COMMUNICATING PERFORMANCE KNOWLEDGE AMONG SERVICES

Ian Douglas, Michelle Wright, and Chris Nowicki
Knowledge Communities Research Group
Learning Systems Institute, Florida State University
Tallahassee, Florida
idouglas@lsi.fsu.edu, mwright@lsi.fsu.edu, and cnowicki@lsi.fsu.edu

ABSTRACT

There are learning and performance requirements that are common to some or all of the services (e.g. vehicle maintenance, small arms operation, and mission planning). One barrier to reuse and sharing of knowledge related to these common requirements is the fact that different services, and often different units within a service, use different methods and terminology when collecting data and reporting on the constituent tasks and how they are performed. Knowledge about performance is primarily communicated in documents which do not have a standard format. Given that standardizing the whole of the DOD on one methodology is not an attainable goal in the immediate future, workarounds are required in order to prevent costly duplication of performance analysis work.

We will present a comparative analysis of three methodologies for performance analysis from the Navy, the Coast Guard, and a generic model. The analysis of these methodologies will illustrate that even though there are commonalities, they are obscured by differences in terminology. This comparison forms the basis of a simple knowledge ontology for the domain of military performance analysis.

The resulting domain ontology is used to test the feasibility of the automated translation of digitized data among different methodologies and formats. This is achieved by linking customized web interfaces to a common digital repository which uses the domain ontology to translate among different methodologies of performance analysis. Such a system, if implemented on a large scale, would assist in alerting analysts to relevant data from prior projects. It would facilitate the rapid evaluation and assimilation of such data by presenting it in a format and with terminology familiar to the end user.

ABOUT THE AUTHORS

Ian Douglas is an assistant professor of Information Studies and a faculty member of the interdisciplinary Learning Systems Institute (LSI) at Florida State University.

Michelle Wright is an assistant in research in the Learning Systems Institute (LSI) at Florida State University.

Chris Nowicki is a specialist in computer research in the Learning Systems Institute (LSI) at Florida State University.

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INTRODUCTION

Over the last few years there has developed a movement to facilitate the reuse and sharing of content between the services. The advanced distributed learning (ADL) initiative through its sharable content reference model (SCORM) has done much to facilitate the technical feasibility of achieving these ends; however other non-technical issues may prevent the widespread realization of reuse and sharing. For example, it may be possible that due to service rivalries one service may reject the reuse of expensively shot video, which otherwise would serve its needs, due to it showing people in uniform from another service. This is a well recognized phenomenon in relation to reuse and is commonly referred to as the "not invented here syndrome". Unless there is a way to avoid the branding of content this will be a difficult problem to overcome.

In previous presentations (Douglas et al, 2003) we have argued that in order to get reuse to work optimally you must move reuse thinking upstream from the creation of content, i.e. it has to start at analysis and run throughout the lifecycle, it should not just start at content creation. This follows the experience of over thirty years of trying to get reuse to work in the software industry. In this paper we will briefly describe a new category of software tools to facilitate the up-front analysis of human performance prior to the development of any solution systems or content. The tools facilitate the visualization, componentization, and reuse of performance analysis knowledge. We will illustrate how these tools can be customized (and branded) to the specific services, and yet sharing can occur between the services through use of and underlying service neutral data representation.

Currently, the primary method of communicating understanding of problems in the military is through large Microsoft Word or Adobe .pdf documents, which are not usually organized in any standard format. It can be difficult to find a document relating to a specific problem. When the document is located, finding specific information within it is not always easy. One solution to this problem may be to create a standard

document format. This is an approach that has become popular in some domains, for example, clinical trails and usability test reporting. Consolidated Standard of Reporting Trials, or CONSORT (Begg and Eastwood, 1996), seeks to define guidelines for the reporting of clinical trials so that the results of these studies can be better communicated, understood, compared, and consolidated. The Common Industry Format (CIF) (NIST Industry Usability Reporting project, 2001) seeks to do the same for product usability testing.

Common document formats are only a partial solution as they are still constrained by the traditional document-centric view of knowledge communication. The next stage toward increasing reuse and sharing is to granularize the components of knowledge contained in a document and store them as separate objects in a searchable database.

ANALYSIS OBJECTS

There are a few local databases storing data related to performance analysis (e.g. https://calldbp.leavenworth.army.mil/calldb.html), but we have not found a single central repository of military performance knowledge. If such a repository existed and its content was organized in a standard and easily searchable manner, it could lead to real cost savings by reducing the chances of expensive analysis work being repeated throughout the services. It could facilitate the selection of cost-effective and proven solutions to commonly recurring problems. It could also facilitate the development of online communities-of-practice (Wenger et al, 2002) focused on problem understanding and optimal solution selection.

For a performance knowledge repository to work optimally, the development of a database-centered approach to communicating knowledge rather than a document-centered approach is necessary. The concept of the reusable object that is currently being applied to content used in learning and support solutions (ADL SCORM) needs to be extended to the knowledge used in performance analysis. Similarly the work on sharable content repositories can be extended to sharable performance and knowledge repositories. In working in the area of performance analysis in collaboration with the US Army, Coast Guard, and Navy, we have identified a basis for what we call an analysis object. An analysis object consists of the key data collected that leads to a recommended solution or intervention following an analysis. Throughout our research we have discovered that while the methodology and data elements are different for each organization, the key data necessary to determine performance problems and opportunities are very similar in concept.

The analysis of a problem space begins with the creation of a visual model representing the roles and goals of an organization, and establishing optimal and current performance. This can be extended in various ways but we envisage a basic analysis object to contain the data fields listed in Table 1.

Table 1. Elements of an Analysis Object

Primary Role	The individual performer who is the focus of the performance analysis process.
Performance Goal	The desired achievement, behavior, or output that occurs at the individual level.
Secondary Role	Other roles that interact with the primary role to achieve a performance goal.
Optimal Performance	Describes the desired performance at the individual level required to reach organizational goals.
Gap Statement	The gap in performance the object pertaining to the performance goal
Indicator	Quantifiable criteria for acceptable performance.
Cause	Statement of proposed root cause that is affecting optimal performance.
Recommended Solution	Statement of a proposed solution that is directly related to the root cause at hand.
Solution Links	Unique identifiers of any digital solutions objects that are created subsequent to the analysis.

Working with this initial model of an analysis object, we developed a prototype web-based tool that facilitates the collaborative analysis of performance problems. The tool incorporates a visual modeling scheme for data brainstorming around a problem area and structuring data collection into objects.
To prove this concept we, at KCRG, have designed and developed three prototypes that are all distinctly different in methodology, yet share all of the same features as well as deliver very similar outputs.

PROOF OF CONCEPT PROTOTYPES

The initial purpose of our research was to prove the concept of automated object-oriented performance analysis (AOOPA) for the US Army, i.e. how an IT support system could facilitate the collaborative development, reuse, and sharing of human performance analysis knowledge. This led to the development of the analysis object concept. As we began to work with other services, we became interested in how analysis objects can be shared across the military services as well as other organizations pursuing performance improvement. It seemed to us that many of the examples of performance analysis reports contained problems that at least at an abstract level (e.g. forgetting equipment setup procedures learned during training) were common across organizations.

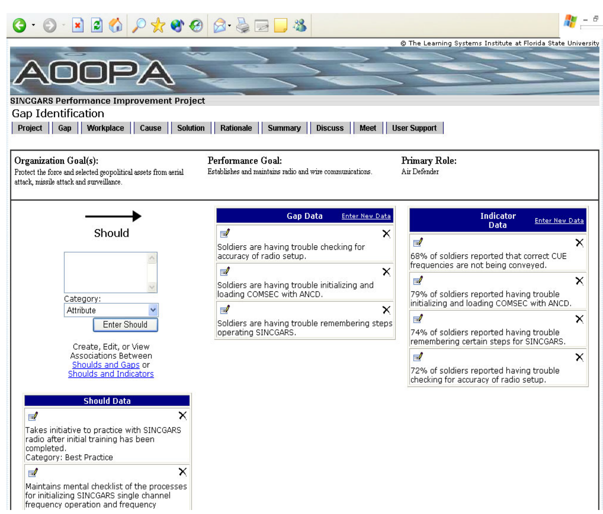

Figure 1. AOOPA Prototype

Descriptions

The first prototype built was a version developed for the United States Army, seen in **Figure 1**. It is based on a methodology derived from several experts and practitioners in the field of Human Performance Technology, including Robinson & Robinson (1996), Alison Rossett (1999), and Rummler & Brache (1995). The prototype allows users to save and share performance data related to individual goals, performance goals, should data, gaps, causes, and solutions (Douglas et al, 2003). This prototype was also built to prove that concepts such as visual modeling, rationale management, reuse, context-sensitive help, and collaboration could be combined into one single prototype to assist performance analysts and all other stakeholders to collect and analyze performance improvement data.

The second prototype developed, Figure 2, was AOOPA CG. It was designed and developed specifically for the US Coast Guard in conjunction with Performance Training Center in Yorktown, VA. The analysts at PTC Yorktown base their front-end analyses on Harless' methodology (Harless, 1998); therefore the prototype also adopted this methodology. This prototype like the generic version collects performance data; it specifically focuses on business needs, job goals, performers, major accomplishments, tasks and other task specific data, findings, and recommendations. The concepts proven in the first prototype remain the same, although their interface is different.

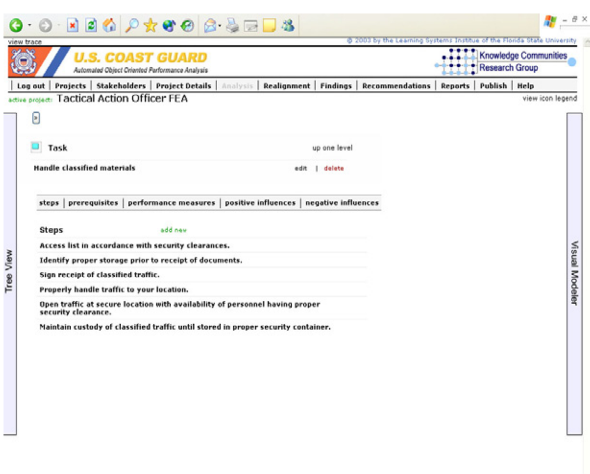

Figure 2. AOOPA Coast Guard Prototype

The third prototype developed, Figure 3, was AOOPA Navy. It was designed and developed specifically for the US Navy in conjunction with the Human Performance Cell in Orlando, FL in collaboration with NAVAIR. The prototype encompasses the Human Performance Improvement (HPI) model methodology, which is based on research, expert opinion, and practitioners' experiences in the field of Human Performance Technology, such as Gilbert (1978), Binder (1998), Langdon, Whiteside and McKenna (1999) and Van Tiem et al (2000). Because of its reliance on research, experts, and practitioners it is very similar to the Army version. AOOPA Navy enables users to collect data such as performance gaps, root causes, possible interventions and projected ROI, and also outlines implementation and evaluation. The prototype also encompasses the same features that both the Army AOOPA prototype and the Coast Guard AOOPA prototype do: visual modeling, rationale management, collaboration, reuse, and context sensitive user support. In this prototype users can import diagrams that they have created using third party software such as Microsoft's Visio and Mind Manager.

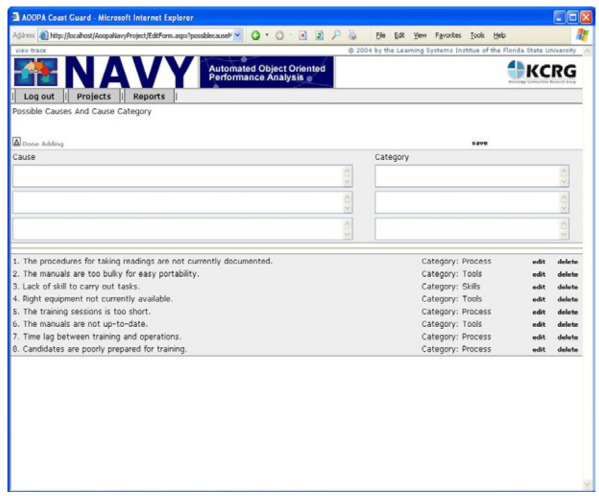

Figure 3. AOOPA Navy Prototype

Key Differences

The essential differences in the three prototypes include differing methodologies for collecting and organizing data and differing data elements which ultimately results in differing interfaces.

Data Elements

While the concepts are generally the same, the data elements and what they are called by each organization differ. For example in the AOOPA Army prototype an analyst enters *Should* data, in the AOOPA CG an analyst enters *Task* data, and in the AOOPA Navy an analyst enters *Desired Performance* data. All of the elements, while classified differently, all indicate successful ways of achieving on-the-job performance. The table in the Appendix outlines how each data element can be compared across the three AOOPA prototypes.

Visual Modeling

While visual modeling is constant in all three prototypes, the software applications used to illustrate the visual models is different. Visual modeling in the

Army prototype, as seen in Figure 4**,** requires users to enter the data into a specific visual modeling tool to create a diagram. Visual modeling in the Coast Guard prototype, Figure 5, is automatically generated according to the data that is entered in the analysis portion of the prototype. In the Navy Prototype, the visual models can initially be created using such software as Microsoft Visio and then be uploaded and linked to pertinent data elements.

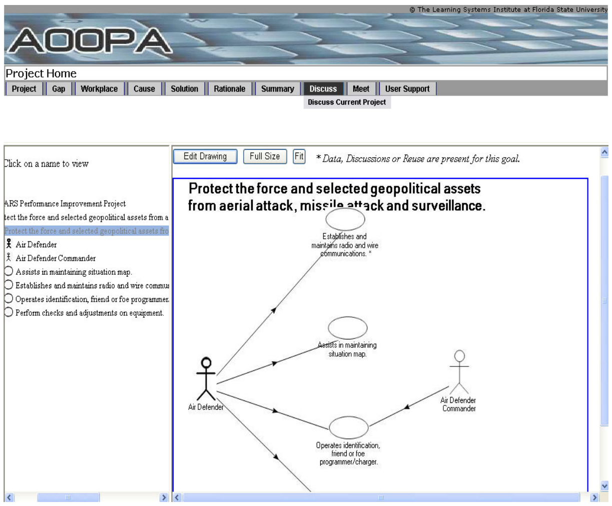

Figure 4. Visual Modeling in Army Prototype

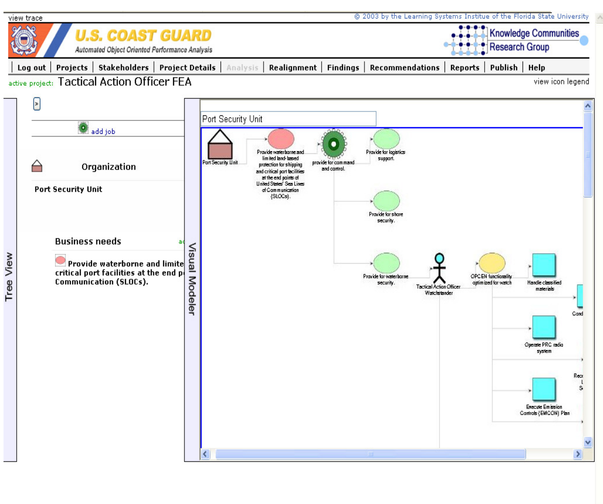

Figure 5. Visual Modeling in the CG Prototype

The reasoning behind these differences is widely due the evolution of our research. It is important to note though, that one version is not necessarily better than the other because of the technological possibilities and preferences. All three prototypes have the ability to adequately depict an organization and performance at different levels.

Rationale

Like visual modeling, rationale management is a constant feature in all three prototypes, but has evolved as our research has progressed. In the Army prototype, Figure 6, rationale is captured using a rating scale as well as written rationale for each gap, cause, and solution. The Army prototype also generates a rationale diagram based on the choices made by performance analysts during analysis. Because the Coast Guard's methodology vastly differs, rationale is captured in the Coast Guard prototype, Figure 7, using a scale to measure the difficulty, importance, and frequency for each task as well as written rationale for each finding and recommendation. The Navy prototype's approach to capturing rationale**, Figure 8**, is very similar to that of the Army's and because we were able to extract and reuse some of the elements from the Army prototype.

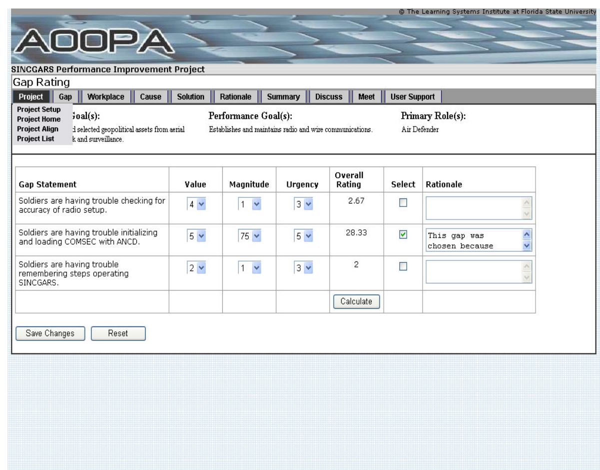

Figure 6. Rationale Management in Army Prototype

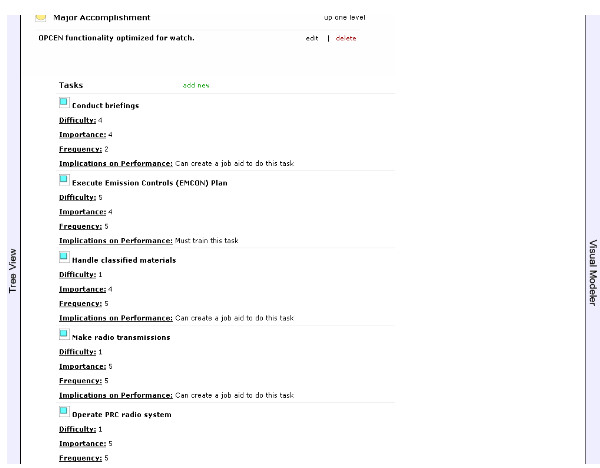

Figure 7. Rationale Management in CG Prototype

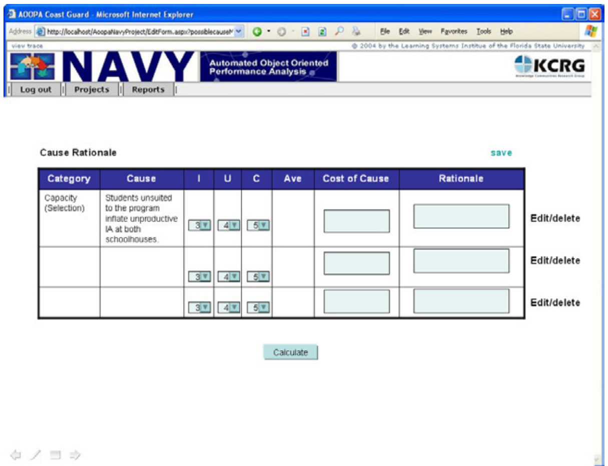

Figure 8. AOOPA Navy Rationale Management

Challenges

It is essential to point out that the data is not always perfectly matched across organizations. The concepts are generally the same, but there tends to be a problem regarding outcomes vs. tasks. Currently, the Coast Guard collects data regarding specific tasks, while the Army and the Navy are results focused. In the absence of a standard method of documenting analysis, it is important that the different branches of the military and homeland defense be aware of these differences and do their best to fit the data into their terminology and methodology.

Another challenge is differing position and job titles. Within the military services there are numerous job titles, but many of these performers are actually doing the same activities using similar procedures and equipment, they are just being classified differently. Within our research we have gotten around this issue by defining the performers, regardless of their title as roles. For example, one of the roles for an Air Defender in the US Army is Radio Operator. If an analysis is done on a problem related to using a radio, the project data can be stored and retrieved in this manner across military services and other organizations.

Example of how the translation works

A Navy performance consultant has just acquired a performance improvement project regarding the use of fleet radio operation on a ship. While organizing the project they reference the AOOPA database to see if similar problems existed not only within the Navy but all military branches. The analyst searches for the problem at hand, frequency hopping on radios, and to her amazement returns a very similar performance improvement project regarding a particular type of radio, SINCGARS. The project the analyst discovered pertained to the role of a radio operator and their inability to operate a SINCGARS radio using frequency hopping. During the analysis it was uncovered that there were several gaps in performance leading to the performance problem. The most important gap was that the radio operators were not able to operate the radio in the field. As the Navy performance consultant collected data for her project, she continued to reference the SINCGARS radio project. Similarities between the data she was collecting and the SINCGARS project surprised her. The gaps and the root causes were so similar that the analysts were able to reuse some of the data as well as some of the solution objects that were created.

It is important to point out that while the Navy consultant is aware that the data she is viewing is from the Army, the data was translated to fit the Navy's methodology and data elements, making it simple for the Navy consultants to view, search, and reuse data. The data that the Army inputted was scripted as Shoulds, Gaps, Indicators, Causes, and Solutions. What the Navy consultant viewed was data from the Navy schema as seen in the Data Table found in the Appendix: Actual Performance, Desired Performance, Gap, Root Cause, and Intervention.

UNDERLYING TECHNOLOGY

The first step in our approach is to create a repository that can store the work products, or analysis objects, in a generic manner. Within the repository, each object is stored along with enough metadata to put it into proper context and to facilitate search and reuse of the object. The metadata included follows the guidelines set out by The Dublin Core Metadata Initiative (http://www.dublincore.org/documents/dcmi-terms/).

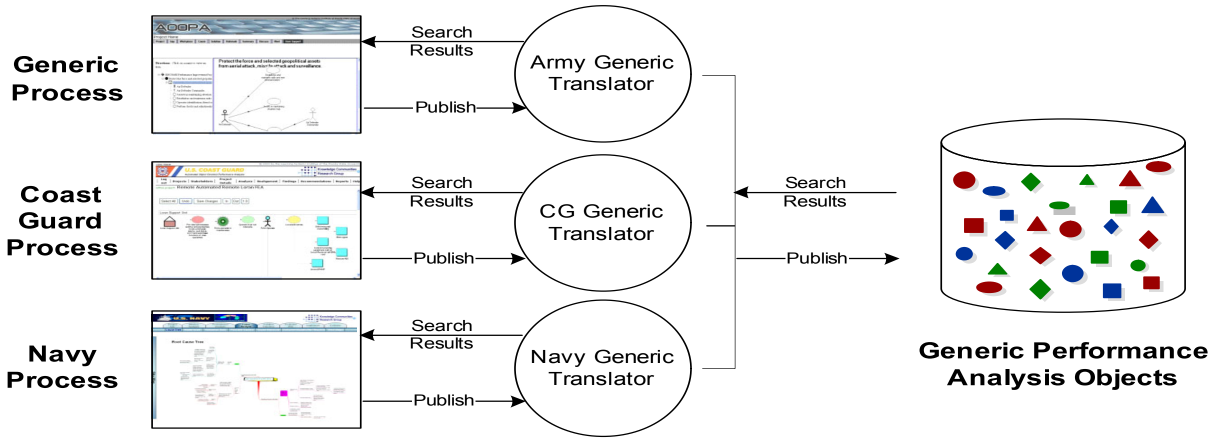

Figure 9. Transferring data between different versions of the AOOPA system

The second step is to publish projects into a repository. The repository does not directly support the methodology of any of the existing prototypes; instead it supports a generic analysis model. The three existing prototypes translate their content into the generic model supported by the repository. This approach allows existing and future prototypes to share their analysis data.

Each of the three prototypes is associated with a translator service that allows it to translate its system specific content to and from the generic model supported by the repository (See Figure 9). The translator services are used for publishing projects to the repository and for retrieving content from the repository in a meaningful format. The mappings to and from the generic to system specific are not necessarily one to one. For example, the Coast Guard system supports work products known as "Findings", which correspond to either "Gaps" or "Causes" in the generic model. Additionally, the "Task", "Step", "Performance Measure", and "Prerequisite" Coast Guard work products all map to "Should" in the generic model. The key to the translators is that they are individually written for each version of the system, greatly simplifying the implementation of the repository itself.

The third step is discovery, which is handled by the repository. The repository search interfaces include a mechanism to specify search criteria as well as the generic and the system specific type of objects to search for. There are currently two search interfaces defined. The first allows a Google type text search, or pull reuse, of the objects in the repository. The second search interface supports automatic, or push, reuse found in Figure 10. The idea behind push reuse is to make reuse more available to the analysts. Specifically, it is intended to offer reuse that the analysts are not aware of or did not think to search for. The work of Fischer suggests that this is an important element in facilitating reuse (Ye and Fischer, 2002). It uses data entered into the system as context clues from the current project to automatically run reuse searches. If the automatic search returns any results, the analyst is given visual clues that existing analysis objects possibly relate to the current focus of analysis, and are thus candidates for reuse.

The simplest type of automatic reuse search depends on a reused item existing in the current project. The automatic reuse search looks for related items of the type the analyst is currently working on.

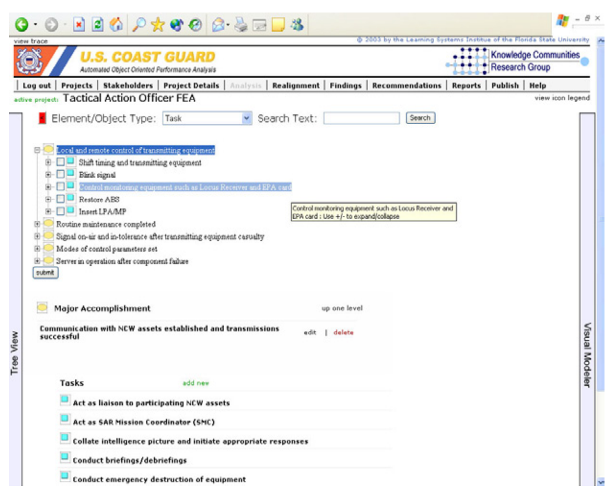

Figure 10. Push Reuse from AOOPA CG Prototype

Once the repository has found candidates for reuse, the last step is to translate the results back into something the source system can assimilate. If the translation mechanism detects that search results came from the same type of system as the destination, the translation is easily accomplished. If the search results came from a foreign system, the results are translated using the same translator service used by the source system to publish objects into the repository.

Throughout our research we have conducted extensive usability testing of the different systems. The testing of the initial system with Coast Guard personnel identified the need to develop customized interfaces geared to the terminology used in each service. Another issue that arose was that the system would require duplication in that traditional reports would still have to be created in MS word. In answer to this issue we have demonstrated that it is possible to generate word documents in the report format of the Coast Guard from the data entered into the Coast Guard version of AOOPA.

CONCLUSION

We have created three prototypes that demonstrate the potential for computer assisted performance analysis. Each prototype is customized to work with a specific methodology, has a unique user interface, uses different vocabulary to describe the various work products, and organizes the information in different ways. This conforms with a key concept of 'configurability', i.e. software tools should be configured to the way people work rather than the other way round. We have demonstrated that it is possible on a basic level to allow data translation between the formats presented in each prototype instance. As we continue to add projects to our database and examine the variety of problems analysts deal with, and the variety of ways in which they communicate their understanding, we envisage that additional issues are likely to emerge. Our research will continue to examine these issues and investigate the use of more advanced ontology in order to facilitate the goal of achieving optimal effectiveness and efficiency in the domain of human and organizational performance analysis.

ACKNOWLEDGEMENTS

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APPENDIX: A Comparison of Data Elements across Military Services

<table>
<tr><th>Army schema</th><th>Coast Guard schema</th><th>Navy schema</th></tr>
<tr><td>Project name</td><td>Project name</td><td>Project Name</td></tr>
<tr><td>Project issue statement</td><td>Project Description</td><td>Project Description</td></tr>
<tr><td>Stakeholders</td><td>Stakeholders</td><td>Stakeholders</td></tr>
<tr><td>Analysis Type (Problem, New Performance)</td><td>Analysis Type (Diagnostic, New Performance Planning</td><td>N/A</td></tr>
<tr><td>Project client</td><td>Client and/or Requestor</td><td>Client</td></tr>
<tr><td>Organization</td><td>Organization</td><td>Mission</td></tr>
<tr><td>Organizational Goal</td><td>Business Needs</td><td>Customer Goals</td></tr>
<tr><td>Process</td><td>Job</td><td>Process</td></tr>
<tr><td>Process Goals</td><td>Job Goals</td><td>Process Goals</td></tr>
<tr><td>Role</td><td>Performer</td><td>Performer Groups</td></tr>
<tr><td rowspan="2">Performance Goal</td><td rowspan="2">Major Accomplishment</td><td>Cost of Performance</td></tr>
<tr><td>Performer Goals</td></tr>
<tr><td>Secondary Role</td><td>Positive and/or negative influences appear on diagram if related to a secondary role</td><td>Performer Groups</td></tr>
<tr><td rowspan="2">Gap Statement</td><td rowspan="2">Findings</td><td>Actual Performance</td></tr>
<tr><td>Gap</td></tr>
<tr><td>“Should” Statements</td><td>Task Data</td><td>Desired Performance</td></tr>
<tr><td>“Should” Categories- Best Practice, Cognitive Process, Attributes</td><td>Task Data-
Tasks, Steps, Prerequisites</td><td>N/A</td></tr>
<tr><td>Indicator</td><td>Performance Measures</td><td>Evaluation Measures</td></tr>
<tr><td>Barriers</td><td>Negative Influences</td><td>N/A</td></tr>
<tr><td>Enhancers</td><td>Positive Influences</td><td>N/A</td></tr>
<tr><td>Cause Statement</td><td>Findings</td><td>Root Causes</td></tr>
<tr><td>Cause Categories
• Expectations and Feedback
• Knowledge and Skills
• Motivation and Self-concept
• Performance Capacity
• Rewards and Incentives
• Tools and Environments</td><td>Finding Categories
• Skills/Knowledge
• Motivation/Incentives
• Assignment/Selection
• Environment</td><td>Depends on the Model used. Could use any number of categories.</td></tr>
<tr><td>Solution Statement</td><td>Recommendations</td><td>Interventions</td></tr>
<tr><td>Solution Categories
• Feedback Systems
• Job Aids
• Organizational Redesign
• Reward and Recognition
• Selection Practices
• Training</td><td>Recommendation Categories
• Skills/Knowledge
• Motivation/Incentives
• Assignment/Selection
• Environment</td><td>Based upon the issues at hand.</td></tr>
<tr><td>N/A</td><td>N/A</td><td>Projected ROI</td></tr>
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<tr><td>N/A</td><td>N/A</td><td>Evaluation Plan</td></tr>
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