Linking Reusable Competency Definitions to Learning Activities

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ABSTRACT

The lack of standardization of competency records hampers enterprise integration efforts, preventing organizations from linking their personnel databases to their training and assessment efforts. This lack of standardization leads to a greater risk level to their personnel and to the decisions these personnel must make at all levels. This also negates any immediate assessment of skilled personnel selection from high risk tasks to high risk decision making. This application effects many civilian organizations but is particularly applicable to many of the common Joint Environments DOD faces today. Automation of this linkage and creation of this process can reduce corporate costs and automatically provide the personnel databases with the assessment records and improve the documentation of personnel skills. Furthermore, an audit trail linking the assessment records of its employees to competencies desired by the enterprise is a valuable form of corporate knowledge and also valuable information for proving the fairness of promotions and salary increases. Training systems can increase their value to their sponsoring organization by supporting this linkage. Training systems can also employ this information to customize the learning for the individual based on gap analysis of the available evidence as compared with the desired evidence of the individual's competency.

The IEEE Learning Technology Standards Committee is developing a standard for reusable competency definitions to enable effective exchange of worker competency information. This standard is based on an existing IMS specification for which there is existing practice. The standard is designed to achieve reuse by combining reusable component competency definitions and referencing existing catalogs of job descriptions, skills, knowledge, assessments, etc.

This paper presents a scenario that shows how to characterize competencies in terms of the U.S. Army's existing catalog of Military Occupational Specialties (MOS), critical tasks, and performance measures. The paper also describes how the assessment capabilities of SCORM 2004 can define policy in terms of alternative means of demonstrating competency and how a SCORM-compliant simulation can supply records needed to support a claim of competency. The scenario describes how two soldiers and their supervisor interact with a system using the standard to select assessment methods and tailor training for the soldiers.

ABOUT THE AUTHORS

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Donald Gemeinhardt is a retired Air Force Colonel is a former Director of Aerospace Expeditionary Force Training to the Director of Anti-Terrorism training for US European Forces. His E-Learning experience spans from development of course and curriculum to being an Associate Professor at various universities, both E-Learning and traditional.

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INTRODUCTION

Understanding the competencies of the human resources available to an enterprise is essential for management, particularly as the personnel costs of an operation have become predominant. The lack of standardization of competency records hampers enterprise integration efforts, preventing organizations from linking their personnel databases to their training and assessment efforts. Automation of this linkage can reduce corporate costs and automatically provide the personnel databases with the assessment records and improve the documentation of personnel skills.

The IEEE Learning Technology Standards Committee is developing a standard for reusable competency definitions to enable effective exchange of worker competency information. This standard is based on an existing IMS specification for which there is existing practice. The standard is designed to achieve reuse by combining reusable component competency definitions and referencing existing catalogs of job descriptions, skills, knowledge, assessments, etc.

THE PURPOSE OF REUSABLE COMPETENCY DEFINITIONS

The goal of reusable competency definitions is to allow the capture and reuse of competency definition data that may apply to different people, in different contexts and with different metrics. A reusable competency definition may describe a competency at any level of granularity. By referencing reusable competency definitions rather than reinventing them or restating them for every application, it becomes possible to support various kinds of automation, such as systematic recording of evidence of competency for individuals or teams as shown in Figure 1.

Reusable Competency Definitions (RCDs) can also help in training automation. As shown in Figure 2, the objective for a learning object can be specified using a reference to a competency definition in the metadata that describe the learning object.
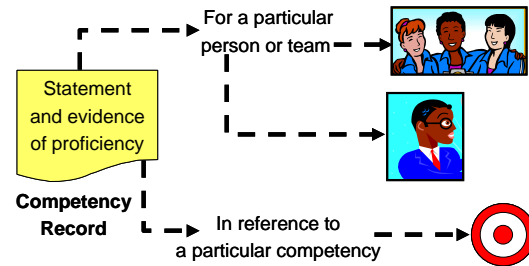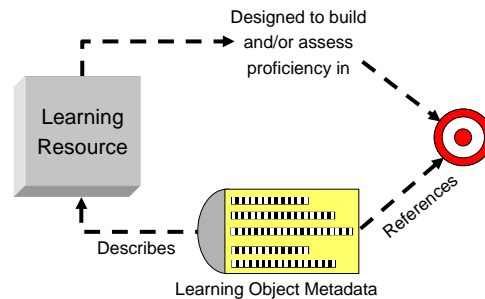

Figure 1. Competency records

Figure 2. Relating learning objects to competencies

Reusable competency definitions can be used as building blocks in modeling competencies. For example, the components and facets of the competency requirements for a job may be defined by building a map in which each node references a reusable competency definition, as shown in Figure 3. This provides a simple and measurable way to define each component competency, often by reusing competency definitions that may also be applicable for different jobs.
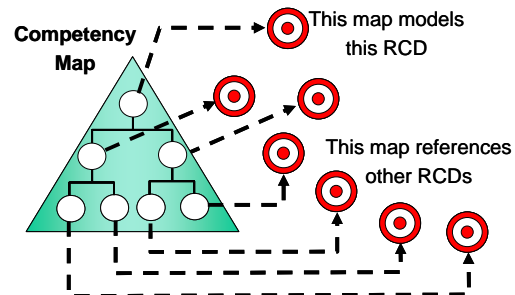

Figure 3. Simple competency model

A competency map can be defined formally in both syntax and semantics so that computers can process the structure. The structure of the competency map can then provide guidelines for assessing competency through a rollup of metrics of component competencies.

Such maps already exist in various forms, For example, the Bureau of Labor Statistics had defined the O*NET model of occupational descriptions, and uses that model to filter and aggregate the data that it has collected about workers and competency requirements for various occupations (O*NET 2000). However, the O*NET reusable competency definitions are described at a high level only. Operational requirements, such as practical assessments and training, typically need definition and mapping of much more finely grained competencies. This can be done using reusable competency definitions and competency maps appropriate to specific communities of practice. Work is in progress to standardize a data model for competency maps that will allow the capture of many existing competency models.

There is increasing legal emphasis on standardizing competency definitions and personnel assessments. An audit trail linking the assessment records of employees to competencies desired by the enterprise is a valuable form of corporate knowledge and also valuable information for proving the fairness of promotions and salary increases. Reusable competency definitions provide a practical way to index and compare those records.

REUSABLE COMPETENCY DEFINITIONS AS A SHARED RESOURCE

Competency definitions are an interface between multiple elements of corporate and government enterprises. As shown in Figure 4, each of these intersecting circles has its own set of interests in competency definitions. For example, in the military, the definition of the skills of the personnel in a particular unit is of major concern. This is true for almost any team effort; the team will be most effective if it knows how to use the special skills of its members effectively. The Human Resources group is very much involved in the logistics of organizational skill sets, including making sure that there are enough people with the right skills to fit the needs as defined by the policy, doctrine, and organizational strategy, and in providing career paths for the people in the organization. Finally, the training part of the organization is involved organically growing the skill set of the people in the organization. So enterprises may use aggregate (or individual) competency

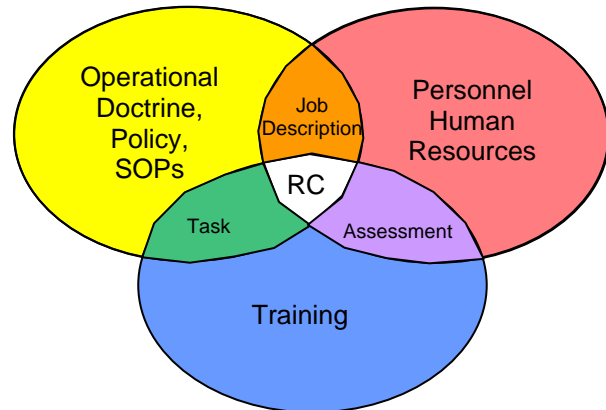information to make "build (i.e., train) vs. buy (i.e., hire)" decisions.

Figure 4. Overlapping Competency User Communities

The payoff for formalizing the structure of RCDs comes when a high-level competency is defined as a complex structure, that high-level competency is referenced in different contexts, and there are ways for processing that structure appropriately in those different contexts. We will show a scenario where processing the competency structure helps to adapt the training.

Standardized job descriptions will help organizations compare "apples to apples," and help organizations automate the processing of personnel records. RCDs with XML bindings will support the exchange of data between personnel databases, which can be a major issue for companies that are merging, or can be used to help collect statistics about jobs. For example, the Bureau of Labor Statistics has invested a lot of effort into definition of job categories. Labor categories are a key element used for contract negotiations and for determining the personnel requirements of large or small organizations.

Finally, RCDs can provide a link between Human Resource organizations and training organizations, ensuring that the right people get the right training. This is becoming more important as the focus shifts to "just-in-time" training where the training has to be rapidly adapted to exactly what the learner needs to know.

REUSABLE COMPETENCY STANDARDS

The IEEE is developing a standard for RCDs, which is now identified as IEEE Draft Standard P1484.20 (LTSC 2000). This IEEE standard is based on the IMS

Reusable Definition of Competency or Educational Objective Specification (RDCEO) (IMS 2002).

This standard supports the composition of complex competencies from simpler competencies. The standard does not dictate the way that these competencies are aggregated, but typical methods of aggregating competencies include lists, hierarchies (or taxonomies), and ontologies.

The draft RCD standard also supports references to catalogs of related data, such as equipment taxonomies, technical data repositories, and learning objects, including SCORM Shareable Content Objects (SCOs) (ADL 2004).

Several other standards are under development around the world to take advantage of the RCD standard, such as standards for competency maps (HR0XML, 2004a), competency evidence records and competency assesssments (HR-XML, 2004b).

Elements of a Competency Definition

- **Identifier:** A globally unique and permanent identifier for the RCD. This is a required element because it allows unambiguous references to this RCD. It is a little like the ISBN for a book. There may be more than one book with the same title, but there can only be one book with a given ISBN.
- **Title:** This is the human redable title of the competency. This is a required element, since the identifier will typically be meaningless to human readers.
- **Description:** This is a text field containing a human readable description of the competency that provides more information than the title.
- **Definition:** This part of the RCD is optional and specific to a community of practice, according to a specific model that should be specified in the definition. For example, the reusable competency definitions from O*NET are not specific enough to include anything that would be applicable here. The model used for the definition typically specifies formal statements for the definition. This could be a multi-part learning objective or task definition, such as action, condition and standard or action, condition, criteria and materials. A particular model may include statements that reference specific contexts or equipment. Of course, the more context-specific the statements are, the less reusable the competency definition is. The main advantage of this flexibility in the definition of the RCD is that the same data model

allows capture of definitions at different levels of specificity.

- **Metadata:** This part of the RCD includes additional information about the competency definition, including information that may be useful for search engines or other filtering operations. This section is also where known linkages with other RCDs may be captured, as well as known classifications of the RCD in specific competency maps or task descriptions. The metadata may also include a typing of the competency in a model such as Bloom's taxonomy. The RCD metadata reuse data elements and structures defined by the IEEE standard for Learning Object Metadata (IEEE 2002). This standard is also used by SCORM (ADL 2004). This commonality is not accidental. It allows automated processing of linkages between RCDs learning resources, such as SCORM Sharable Content Objects (SCOs) and SCORM packages.
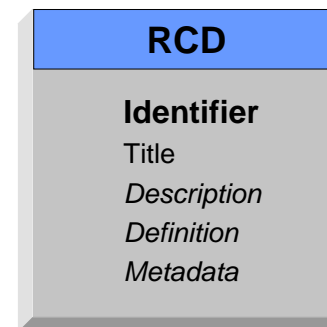

Figure 5. Elements of a Reusable Competency Definition

EXAMPLE OF AN RCD AND ITS CONTEXT

As described in the previous section, RCDs are reused by being composed into more complex competencies and by using linkages to catalogs of digital data from other sources. Figure 6 is a visual representation of such a decomposition, where a competency has been defined as a composition of skill competencies, knowledge competencies, and aptitude competencies. The metadata for the component RCDs includes the links to other related catalogs. Although we are showing a decomposition of competency facets in terms of Knowledge, Skills, and Aptitudes, other decompositions are possible, such as using Bloom's Cognitive Taxonomy for defining the decomposition. The atomic competencies should be kept simple, with the simple linkages. In Figure 6, the black lines connecting the RCDs represent references to RCD IDs, while the red arrows pointing from the RCDs to the
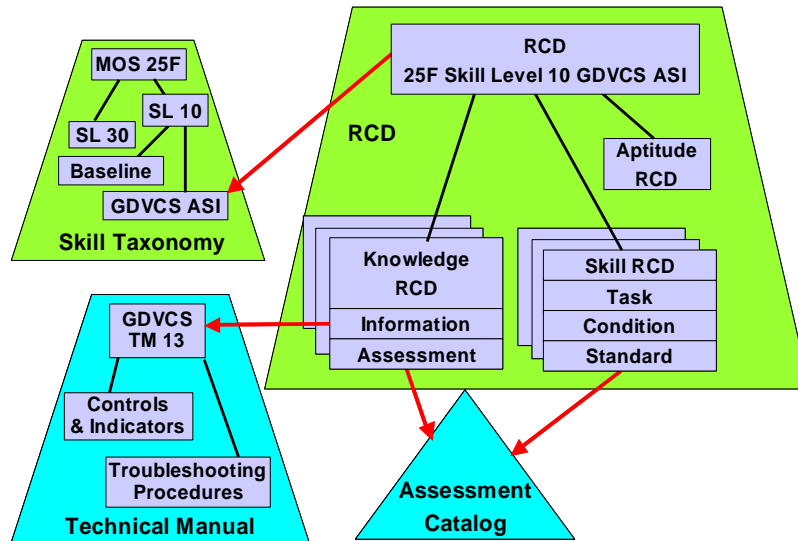
Figure 6.   Linking RCDs to Related Data

catalogs represent metadata links.   The triangles represent existing databases that are continuously evolving that contain related and relevant information. The assessment catalog represents a collection of assessment tools that support the component RCDs.

Figure 6 represents the concept of an RCD linking together multiple distributed databases. In a scenario developed for this paper, an RCD is created for a new Additional Skill Identifier (ASI) associated with the 25F (Radio Operator) Military Occupational Specialty (MOS). This ASI is associated with the skills of operating a fictitious communication device, the Generic Data and Video Communication System (GDVCS) (TAL 2002). This RCD is linked to a hierarchy of competencies associated with the 25F MOS, including multiple Skill Levels (SL 10 and SL 30), baseline competencies for this MOS, and the GDVCS ASI for Skill Level 10. Hierarchies of competencies like this are already defined and maintained in the Army's ASAT and TDDT databases (ATSC 2003). In this case, the particular ASI RCD is further defined in terms of Knowledge, Skill, and Aptitude competencies. The RCD for the knowledge competencies have included references to sections of the technical manual for the GDVCS in their metadata. Both the knowledge RCDs and the Skill RCDs include linkages to elements of a SCORM assessment catalog in their metadata.

REUSE OF COMPETENCY DEFINITIONS

Figure 7 illustrates how competency definitions based on the US Army MOS, Critical Task, and Performance Measure hierarchy of competency definitions can be reused. The figure shows the decomposition of competencies for two related MOS: the 25F Radio Operator and the 25P Radio Maintainer. Both MOS have multiple skill levels and overlapping baseline competencies, and both may have additional skill identifiers for particular types of equipment. Figure 7 shows how their competencies for a particular piece of equipment (such as the GDVCS) typically overlap.

The competencies for the 25F GDVCS ASI and the 25P GDVCS ASI are both defined in terms of the critical tasks associated with the two ASIs. These two ASIs share as common critical tasks **Startup GDVCS in Data Mode**, **Shutdown GDVCS**, and **Troubleshoot GDVCS**. They differ in that the 25F GDVCS ASI has the additional unique task of **Startup GDVCS in Video Mode**, while the 25P GDVCS ASI has the additional unique task of **Maintain GDVCS**. Each of these critical tasks has a set of Performance Measures that are used to assess the competencies of soldiers with these specialties. There is a similar overlapping of technical data. Both MOS should be familiar with the controls and indicators of the GDVCS, but the 25F will need to know more about the video operation of the GDVCS, while the 25P will need to know more about the repair parts and special tools needed for the GDVCS.

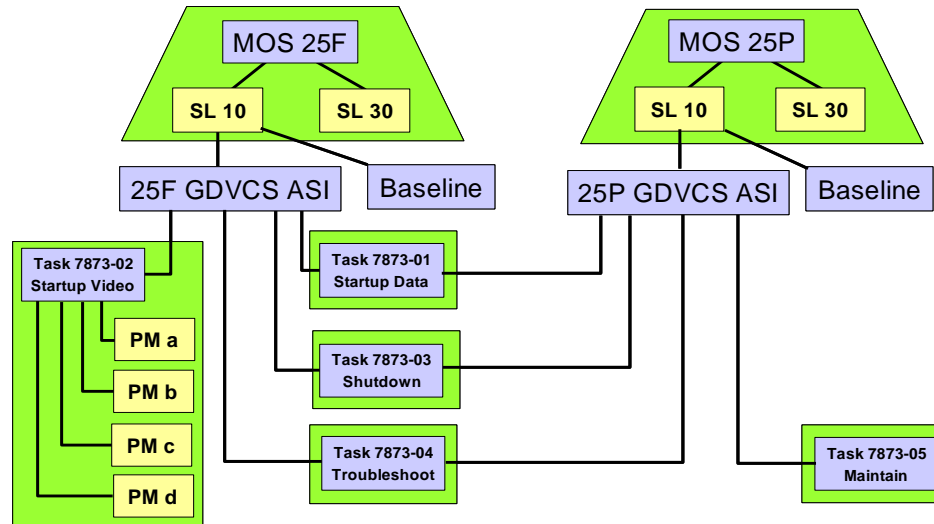## USING COMPETENCY DEFINITIONS TO CUSTOMIZE TRAINING

Figure 7. Reuse of Competency Definitions

Tools and Databases for Processing Competencies

Figure 8 depicts a flow of control and information involved in using RCDs to customize training based on student experience. In the following scenario, three people are involved: two learners and their supervisor. This system uses three key databases:

- A competency definitions database containing RCDs.
- A database of competency records for the individuals, including live and DL test scores and feedback from live and virtual training exercises keyed to critical tasks and performance measures. These competency records are linked to the RCDs by including appropriate RCDIDs.

- A SCORM repository containing assessment policies, assessment instruments, and training materials in the form of Sharable Content Objects (SCOs). These SCOs are linked to the RCDs by including appropriate RCDIDs as metadata. The Army Learning Object (ATSC 2003) includes critical task information in the metadata for SCOs.

These databases are processed by a collection of tools. XML bindings for these databases make a high level of interoperability possible between different database systems, and also support distributed queries over the Internet.
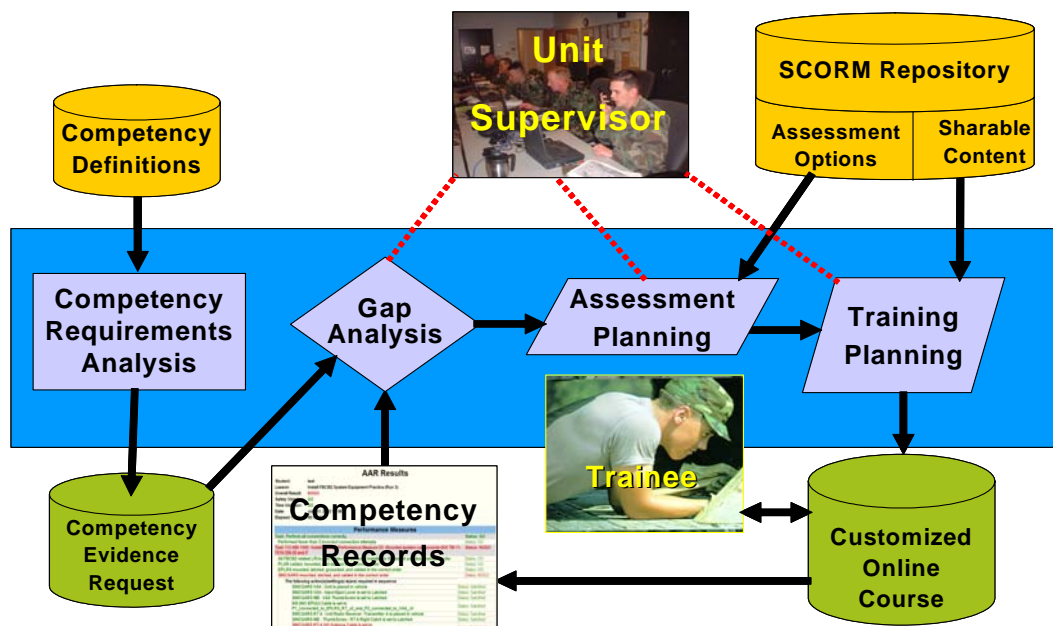

Figure 8. Using Competencies to Customize Training

The first tool conducts competency requirements analysis to generate competency evidence requests, which are in effect queries into the database of competency records. The linkage of assessment methods to competencies is not one-to-one, so that multiple ways of demonstrating a competency are possible. Since the desired competency is likely to be a composite of many simpler competencies, the result of a competency request may be partial competency.

The second tool conducts a gap analysis by comparing competency records for a selected range of individuals against the competency evidence requests and provides a rank ordered list of individuals and the gaps, if any, in their competency records.

A third tool takes the gap analysis results and searches the database of assessment policies to create a set of options for filling the gaps in the assessment records. This tool is an assessment planning aid. The recommended assessments may include a wide variety of options, such as on-the-job training, participation in live or virtual collective training, written exams, or successful completion of on-line courses.

The fourth tool takes an assessment plan and provides options for training to obtain those competency records. Those options may include on-line courses, in which case this tool provides the guidance for selection of SCOs to be included in the on-line course, working back from the assessment requirements and creating a customized content aggregation package.

Linking Competency Definitions to Training

Figure 9 shows how competency definitions can be linked to the assessment evidence produced by an online training course. In this case, the training course consists of an Interactive Multimedia Instruction (IMI) module that describes the functions, controls, and indicators of the GDVCS, and a simulation module with "how-to" training on troubleshooting the GDVCS. The IMI module consists of an interactive lesson and an on-line multiple choice test. The simulation module consists of familiarization with the GDVCS, an acquire lesson that leads students through the troubleshooting procedures of the GDVCS, a practice lesson where students can practice troubleshooting the GDVCS, and a validate lesson, where students can demonstrate their mastery of troubleshooting procedures. The center column indicates elements of an assessment policy for the ASI competency in terms of a collection of Competency Evidence Requests (CEREQ) and Competency Records (COMPREC).

Using Competency Definitions to Adapt Training

The following scenario illustrates how these tools might be used in the context of the 25F GDVCS ASI competency definition presented above.

SFC George Smith is crew chief for the Network Operations Center of a Unit of Action. Last year, his unit got an upgrade of its Generic Digital and Video
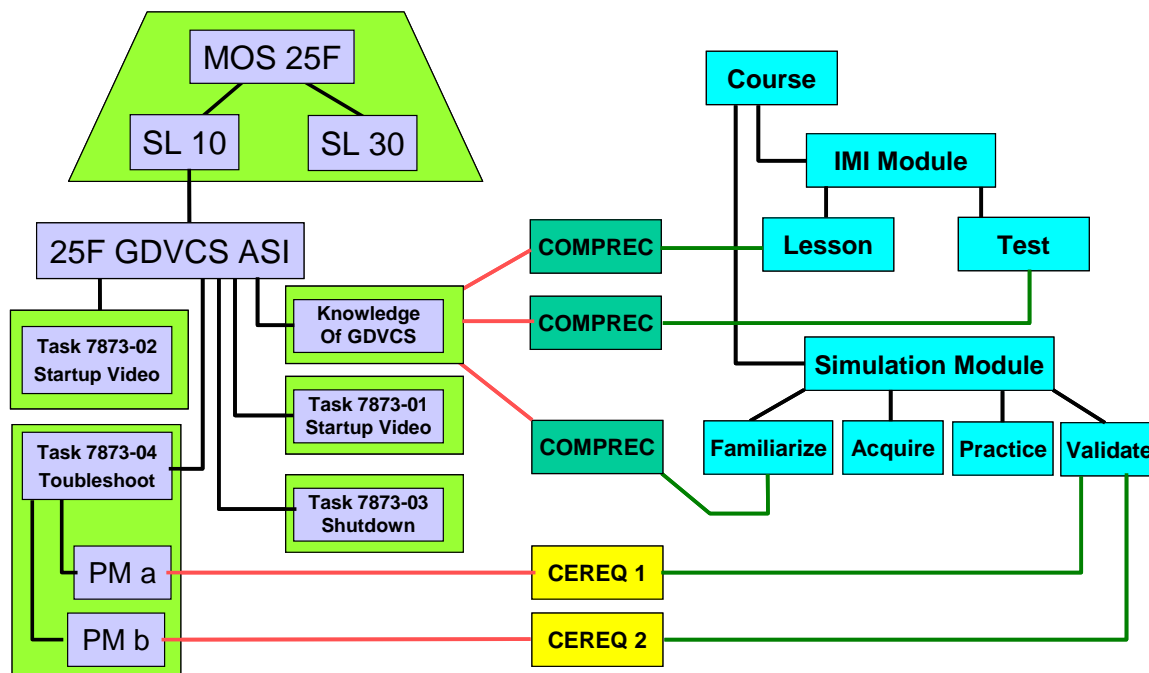

Figure 9. Linking Competency Definitions to Course Objects

Communications System (GDVCS). However, all three of the soldiers who got the delta training for that upgrade have left the unit. Their new mission will include supporting Video Teleconferencing (VTC) with a remote unit that is also equipped with GDVCS.

PFC Johnny Jones is a 25F MOS (Radio Operator) with some experience with the GDVCS, but has never used it for video teleconferencing.

SSG Jose Rodriguez is a 25P (Radio Maintainer) with experience on an obsolete VTC system, but he has never worked with the GDVCS.

SFC Smith goes to the University of Information Technology (UIT) Lifelong Learning Center web portal and searches for a competency definition for operators and maintainers of GDVCS. He finds out that the 25F MOS and the 25P MOS both have an Additional Skill Identifier (ASI) for the GDVCS. SFC Smith then searches his unit roster for 25F and 25P soldiers with the GDVCS ASI, and comes up empty-handed. SFC Smith runs a search of the competency records of his roster. He finds that none of his 25F or 25P soldiers have the GDVCS ASI, but finds out that PFC Jones is a 25F with experience on the GDVCS, and SSG Rodriguez is a 25P with VTC experience.

SFC Smith decides to get PFC Jones and SSG Rodriguez qualified with the GDVCS ASIs before their rotation to the field with the new mission. He accesses the 25P GDVCS ASI Assessment Plan Template (APT) at the UIT web portal and runs a Gap Analysis comparing SSG Rodriguez Competency Records (COMPRECs) against the required Competency Evidence Requests (CEREQs) for the ASI in the APT, and finds two options:

1. A GO COMPREC for each of the four critical tasks of the ASI using the actual equipment with no Safety Violations
2. A COMPREC for successful completion of Signal COHORT training conducted at Ft. Gordon

He decides to send SSG Rodriguez to COHORT training rather than risk damaging his GDVCS radios, because he is down to a minimum of spares.

SFC Smith accesses the 25F GDVCS ASI APT at the UIT LLC web portal and runs a Gap Analysis comparing PFC Jones COMPRECs against the required CEREQs for the ASI in the APT, and finds two similar options:

1. A GO COMPREC for the Startup Video (7873-02) critical task of the ASI using the actual equipment with no Safety Violations. PFC Jone's previous experience provides GO COMPREC for the other three critical tasks

2. A GO from Signal COHORT training conducted at Ft. Gordon

Since PFC Jones has been working with the GDVCS and hasn't broken one yet, he decides to have PFC Jones qualify with a live training exercise.

Now that SFC Smith has decided on an assessment plan, he interacts the UIT LLC web portal to build a training plan for PFC Jones. He wants PFC Jones to work through some distance learning materials before setting up the live certification exercise.

The UIT LLC training plan wizard works backwards from the assessment requirements to design a course for PFC Jones, and comes back with the following recommendations:

- A level 2 IMI lesson on VTC principles (recommended)
- A level 3 IMI lesson on familiarization with the GDVCS (optional)
- A simulation lesson for acquiring the Startup Video Task skills (recommended)
- A simulation lesson for practicing the Startup Video Task skills (recommended)

SFC Smith also interacts the UIT LLC web portal to build a training plan for SSG Rodriguez . He wants SSG Rodriguez to work through some distance learning materials before going to Ft. Gordon, which will reduce his time away from the unit from 5 days to 3 days.

The UIT LLC training plan wizard works backwards from the assessment requirements to design a course for SSG Rodriguez, and comes back with the following recommendations:

- A level 3 IMI lesson on familiarization with the GDVCS
- Simulation lessons for acquiring, practicing, and validating the GDVCS Maintenance Task skills.

WHAT IS BEING DONE NOW

Human Resource (HR) organizations are working to create XML-based standards for competency related data, such as competency records (HR-XML 2004a) and assessment requests (HR-XML 2004b). Their consortium members are creating XML bindings and database implementations for competency records.

The U.S. Army's Lifelong Learning Centers (Wilson and Helms, 2003) are using LMS to collect student grades from distributed learning efforts by students around the world in support of MOS certification efforts. Through their Virtual Campus efforts, these Lifelong Learning Centers (LLCs) are working with crew chiefs and other unit instructors to developed blended learning approaches combining computer-

based DL training with mentoring, hands-on instruction, and on-the-job training to achieve higher levels of readiness. The LLCs are also collecting detailed performance records from simulations using the SCORM format (Frank et al, 2004).

The Navy has been working Personal Digital Appliances (PDAs) to collect assessment records and upload them to student record databases. The common format is a task, condition, standard format.

LINKING COMPETENCY DEFINITIONS TO OPERATIONS

While these definitions are beginning to be standardized and developed into areas that can be easily seen as cross functional, these readily available RCDs give Joint Force Commanders and civilian equivalents the flexibility to quickly or the" Just-In-Time" selection ability of personnel under emergency situations to take control of a crisis or to accomplish a specialized task. This reaching down quickly in an organization can not only reduce risk to a crisis but also better utilize personnel far better than in the past.

FUTURE DIRECTIONS

Work is proceeding on the use of competency taxonomies as a means of standardizing requirements across different military organizations in order to support the development of joint simulations and training packages. This work is also investigating how to prioritize training based on risk data, and how to use competency taxonomies to determine which training methods and devices provide the most cost-effective training.

The Department of Homeland Security has requested an open source Reusable Competency Definitions repository and a competency records management system.

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