>
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</table>

Figure 28. Sorted Themes as Candidates for Action Plans

Recommendations for Future Work

Crowd sourcing can be used to provide meaningful feedback to current business processes in cross-cutting themes such as energy reduction and the efficiency of business innovation initiatives such as OSA strategy. In the future, we plan to build the MMOWGLI game infrastructure in tandem with the LLA computational structure to reduce manual labor and maximize analyst flexibility. We will continue to work on real datasets that spur meaningful analysis, and produce further data visualizations tuned to support focused analytic queries by players and decision makers. For example, we plan to optimize the following LLA and MMOWGLI integration process for a two-week future game:

- **Step 1:** Request the internal documents (e.g., PE documents or a OSA strategy document) for a business process prior to the game for LLA in order to compare and generate match matrices.
Step 2: Prepare the analysis from Monday to Wednesday in the first week, and deliver the mid-game report including initial LLA themes, images, graphs, and visualizations on Thursday night. Game Masters will assess whether the mid-game analysis appear helpful for the second week of the game. The improved and accelerated responses appear to produce incremental products that can accomplish the following:

- Help game designers, masters, and players to view the overall effectiveness of a game: for example, how does a game correlate with an existing business process visually?
- Help game designers design action plans from the LLA results
- Help game players answer a query or seed question using the drill-down, search and link capabilities.
- Help game moderators notice areas of activity with particularly high relevance using initial LLA graph images, LLA graph visualizations and analysis reports.

Step 3: Generate the post-game report. We will focus on how to link the collected MMOWGLI game data to the business processes for the organizations involved, and build the concept and framework of the business process via reinforced learning.

We plan to design and conduct a new energy related MMOWGLI game in a two-week timeframe and incorporate the LLA analysis steps outlined previously. We also plan to incorporate the most current acquisition artifacts, for example, the congressional budget process documents and PEs from http://www.dtic.mil/descriptivesum. We also seek to measure the impacts of the game jointly with increased focus on key acquisition metrics such as cost, schedule, and performance to see if the collective intelligence enhanced through business process learning might be used to improve the current acquisition process. With the new game data, there can be new patterns of improvement. The improved awareness might be brought into the business process for a significant and visible improvement. The evidence can also be used as the measurement of the impact of the MMOWGLI game as our effort continues.

In addition, we see excellent potential in:

- Crowd sourcing to provide meaningful feedback on either cross-cutting themes (such as energy reduction/efficiency) or specific acquisition programs.
• Building the MMOWGLI game infrastructure in tandem with LLA computational structure to reduce manual labor and maximize analyst flexibility with each round

• Continuing work on real datasets that spurs meaningful (rather than toy or contrived) analysis, and produce further data visualizations tuned to support focused analytic queries by players and decision makers.

• Maintaining backwards compatibility among games to enable steady growth via the available corpus and products each year. This further enables longitudinal analysis and observability of trends and evolution over time.

• Stabilizing the data-model design of LLA computational products, which may enable future visualization improvements to be directly applied to past products

• Speedier production of LLA products which can influence fast-react game rounds or program changes as they proceed, rather than after the event. We want to reduce analysis cycles from weeks to days, and even to hours, approaching real time.

• Program-support brainstorming and collective intelligence experiments which should continue, both for proposed and current programs of record. Games, together with LLA, connecting the record of “what is reported being done” with “what do people think,” all help normalize the use of concept terminology and also identify unsuspected applicability of new breakthrough capabilities.

• Overall progress and process improvements that may now be measured so that causes and effects of improvements in acquisition system cost-effectiveness and responsiveness are documented.

• Navy strategies for improving energy efficiency that needs to be handled consistently across programs. Terms of reference, metrics, opportunities all need to be addressed consciously and consistently.

• Following a series of deliberate experiments, long-term procedural improvements to the formal milestone acquisition process can be considered. For example:
  o Are program terms of reference consistent with Department-wide best practice?
  o Are all applicable energy reduction and energy efficiency techniques identified?
- Routine crowd sourcing as due diligence: subject-matter expert
  and public reviews (as appropriate) to accompany milestone
  decisions
- Has in-game or post-game analysis identified synergies among
  different programs that deserve further investigation?

The validation of LLA results have been validated by domain experts. For
example, experts can visually examine the concepts extracted by LLA as shown in
Appendix B.

In order to achieve these long time goals, it is important to continue validating
the LLA method and integrating it with the crowd-sourcing MMOWGLI platform.
References


Zhao, Y., MacKinnon, D., & Gallup, S. (2012b, June 19–21). Semantic and social networks comparison for the Haiti earthquake relief operations from APAN


Appendix A. Gaps and Opportunity Areas to Integrate the Innovative Concepts and Action Plans From the MMOWGLI Energy Game Into Current Navy Program Elements (PEs)

This appendix lists the themes discovered by LLA and matches between energyMMOWGLI game action plans and Navy PEs. These are the opportunity areas for improving Navy energy efficiency.

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<td>6</td>
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</table>

The match matrix for Theme 430 suggests that PEs mentioned the concepts “existing fleet”, “shipboard system(s)”, “shipboard equipment” and “secondary power” that might have the overall potential to engage action plan 10, 26 and 18.

- action plan 10: In this era of convergence reduce the number of shipboard systems and focus more on small computers with high capability (Android, iOS apps)
- action plan 26: Expand the use of nuclear power in the fleet and ashore
- action plan 18: Offshore basing.
The match matrix for Theme 393 suggests that the PEs with the concepts “Navy energy”, “energy systems”, “power generation”, “alternative fuel”, “alternative energy”, “renewable sources” and “costs – energy/infrastructure” could be used good candidates to implement the innovative ideas related to action plans 11, 18, 22 and 35.

- action plan 11: Enhanced Education to Develop an Energy Efficient Fleet;
- action plan 18: Offshore basing

The match matrix for Theme 458 shows that the PEs mentioned “Naval expeditionary”, “ship board” and “strike carrier,” which can be good candidates to engage action plan 15 and 26.
- action 15: A global navy formed by an alliance of nation linked in real time. That way the nearest force will respond and reduce travel distances.
- action 26: Expand the use of nuclear power in the fleet.
- Related concepts include “multiple hardware,” “operating time,” and “dashboard energy”

The matrix for Theme 905 showed that the PEs involved “unmanned systems,” “surface ships,” “nuclear powered,” “operational environment,” “water treatment,” which can be good candidates for engaging action plan 18, 19, 20, 26, 31, 35, 4 and 7.

- action plan 18: Offshore basing
- action plan 19: Implement a self-sustaining support infrastructure on all Navy bases
- action plan 20: Sails on vessels, use sails that are foldable on the sides of vessels.
- action plan 26: Expand the use of nuclear power in the fleet and ashore
- action plan 31: Add “reducing energy consumption” to Battle E criteria
- action plan 35: Create 3D/vertical farms for use in growing biofuels, and crop for human consumption.
- action plan 4: Change small land vehicle transportation to hybrid vehicles in non-combat capacities.
- action plan 7: Install "sea brakes" that generate electricity, like a Prius. These could be used to aid in docking/slowing ships, and reduce need for tugs.

The match matrix for Theme 132 shows that the PEs mentioned "additional energy," "ground forces" (e.g., PE 0602131M, PE 0603640M, PE 0206313M, PE 0602750N, PE 0603013M, PE 0604404N), "harvesting energy" (e.g., PE 0602236N: Warfighter Sustainment Applied Res; PE 0603673N: (U)Future Naval Capabilities Advanced Tech Dev; PE 0601153N: Defense Research Sciences; PE 0602123N: Force Protection Applied Res), “potential energy,” and “hydrodynamic forces,” which are good candidates to engage action plan 14, 15, 17, 18, 34 and 7.
- action plan 14: Recycle everything biological into fuel.
- action plan 15: A global navy formed by an alliance of nation linked in real time. That way the nearest force will response and reduce travel distances.
- action plan 17: Energy harvesting satellites in outer space transmit energy to earth via microwave or laser beam.
- action plan 18: Create flotillas of ships and sea platforms as off shore bases in critical regions such as the South China Sea.
- action plan 34: Create an online system or suggestion card system for Navy personnel to input where they see energy savings in their job.
- action plan 7: Install "sea brakes," that generate electricity, like a Prius. These could be used to aid in docking/slowing ships and reduce the need for tugs.

The match matrix for Theme 787 suggests that “energy efficiency” and “fuel efficiency,” which can be viewed as “survivability requirements,” therefore, any PEs related to “survivability requirements” (e.g. PE 0603216N: Aviation Survivability) or “operational requirements” can be used to engage action plans 10, 11, 20, 27, 31, 34 and 9.

- action plan 9: Composite Ship Design: Explore the Use of Polymer Substrates for Improved Ship Structural Design
- action plan 10: In this era of convergence reduce the number of shipboard systems and focus more on small computers with high capability (Android, iOS apps)
The match matrix for Theme 494 shows that the PEs mentioned “shared information,” “signal intelligence,” “share data,” “data structures,” “intelligence systems,” “artificial Intelligence,” and “maritime warfare” might be good candidates to engage action plans 16, 18, 26, 31, and 36.

- action plan 16: Use synthetic lubricants to save 5 - 25% of energy costs
- action plan 18: Create flotillas of ships and sea platforms as off shore bases in critical regions such as the South China Sea
- Action plan 36: Become more efficient at structured, logical dialogue to find the solutions you seek

The match matrix for Theme 633 suggests that the PEs mentioned “advanced tech” (e.g. PE 0603673N: (U)Future Naval Capabilities Advanced Tech Dev), “greater efficiency” (e.g. PE 0603747N: Undersea Warfare Advanced Tech) and “power plants,” which can be good candidates to engage action plans 11, 21, and 4.

- action plan 11: Enhanced Education to Develop an Energy Efficient Fleet
- action plan 21: DOD Shore Facility Energy Independence: Explore use of Thorium-Based Reactors (LFTR-Liquid Flouride Thorium Reactor) for power generation off the grid.
- action plan 4: Change small land vehicle transportation to hybrid vehicles in non-combat capacities.
The match matrix for Theme 326 suggests that the PEs mentioned "energy security," "missile defense," "operational security," "cyber security," "national security," and "naval postgraduate school," which might be good candidates to engage action plans 17, 19, 4, 27, 4, 35, and 5.

- action plan 17: Energy harvesting satellites / Space based solar power.
- action plan 19: Implement self-sustaining support infrastructure on all Navy bases.
- action plan 4: Change small land vehicle transportation to hybrid vehicles in non-combat capacity.

The match matrix for Theme 917 suggests that the PEs mentioned "nuclear power," "nuclear technology," "safety standards," "logistics systems," "logistics management," "standards development/data," and "common standards," which might be good candidates to engage action plans 16, 18, 25, 26, 31, 34 and 9.
- action plan 34: Create an online system or suggestion card system for Navy personnel to input where they see energy savings in their job.

The match matrix for Theme 579 suggests that the PEs mentioned “energy management,” “composite materials,” “processing capabilities,” “supply chains,” “electrical energy,” “hazardous waste,” “energy absorbing,” “sinks heat,” “heat reduce,” and “naval academy,” which might be good candidates to engage action plans 8, 20, 26, and 9.


The match matrix for Theme 854 suggests that PEs mentioned “turbine engine,” “diesel engine,” “energy sources,” “power sources,” and “greenhouse gas,” which might be good candidates to engage “behavior modification” related to action plans 27, 8, and 5.

- action plan 27: Upgrade Navy housing with SMART Grids to reduce energy consumption. By individualizing electricity/utility bills to single households, family users will be motivated to increase energy saving efforts.
- action plan 5: Incentivize behavior to reduce electricity usage in Navy housing.
- action plan 8: Update older buildings to be more energy efficient. The Navy is still using buildings that are almost a century old.

These PEs include, for example, PE 0603573N: Advanced Surface Machinery Sys, PE 0603724N: Navy Energy Program, PE 0205633N: Aviation Improvements, PE...
They might be good candidates to engage action plans that mention “mobile power,” “electric warship,” “training centers,” and “ocean wave.” These action plans include

The match matrix for Theme 732 suggests that the PEs mentioned “ship surface,” “fleet surface,” “power management,” “ship power,” “supplying power,” and “generating power.” These PEs include, for example,

- PE 0603563N: Ship Concept Advanced Design
- PE 0602123N: Force Protection Applied Res
- PE 0603573N: Advanced Surface Machinery Sys
- PE 0206624M: Marine Corps Cmbt Services Supt
- PE 0603114N: Power Projection Advanced Technology
- PE 0601153N: Defense Research Sciences
- PE 0602131M: Marine Corps Lndg Force Tech

They might be good candidates to engage action plans that mention “mobile power,” “electric warship,” “training centers,” and “ocean wave.” These action plans include action plans 23 and 11.

action plan 11: Enhanced Education to Develop an Energy Efficient Fleet and engage major universities to create a cross disciplinary curriculum for “energy design” in all fields for all forms of energy.

The match matrix for Theme 449 suggests that the PEs mentioned “power projection,” which can be used to engage “social media” for “fuel/energy saving.”

- Action 11: Enhanced Education to Develop an Energy Efficient Fleet and engage major universities to create a cross disciplinary curriculum for “energy design” in all fields for all forms of energy.

The match matrix for Theme 682 suggests that the PEs mentioned “ship construction,” “ship operations,” “fleet operations,” “military construction,” “operations research,” which can be good candidates to engage action plans 10, 26 and 6.

- action plan 10: In this era of convergence reduce the number of shipboard systems and focus more on small computers with high capability (Android, iOS apps)
- action plan 26: Expand the use of nuclear power in the fleet and ashore
- action plan 6: Implement large umbrellas for ships to use shading to keep ships cooler and also use "carport" structures for ships docked on the pier

<table>
<thead>
<tr>
<th>action plans mentioned</th>
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<tr>
<td>16: Use synthetic lubricants to save 5--25% of energy costs.</td>
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<tr>
<td>18: Offshore basing.</td>
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<tr>
<td>27: Upgrade Navy housing with SMART Grids to reduce energy consumption.</td>
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<tr>
<td>28: Power on-board minor electronics with stationary bikes used for personnel fitness training</td>
</tr>
<tr>
<td>34: Online Feedback &amp; Social Networking</td>
</tr>
<tr>
<td>35: 3D farming--Less land use and local agriculture reducing fuel use and potential location of bio-fuel crops.</td>
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The match matrix for Theme 257 suggests that the PEs mentioned “parts replacement,” “communication equipment,” “air wing,” “communication data,” and “urban environments,” which might be good candidates for action plans 16, 18, 27, 28, 34 and 35.

<table>
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<th>action plans mentioned</th>
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<tbody>
<tr>
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<td>35: 3D farming--Less land use and local agriculture reducing fuel use and potential location of bio-fuel crops.</td>
</tr>
</tbody>
</table>

The match matrix for Theme 198 suggests that the PEs mentioned “energy saving,” “fuel savings,” “cost savings,” “fuel cell,” “cell technologies,” “storage
energy,” and “storage systems,” which might be good candidates to engage action plans related to these concepts.

The matrices that resulted from this task will help design the specific questions to address the issues in a program-to-program basis to continue the energy/MMOWGLI game with acquisition professionals on the acquisition research community in the future.
Appendix B. Visualizations for Themes Identified in biimMOWGLI Game Round 2

This appendix lists sample themes in Figure 19. The red links represent the word pairs or concepts shared by the idea cards and the strategy book. The green links represent the word pairs unique to the strategy book. The yellow links represent the word pairs or concepts unique to the idea cards. Each theme is labeled using the words in the red nodes. Word pairs shared in both idea cards and the strategy are red links. Word pairs unique to the strategy book that are not discussed in the biimMOWGLI game Round 2 are green links. Word pairs unique to the idea cards which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas are yellow links.

Figure B1. Theme Centered Around “Open, System, Systems”

In Figure B1 word pairs shared in both idea cards and the strategy (red links) include “open systems,” “open standards,” “enterprise architecture,” and “insert capability.” Word pairs unique to the strategy book (green links) that were not discussed in the biimMOWGLI game Round 2 include “OOC systems,” “TRFS
system,” “constructed system,” “relative standards,” “ Naval open,” “accommodate open,” “architecture strategy.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “combat system,” “weapon(s) system,” “accounting system,” “systems availability,” “legacy system,” “technology insertion,” “COTS insertion,” etc.

Figure B2. Theme Centered Around “Personnel, OSA, Change”

In Figure B2, word pairs shared in both idea cards and the strategy (red links) include “OSA strategy,” “assess OSA,” “OSA progress.” Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “Timely OSA,” “timely target,” “sponsors resource,” “platform types,” “strategy execution,” “guidebook execution,” “acquisition change,” “successful personnel.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “OSA infrastructure,” “OSA proof,” “OSA platform,” “disruptive change,” “personnel burnout,” “personnel requirements,” and “personnel effectiveness,” etc.
In Figure B3, there are no word pairs shared in both idea cards and the strategy (red links). Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “adjust funding,” “adjusting incentives,” “integrated platform,” “multiple platforms,” “highly integrated.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “ECP incentives,” “industry incentives,” “discuss incentives,” “motivate incentives,” “contract incentives,” “profit incentives,” “incentives term,” “positive/negative incentives,” etc.
(i) (detail)
Figure B4. Theme Centered Around “Life, Cost, Costs”

In Figure B4(i), word pairs shared in both idea cards and the strategy (red links) include “total ownership”, “ownership cost(s),” “life cycle cost,” “system life,” “program life,” “cost savings.” Word pairs unique to the strategy book (green links) that were not discussed in the biMMOWGLI game Round 2 include “reduced cycle,” “reduced costs,” “reduced total.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “cost tracking,” “indirect cost,” “cost infrastructure,” “infrastructure requirements,” “realized lifecycle,” “actual lifecycle,” “lifecycle product,” “evaluate compliance,” “evaluate metrics,” “contract cycle,” “IP ownership,” etc. When highlighting these word pairs, we used Figure B4(ii) where LLA detected more important keywords in the inner circle and more popular keywords in the outer ring.
ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

(i)
In Figure B5(i), word pairs shared in both idea cards and the strategy (red links) include “software development,” “development environments,” “Naval acquisition.” Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “development concept,” “Naval enterprise,” “Naval OSA,” “technical practices,” “communication materials,” “modular driven,” “training guide,” “iterative set.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “iterative development,” “iterative design,” “agile model,” “agile development,” “agile processes,” “incremental development,” “incremental funding,” “reuse driven,” “costs driven,” “open communication,” “contractor communication,” “existing practices,” “practices sustainment.” etc. When highlighting these word pairs, we used Figure B5(ii) where LLA detected relatively important keywords in the inner circle and popular keywords in the outer ring.
Figure B6. Theme Centered Around “Business Model, Incentive”

In Figure B6(i), word pairs shared in both idea cards and the strategy (red links) include “business model.” Word pairs unique to the strategy book (green links) that were not discussed in the biIMMOWGLI game Round 2 include “integrates business,” “integrates approach,” “acquisition model.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “big data,” “big program,” “big Navy,” “big companies,” “big gov,” “big savings,” “big money,” “integrates apps,” “integrate android,” etc. When highlighting these word pairs, we used Figure B6(ii) where LLA detected relatively important keywords in the inner circle and popular keywords in the outer ring.
In Figure B7, word pairs shared in both idea cards and the strategy (red links) include “common OSA.” Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “increase interoperability,” “interoperability protocols,” “common TRFS.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “common data,” “common supply,” “common software,” “common RFP,” “common source,” “common test(ing),” “common requirements,” “common protocols,” “legacy interoperability,” etc.
In Figure B8, there are no word pairs shared in both idea cards and the strategy (red links). Word pairs unique to the strategy book (green links) that were not discussed in the **biiMMOWGLI** game Round 2 include “current programs,” “reusable components,” “enterprise adoption,” “program adoption.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “current contracting,” “current data,” “current profit,” “current RFP,” “current acquisition,” “current proprietary,” “industry vendors,” “rewarding industry,” “industry understanding,” “encourages industry,” “encourages IP,” “encourages FOSS,” etc.
Figure B9. Theme Centered Around “RFPs, Contract, Contracts”

In Figure B9, there are no word pairs shared in both idea cards and the strategy (red links). Word pairs unique to the strategy book (green links) that were not discussed in the biIMMOWGLI game Round 2 include “contract solicitations,” “contract language,” “language templates,” “create contract.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “SI contract,” “IDIQ contract(s),” “contract style,” “RFPS pillars,” etc.
Figure B10. Theme Centered Around “Government, Navy Performance”

In Figure B10, Word pairs shared in both idea cards and the strategy (red links) include “program executive.” Word pairs unique to the strategy book (green links) that were not discussed in the **biiMMOWGLI** game Round 2 include “involved workforce.” “executive offices”. Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “Naval leadership,” “leadership performance,” “government stakeholders,” “government procurement,” “initial procurement,” “risk involved,” “IP involved,” “stakeholder involved,” “employees involved,” “drive software,” “drive design,” “drive innovation,” etc.
In Figure B11, Word pairs shared in both idea cards and the strategy (red links) include “consolidate technical,” “technical frameworks.” Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “technical designs,” “technical OSA,” “technical reference,” “reference framework(s),” “framework elements,” “TRF elements,” “volatile elements.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “proprietary framework,” “testing framework,” “consolidated framework,” “EA framework,” “framework support,” “OSA framework,” “framework architecture,” “acquisition elements,” “reference implementation,” “open framework(s),” etc.
In Figure B12, there are no word pairs shared in both idea cards and the strategy (red links). Word pairs unique to the strategy book (green links) that were not discussed in the *biMMOWGLI* game Round 2 include “user requirements.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “OSA requirements,” “data requirements,” “nonconforming requirements,” “performance requirements,” “customer requirements,” “system requirements,” “requirements oriented,” “internal costs,” “internal innovation,” “internal profit,” “internal investment,” “internal funds,” “internal spend,” “internal rate,” “performance evaluation,” “evaluation team,” “evaluation metrics,” “evaluation driven,” “success rate,” “rate contributions,” “rate changing,” “user community,” “test(ing) community,” “license shift,” “funding shift,” “IA requirements,” “IA certification,” “centralize IA,” “reduce IA,” “certification process,” “CISSP certification,” “certification phase,” “operational scenarios,” “operational capability,” “manpower capability,” “upgrade impact,” etc.
In Figure B13, Word pairs shared in both idea cards and the strategy (red links) include “data rights,” “restricted rights.” There are no word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2. Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “(un)limited rights,” “digital rights,” “modified rights,” “squabble rights,” “IP rights,” “license rights,” “requested rights,” “purchasing rights,” “IP license,” “OSA license,” “license model,” “negotiate(d) license,” “government license(s),” “license renewal,” “open licenses,” “commercial licenses,” “software licenses,” “common licenses,” “standard licenses,” “purchasing process,” “prototyping process,” “broken process,” “traumatic process,” “audit process,” “appropriation process,” etc.
Figure B14. Theme Centered around “Enable Enterprise, Enterprise Money”

In Figure B14, Word pairs shared in both idea cards and the strategy (red links) include “enterprise architecture.” Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “OSA enterprise,” “proven enterprise,” “operable enterprise,” “enable enterprise.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “enterprise money,” “enterprise COTS,” “enterprise commonality,” “enable interfaces,” “enable PMS,” “enable competition,” “enable contractors,” “sharing expertise,” etc.
Figure B15. Theme Centered around “Provide, Large, Reward”

In Figure B15, there are no word pairs shared in both idea cards and the strategy (red links). Word pairs unique to the strategy book (green links) that were not discussed in the *biMMOWGLI* game Round 2 include “reward mechanisms,” “delivery mechanisms,” “mechanisms transparency,” “provide transparency,” “establish reward.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include “compliance mechanisms,” “FOSS criteria,” “FOSS license,” “FOSS proponent,” “FOSS software,” “biggest FOSS,” etc.
In Figure B16, Word pairs shared in both idea cards and the strategy (red links) include "meaning metrics," "OSA metrics." Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include "program metrics," "update metrics," "enterprise metrics," "qualification standard." Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include "common metrics," "metrics collection," "savings metrics," "performance metrics," "measurable metrics," "financial metrics," "ISO metrics," "ISO standard," "missile standard," "source standard," "instrumentation standard," "industry standard," "license standard," "middleware standard," "standard categories," "IP categories," "acquisition categories," "similar metrics," "similar framework," "similar programs," "similar systems," etc.
Figure B17. Theme Centered around “Review Process, ACQ”

In Figure B17, Word pairs shared in both idea cards and the strategy (red links) include "peer review." Word pairs unique to the strategy book (green links) that were not discussed in the biiMMOWGLI game Round 2 include “review gate,” “technical review,” “review process(es),” “alignment processes,” “acquisition processes,” “communications processes.” Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include "review reasons," “multiple reasons,” “security reasons,” “review requirements,” “CPARS review,” “sponsor review,” “sponsor innovation,” “expedite sponsor,” “sponsor success,” “ACQ strat,” “ACQ DAU,” “professional ACQ,” “peer ACQ,” etc.
In Figure B18, Word pairs shared in both idea cards and the strategy (red links) include "data models," "exercise data rights." Word pairs unique to the strategy book (green links) that were not discussed in the \textit{biiMMOWGLI} game Round 2 include "monolithic business," "decompose monolithic," "monolithic acquisitions," "modular acquisitions," "OSA acquisitions." Word pairs unique to the idea cards (yellow links) which are not mentioned in the current strategy and considered as interesting and crowd-sourced ideas include "monolithic contracts," "monolithic data," "accessible data," "proprietary data," "data learned," "open data," "data mining," "data analytics," "data flows," "distributed data," "data interchange," "data streams," "collect data," "RFP models," "license models," "coupled models," "CAD models," etc.