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AN APPROACH TO OPERATIONAL ANALYSIS: DOCTRINAL TASK DECOMPOSITION

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ABSTRACT

The Army Acquisition community has a significant deficiency in the amount of operational expertise to influence a particular S&T technology or acquisition program. As a result, emerging materiel solutions often fall short of their desired utility in the eyes of the warfighter. In a fiscally constrained environment, the product development team must use all available resources in the most efficient manner to produce the highest quality product in the shortest time possible for the end user. By repurposing the information contained in the Combined Arms Training Strategies (CATS) task database, an engineering team can gain the operational knowledge and environment from the training tools the Army uses, requiring less burden on the few operational experts that exist within the Acquisition Corps. A process to accomplish this is being developed at TARDEC and has had early success in characterizing vehicle operator behaviors beyond what occurs within structure of a vehicle.

INTRODUCTION

In an increasingly complex operating environment, cutting-edge technology can quickly become the discriminator between mission success and failure. As financial resources tighten and more scrutiny is applied to development programs, it becomes more important to understand the operational utility (i.e., the benefits) of a technology early in the life cycle. Technologies that cannot show direct utility to the soldier end up falling below the cut line when decisions are made to fit within financial constraints for a fiscal year. Ideally, the applicable Training and Doctrine Command (TRADOC) Center of Excellence (CoE) would develop a detailed Concept of Operations and set of User requirements, but this level of concept maturity is typically not available for emerging Army Science and Technology (S&T) projects, especially early in the project lifecycle. As a result, S&T Project Teams are often left to use their own judgment to determine the use cases and utility of a technology.

In this situation, a weakness in the Army's materiel development lifecycle is observed. The Army relies on its S&T process to mature cutting-edge technologies to prepare them for inclusion in a materiel solution that will continue U.S. military superiority. However, the active and reserve forces of the Army do not produce a significant amount of degreed engineers, with the exception of civil engineers. As such, the Army Corps of Engineers is strong with operational Army expertise, but the Army Acquisition community is left to rely on the civilian engineer workforce, many of whom have no soldiering experience.

The lack of operational expertise in the Army Acquisition Corps is an issue identified at the highest levels of Army leadership. At the Association of the US Army's Global Force Symposium the acting Assistant Secretary of the Army (Acquisition, Logistics & Technology), Katrina McFarland, stated the Army tends to jump at materiel solutions without fully understanding the long-term unintended consequences. She attributed part of the problem to the removal of operational research science and advisors as part of work force downsizing. According to McFarland, "Guys that look at the military part of war" as part of a larger, long-term picture of the impact of new technologies are needed in the acquisition community [1].

As a result of these shortcomings, Project Teams are forced to scavenge the operational expertise they need from the isolated pockets of knowledge that do exist in organizations, but with tens or hundreds of projects occurring at once, there is not enough support to go around. Projects that cannot find the support they need either use best judgment, or worse, start ignoring the operational utility questions that hover over head. These habits are contributing causes to why emerging technologies in Army S&T have trouble transitioning to Programs of Record.

BREAK THE CYCLE

In response to the problem above, S&T programs need a quick, efficient, and accurate method to incorporate the user perspective and operational utility of a technology at the program's onset. The method needs to minimize burden to both the technology development team as well as the user community, while maximizing return on the resources invested.

Fortunately, detailed descriptions of the capabilities for a particular Army unit already exist, albeit for a different purpose than Army Acquisition. For years, the Army has used its doctrinal publications as the basis for training its units and measuring training proficiency. Army manuals produced under the Army Training and Evaluation Program (ARTEP) provided all the tasks, conditions, and standards for each Table of Organization and Equipment (TOE) unit in the Army. With the digitization of Army resources over the past ten years, the printed ARTEP manuals have been replaced by a digital system called Combined Arms Training Strategies (CATS), but the information has remained the same.

While CATS is intended as a training resource for unit commanders, the content it contains is useful to the development community since it contains the unit functionality in the intended operational environment. By manipulating the CATS data for a given unit(s) of interest, using common system engineering practices, a doctrinal task model can be derived from TRADOC validated source material, providing a traceable linkage to operational utility.

Although the process that is outlined below relies on published doctrine from TRADOC and requires much less Subject Matter Expert (SME) support to develop, it cannot be executed in the absence of any operational expertise. Application of CATS is an art, subject to the training and experience of the user. However, CATS enables people familiar with Army operational language to understand how all Army units doctrinally behave. Army officers and most Non-Commissioned Officers (NCOs) have familiarity with the CATS tool and working with the tasks within it and the tasks and concepts within it are common to the maximum extent possible. Therefore, to describe Army Armor doctrine, for example, the project team no longer needs a former Armor officer; but, an officer or NCO from any branch, such as logistics, can describe Armor doctrine to the TRADOC standards.

DOCTRINAL TASK ANALYSIS FRAMEWORK

This approach to operational analysis relies on the source data stored within CATS. By extracting the CATS data for a specific unit of interest and applying common systems engineering practices to the data, the project team can generate a quality operational analysis to derive their system requirements and architecture. The approach described herein to generate analysis using doctrinal training data decomposes CATS to an Operational Task Model, which decomposes to a Unit Behavior Model (Figure 1).

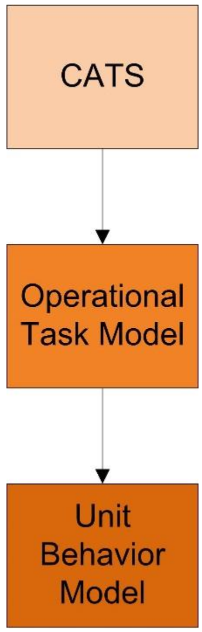

Figure 1: Doctrinal Task Analysis Process

COMBINED ARMS TRAINING STRATEGIES (CATS)

The CATS tool is available to anyone who has a DoD Self-service (DS) Logon, effectively meaning anyone with a Common Access Card (CAC) can access the data. CATS is accessed through the Army Training Network (ATN) (https://atn.army.mil). ATN is the tool the unit commander uses when developing and accessing his Mission Essential Task List (METL), which is the key tasks the unit must conduct in wartime to complete its mission. While the approach described herein specifically refers to decomposing unit-level collective tasks, it is important to note that the same process could be executed on individual or common soldier tasks, all of which can be accessed from CATS or other areas within ATN.

The CATS tool requires either the Standard Requirements Code (SRC) for the specific TOE unit of interest or allows the operator to browse for the unit, organized by proponent, as shown in Figure 2. Once the unit is selected, CATS will output all of the doctrinal collective tasks associated with the unit. Currently, CATS outputs this information using HTML and hyperlinks to the lower level functional data. Some human effort is required to translate the hyperlinks and HTML data into a useable form going forward. As of the time of publication, TARDEC manually extracts the data from CATS and places it into Microsoft Excel for manipulation.

While labor intensive, this process can be completed by a single person in 3-5 days, which includes some refining of the raw CATS output.

Figure 2: The CATS Home Page

It is important to note that CATS is a training resource for unit commanders and the functionality to manipulate the data is not required under its intended use. Therefore, the labor intensive task to extract the data in a useable format for engineering is not an imperfection in the tool as much as it is a function of using the tool in a manner other than designed. However, an opportunity exists where the Army engineering community can plug directly into the database behind the tool and extract the information using an integration tool, such as the Integrated Systems Engineering Framework (ISEF). Such a capability would not only minimize the labor required to extract the data from CATS, but enable real-time updates as the doctrine is updated over time.

Understanding the CATS Output: Operational Task Model

When reviewing the CATS output it is important to organize the data in a common manner so it can be manipulated later. For example, the CATS output for a Palletized Loading System (PLS) Truck Company (SRC 55728R300) reveals 99 top-level collective tasks that are associated with the unit. These top-level collective tasks are the level 1 functions for that specific unit.

Within the documentation for each level 1 function, CATS describes the sub-tasks required to complete the level 1 function. These tasks are arranged in a hierarchy where the sum of level 4 tasks imply completion of a level 3 parent; the sum of level 3 tasks imply completion of a level 2 parent; and so on. However, logical arguments such as “if”, “or”, and “and” may modify the hierarchy as necessary. CATS decomposes a level 1 task down to at least level 4 and in most cases level 6 or beyond.

The entire list, when fully assembled and referenced is called the Operational Task Model and represents every function that the unit, as a collective whole, can execute. For purposes of understanding the size of this model, the PLS Truck Company Operational Task Model contains approximately 4,200 functions as has detail and low as level 7.

Example of the Operational Task Model

The actual operational tasks for any Army unit are controlled data items, but for explanation purposes consider this simple example using a restaurant as the unit of interest. Table 1 shows an example Task Model for a restaurant using language and format similar to what CATS provides. Only 3 levels are shown in the example, but each task could be decomposed to level 7 or beyond, each level providing more detail.

Task No.	Task Description
1.	Prepare food in a kitchen
1.1	Prepare cold food items
1.1.1	Make sandwiches from an order ticket
1.1.2	Make salads from an order ticket
1.2	Prepare hot food items
1.2.1.	Cook foods using a gas grill
1.2.2.	Cook foods using a gas or electric oven
1.2.3	Prepare foods using a deep fryer
2.	Collect and serve orders using wait staff
2.1	Collect customer orders for service
2.2	Prepare an order ticket using computer system
2.3	Serve customers in accordance with orders
3.	Manage customer complaints

Table 1: Example Operational Task Model

BUILDING THE UNIT BEHAVIOR MODEL

The Operational Task Model can be transformed into a more informative unit behavioral model that accurately describes the unit operation. Using SysML to describe the behaviors indicated in the Operational Task Model, the operational language of CATS can be parsed and translated into activity diagrams and use cases to support engineering development. These products represent two of the most important views of the Unit Behavior Model.

Behavior Model Activity Diagrams

Activity diagrams represent behaviors in a logical workflow, akin to what many people recognize as a flow chart. Development of activity diagrams is an important step to maturing the operational understanding of the unit of interest because the tasks directly out of CATS does not imply any sequencing or timing in the tasks, although some sequencing can be inferred from the language or implied through the hierarchy. A simple activity diagram for task 2 in the example Operational Task Model is shown in Figure 3.

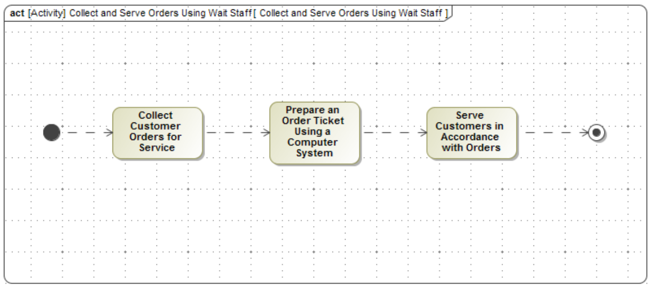

Figure 3: Collect and Serve Orders Activity Diagram

Often the translation of Operational Tasks onto one or more activity diagrams requires the operator to exercise artistic license in order to simplify and streamline the model without losing the intent of the function. Remembering that CATS was developed for training purposes and the author of each specific CATS task may have used different words to describe the same intent, this artistic license here does not invalidate the authenticity of the tasks, only simplifies and condenses the task model to the core intent of the task.

An example where artistic license is required is as follows: One task may have a sub-task stating "Enforce safety procedures as necessary." Another may state "Enforce safety in accordance with (IAW) AR 385-10". Yet another may state "Enforce safety procedures IAW with commander guidance, SOP, and regulations". All three functions are describing the same intent and instead of complicating the model with three separate functions verbatim from CATS, it makes more sense to condense the functions into one common wording and point to it in three different activity diagrams. This issue occurs often in an Operational Task Model and tolerance to condense like-functions reduces model size by 20-30%. A SME with relevant soldiering experience is recommended to assess/review any proposed artistic license simplification to ensure the core intent is not misunderstood.

Behavior Model Use Cases

The Operational Task Model can also be used to develop collective-level use cases. Most collective tasks sourced from CATS indicate the actor or actors that are doctrinally associated with completing the task. In this case, developing a use case is simply a matter of translating the text from the Operational Task Model into a Use Case Diagram using SysML notation.

CATS is not always consistent, however, and some tasks do not explicitly define the actors within the task. In these cases, it is important to have a SME assist with use case development to fill in the gaps left by CATS.

Although a variety of methods could be used to develop use cases, TARDEC found using Microsoft Excel to assign actors to tasks was a simple method to building the source data that could later be developed into use cases if necessary. By assigning actors and other objects in separate columns, either through the CATS data or using SME assistance, the use case data could be captured efficiently, minimizing manual labor and maximizing the time of specialized resources, such as SMEs. In this format the data can be imported into system architecture tools for addition to the Unit Behavior Model. An sample diagram within the Unit Behavior Model for the the example (Table 1) is shown in Figure 3.

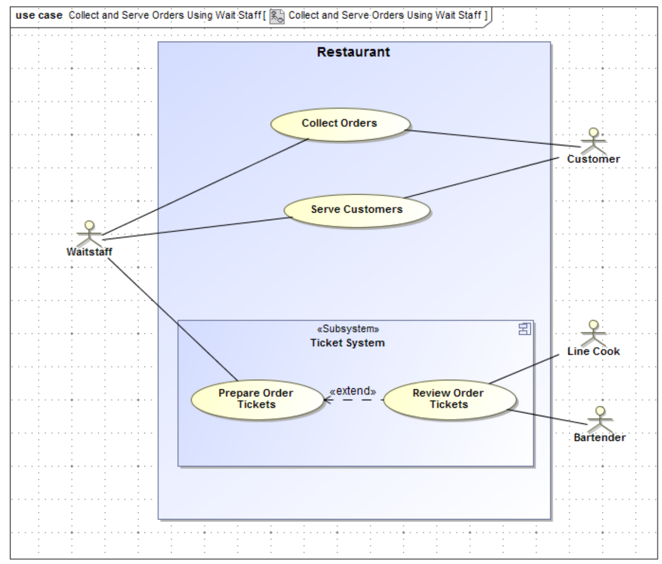

Figure 4: Collect and Serve Orders Use Case Diagram

Other SysML Diagrams

Depending on the intended use of the model and the degree of complexity other diagrams may also be useful to the project team to organize and describe the relationship between the tasks. On a larger project, TARDEC found it useful to use Block and Package Diagrams to organize the high level tasks within the model, where the package diagram includes the Level 2 activity diagrams for the unit. In this manner, one could open the model and easily understand the unit's primary functions all in one view, enabling drill down through a particular task thread from a common starting point.

USES FOR THE DERIVED MODELS

At the most abstract level, the Unit Behavior Model depicts a representation of the unit operational environment and describes how all the unit functions work together to accomplish the operational objectives of the unit. For the engineering team, the product's system architecture can be linked to Unit Behavior Model resulting in a complete functional hierarchy that's not only traceable through the system being developed, but also through the upper levels of collective unit performance. Measures of Effectiveness (MOEs) and Measures of Performance (MOPs) naturally fall out from this process since the connection between a system's function and the intended unit effect is explicitly defined.

While tracing the system's functionality to unit behaviors is an important step to developing a fully complete and traceable architecture model, the Unit Behavior Model has been useful in other aspects of functional decomposition. In particular, CATS tasks are very explicit at describing the "what" that needs to happen to achieve a certain objective and virtually silent about "how". To that effect, CATS describes much of the Mission Command functions (the military art) of a given task and it is generally written independent of hardware or software solutions. This solution agnostic approach is particularly useful on projects investigating autonomy or the removal of the human soldier in part or in whole from the system.

Instead of using the functional decomposition for a current system, which implies a human-in-the-loop for operation, and then backing into the functions desired to be automated, this approach starts with a clean sheet based on the required higher level unit functionality. By decomposing the unit functionality into the system of interest, the engineering team is assured that all functions are accounted for, and a decision can be made at a later point whether to automate a specific task, or assign it to a human operator.

TARDEC found this approach to be powerful and applied it to a handful of projects in Fiscal Year 2016, to help understand and characterize the system operator's role as part of the larger unit's objectives. On TARDEC's Autonomy in Operational Energy project, the engineering team is using the Unit Behavior Model developed for a PLS Truck Company to understand the operator behaviors beyond the physical operation of the vehicle. These functions are being cataloged to ensure that a future autonomous PLS truck is able to accomplish all of the behaviors that constitute mission success, not just the obvious ones of drive from point A to point B.

Another example of the Unit Behavior Model in use is on a TARDEC project to convert the three-person crew of a Bradley Fighting Vehicle to a two-person crew. The Unit Behavior Model helped the engineering team identify crew tasks that still needed to be accomplished, but did not directly involve a function on the vehicle, such as buddy aid medical tasks. To successfully transition from three crewmembers to two, the engineering team needed to account for all impacts to removing a crewmember, not just the tasks that directly involved the vehicle operation.

LIMITATIONS OF THE MODEL

Development and use of the Unit Behavior Model is an emerging practice in TARDEC and as such, the benefits and limitations are still being studied. The processes detailed above has shown benefits in describing the larger operational picture and influencing technology programs with the art of military operations, particularly in characterizing the Mission Command elements of operations. However, the process is not flawless and limitations are present.

As mentioned before, the current process to extract data from CATS is manual, requiring human interaction and often line-by-line manipulation to get the data into a useable or importable format. There is a significant opportunity to connect directly to the database behind CATS and extract task details automatically, enabling real-time traceably of the Unit Behavior Model to the CATS system using a tool such as TARDEC's ISEF. As of the time of publication, this opportunity remains an item of interest for future investigation as TARDEC continues to mature this operational analysis process.

Another shortcoming to this process that has not been completely resolved yet is providing clear guidance and boundaries on how far to trace task paths in CATS. Most CATS tasks provide a list of other supporting or supported tasks that are associated with original task. These supporting or supported tasks could be either collective or individual level, and some tasks have upwards of 50 other tasks associated with it. The association of tasks in CATS in made in the general sense, without respect to the type of unit performing the task. In other words, a Transportation unit may have a collective task of "Break Contact" which refers to the common Break Contact task where Infantry is the proponent. Break Contact could feasibly be associated with another collective task such as "Conduct an Attack". While this association is correct in an agnostic sense, it is not appropriate for a Transportation unit, which would never execute Conduct an Attack.

The problem gets significantly more complicated for maintenance tasks, such as "Conduct Preventative Maintenance Checks and Services (PMCS)". Collective and individual maintenance tasks for every major end item are associated with the Conduct PMCS task. However, no single unit, at the company level, would have each major end item within its TOE.

Under the normal training use of CATS, the unit commander would apply their discretion to determine what tasks are suitable to train on and what tasks are irrelevant. Using CATS in the engineering environment requires a knowledgeable expert to review the tasks and associated tasks by hand to determine what is applicable to the unit being studied. Doing so will then bound the number and scope of the tasks to be manageable by the engineering team.

TARDEC has used two different guidelines to help resolve this issue uniformly, depending on the type of information desired by the project. The first set of boundaries is only to look at tasks associated with the unit METL. With these boundaries, the Unit Behavior Model will be specifically focused on the tasks that the unit must be highly proficient at to complete its mission. These boundaries produce a very manageable task set suitable for manipulation or accumulation manually in Microsoft Excel, at the cost of ignoring non-METL task details.

The second alternative TARDEC used is to extract all the tasks directly referenced in CATS, without following any associated tasks that are not directly associated with the unit according to the CATS unit task list, not the list within the task itself. This extract from CATS produces a complete picture of the collective-level tasks for the unit, but is too large to successfully manage in a simple spreadsheet and requires a database or architecture tool to manage the data and interactions of tasks. Further trimming of the tasks can be done within a tool, such as Excel. For example ignoring administrative tasks such as “Maintain Unit Strength” in favor for tactical tasks. This was done within TARDEC because the scope of the projects relate directly to tactical tasks. In other organizations, perhaps one where the Army’s next unit strength software is being developed, it would be more relevant to trim tactical tasks, keeping administrative tasks applicable to the technology being developed.

Finally, the process described herein does not fully eliminate the need for SME support to execute, although the requirements for that support have been dramatically reduced. Instead of requiring a 20 year veteran within the specific specialty of the project to act as the project’s operational expertise, the same quality of work can be provided by a 10 year veteran with general combined arms experience. Since the source data for CATS is verified by the appropriate proponent, the only SME required is one that understands the operational language in CATS, not one that literally has executed the tasks.

SUMMARY

Repurposing the CATS task repository for engineering purposes is a tactic that is still under development and evaluation within the S&T environment. However, it has shown promising results in delivering operational data while limiting the amount of subject matter expertise and user knowledge required. Within TARDEC, the Unit Behavior Model, derived from the Operational Task Model, has been successfully used to help characterize the behaviors of vehicle operators which has become significantly more important as the Army moves towards autonomous systems to reduce human error and mental load.

This process is evolving and will continue to mature as more projects execute it, allowing the operations research team to determine its suitability at solving a variety of operational issues while working solutions to the known limitations. Over the past year the process has been used at TARDEC, it has been successful in architecting the current state of military operations at the collective company level. The resultant products from the models developed in this approach are currently supporting three major TARDEC initiatives. While the process continues to mature in the current limited, yet important scope, it has already demonstrated the ability to begin to fill the gaps of operational knowledge lost in the acquisition workforce over the past 20 years.

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