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# Improving Task-operator Analysis for Training through the Integration of Human Learning Taxonomies and Systems Engineering Models

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THESIS

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## Abstract

Training is a critical part of force sustainment, but the life-cycle cost of recurring training can be quite high. Further, the promotion of the Multi-Capable Airman (MCA) concept leads to questions on how best to train airmen on tasks outside of their core career field. The MCA concept, coupled with continued increase of technology effectiveness, incentivize the replacement of formerly in-residence-only training with distance training that enables Just-in-Time (JIT) learning. However, effective implementation of the MCA concept may also require adaptive training which considers the knowledge, skills, and attitudes (KSAs) developed by a trainee within their core career field when training them to perform activities which would typically be performed by individuals in another career field. This research presents a model-based systems engineering approach to support adaptive training in support of JIT for MCA by incorporating a task-operator analysis framework that aids the training requirements development process. This analysis seeks to facilitate training design guidelines that combine both traditional DoD and human system integration (HSI) instructional design methodologies. Data gained from the analysis seeks to identify the cognitive, affective, physical, and contextual training requirements at a level that fits what an airman who has been trained in a relative career field needs to learn given their existing KSAs.

*To my wife and son for their endless patience, support, and love*

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James M. Earley

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# IMPROVING TASK-OPERATOR ANALYSIS FOR TRAINING THROUGH THE INTEGRATION OF HUMAN LEARNING TAXONOMIES WITH SYSTEMS ENGINEERING MODELS

## I. Introduction

### Chapter Overview

This chapter defines the United States Air Force's need for Multi-Capable Airmen (MCA) and the problems which arise regarding this concept due to the lack of mission standardization and agreed upon cognitive and sensory needs of operators who perform these missions. The chapter defines this problem and prescribes a set of research questions and direction which may lead to potential solutions.

### General Issue

It has been estimated that the on-the-job-training (OJT) cost of training new active-duty, enlisted United States Air Force (USAF) Airman is approximately $1.4 billion per year, with an additional $700 million attributed to Initial Skills Training (IST) (Manacapilli et al., 2007). This is a significant contributor to operation and sustainment costs in support of USAF systems. Therefore, the cost of training is often a primary consideration by the program authority during system acquisition (Brown, 2014). Providing improved human training at the same or lower cost through the application of improved integration is consistent with the DoD's HSI strategy and goals (The Defense Acquisition System, 2020). HSI is described in the AF HSI handbook as a "robust process by which to design and develop systems that effectively and affordably integrate human capabilities and limitations" (USAF, 2009).

Efficient technology integration is not a new problem for the USAF, or DoD at-large. However, the need for improved delivery and use of modern technologies is a primary motivation for the adoption of recent digital strategies. The Department of Defense (DoD)

Digital Engineering Strategy, states five goals, including the overall transformation of "culture and workforce to adopt and support digital engineering across the [systems] life-cycle" (DoD, 2018). This goal implies changes in the USAF training acquisition engineering system. This potentially includes digital training design creation methods using model-based system engineering (MBSE) toolsets, such as using System Modeling Language (SysML) within software packages. Additionally, delivery of the training can go beyond traditional training models (e.g., classroom) and can now be developed for delivery through virtual (VR) and augmented (AR) reality that comprise the extended reality (XR) domain. With the concept of *digital twining* becoming more integrated into USAF acquisition culture (Roper, 2020), training centered around those digital constructs would, in-turn, become increasingly possible, providing more effective training, potentially delivered "just-in-time" (JIT).

The concept of JIT XR training may also augment the ability for the USAF to develop Multi-Capable Airman (MCA). CSAF General Charles Q. Brown Jr's published action orders that were focused on the idea to "Accelerate Change or Lose" (Brown, 2020). The MCA concept focuses on quickly training airmen to perform needed mission taskings outside of their own Air Force Specialty Code (AFSC) (Knight, 2021). Essentially taking an individual who is a specialist in one AFSC and giving them generalists capabilities to perform in-time-critical tasks, such as required tasks during Air Combat Employments (ACE) at forward locations where there are no specialists available (436th AW/PA, 2021). This concept seeks improved force adaptation to provide unique knowledge, skills, and attitudes (KSAs) at a location that, if absent, would present a hindrance to mission performance.

Along with digitally focused training methods, implementation frameworks are equally important. HSI training frameworks seek to ensure the human factor is considered, and appropriate implementations are undertaken (Grossman et al., 2015). One framework was proposed by Webel et al. ( 2011) and though cursory, speaks to division of sensory considerations for training with multi-platform resources. Also, it describes pre-modeling of the tasks on a cognitive level and evaluating each relevant sensory cue needed to impart task learning virtually. There-in, several considerations are addressed: cognitive level of instruction, the *how-to-do* of a task along with the *what-to-do*, designing for learning as opposed to only guidance, and procedural skill acquisition (2011). Using these topics, the paper gives a top-down view of a cognitive framework likened to HSI frameworks on human workload and performance which can leverage knowledge developed during system modeling to structure training requirements and material development (Hollnagel & Woods, 2005).

The potential to leverage structured approaches to system development to inform training design spotlights an emergent need for rapid creation and adaptation of training materials to provide robust support to training through implementation of digital constructs (e.g., analysis and design software) that have the potential to reduce training costs while enhancing the adaptability of the force.

**Problem Statement**

A 2007 study was published by the non-profit RAND corporation that estimated time and costs of training from a sampling of active duty enlisted airmen (Manacapilli et al., 2007). Length of training for new airmen averages around 23 weeks, costing approximately $20,000 per airman. The USAF Training Command trains approximately thirty-five thousand new airmen annually, resulting in roughly $700 million in annual cost. Furthermore, OJT traditional methods add an additional $40,000 per trainee annually to the continued learning of these new airman. This does not consider the OJT for all previously enlisted members who continue training. Additionally, the costs of training creation and maintenance of training platforms for delivery is not included in this cost estimate. Implementation of efficient training analysis platforms across the DoD currently has a procedural process that is mostly document-based with static method models and lacks standardization. This can result in gaps of training as well as unnecessary repetition of effort in content creation. Additionally, the MCA and ACE concepts seek to increase the KSAs of airmen beyond the IST and OJT they are traditionally given. This adds another resource requirement to the "training mix" and raises the question how best to implement the KSA requirements?

### Research Objectives

There are several objectives within this paper's research. First, this research will seek to integrate the HSI training analysis structure into legacy DoD guidance to implement human factors analysis that is only vaguely referenced (DoD, 2001). This research seeks to explore human factors analysis customization leveling to support effective training activities. Second, this research will determine a MBSE design process and model structure which supports both DoD and HSI training specializations. This modeling process will seek to increase the digital fidelity and dynamic capabilities of the modeled training system. The final objective is to provide a standardized approach to training analysis with a viable generic framework that encompasses required task KSAs and can be used to develop various training modules.

### Research Questions

To effectively complete this research, a primary question was defined:

***How would you apply MBSE to perform job/task analysis to support training design?***

### Investigative Questions

Subsequently, three investigative questions were formed from the primary research question to aid throughout the paper and focus conclusions. They are:

1. What KSAs are required to analyze tasks within a job?

2. How would you determine and represent the gaps present in KSAs for individuals who have not been specifically trained to perform the job?

3. How can the integration be best depicted and utilized to promote standards of analysis in training that can be duplicated across training designers?

### Research Hypothesis

Human learning taxonomies can be developed digitally which positively facilitates evaluation of an operator's KSAs necessary for task learning and aids training creators in design application.

### Research Focus

This research seeks to develop methods to analyze and model task-operator required work capabilities that subsequently aid in training design. The analysis will apply concepts from HSI and DoD training creation guidance to provide a thorough and repeatable process focused on the *analysis* phase of training creation. The process will accommodate multi-cue inputs necessary for each training activity step, including standard learning domains and procedural measures. Finally demonstrating integration of existing, and proposed, taxonomies into MBSE activity and profile models, facilitating standardized analysis of task activity and training design.

### Methodology

The software tool *Cameo Magic Draw* systems modeler was used to model consolidated training methodologies, along with taxonomy integrations. A use case was also provided as an example. The models are designed with a Human integrative view that includes special considerations for learning and cognitive work processes. A consolidated human-centric taxonomy is proposed that is applied to each task activity that is created within the use case's task-breakdown diagram. The taxonomy is applied to the activity model by stereotype *tags* which describe the types of capabilities required to facilitate task completion. After creating the use case task activity model, the process is applied by multiple SMEs and consistency of use is evaluated.

**Assumptions/Limitations**

The current research provides one example of the modeling process illustrating its use in an individual use case study. The process modeled is the initial phase of a training creation system, the *analysis* phase. These limitation stems from time parameters. It will be necessary to develop additional phase models in order to evaluate full training creation system. Additionally, a larger set of case studies are needed to provide a more confident analysis of the framework.

**Implications**

Results of this thesis may be utilized to support future research into a more standardized digital framework for training creation and implementation throughout the force. This has the potential to ensure a more robust process for training development and potentially avoid degraded training models and systems. Ultimately, this seeks to enhance the readiness of Air Force personnel both in and out of their AFSCs.

**Chapter Summary**

This chapter explained the need for a standardized framework for developing digitally enhanced training models. The next chapter, Chapter II, will go further into related literature and source knowledge extraction. This literature will lay the groundwork for modeling and experiment execution. Chapter III will detail the proposed model specifications and the *how* of its execution. Chapter IV covers the data obtained, relations among the data, and the subsequent results. Chapter V concludes the thesis with final conclusions and prospects for further research.

# II. Literature Review

## Chapter Overview

This chapter reviews the most common theories of learning and describes multiple models of instructional design (including DoD) and how they relate to theory. HSI training creation *before-during-after* model is described, followed by a safety model. A brief review is then provided which illustrates a lack of coordinative data between instructional design and human factors, as well as the use of MBSE practices. The chapter concludes with a description of novel learning artifacts, focusing on digital systems engineering platforms and the lack of research behind the overall affordance of these artifacts to instructional-human factors design.

## Learning Theories & Beliefs

In her 2020 published research, Heaster-Ekholm wrote on multiple instruction design models and their theoretical originations. She posed that the beliefs and nature of knowledge, especially in western learning theories, can be divided into two belief types. Either a learner's knowledge is formed from their environment or knowledge is formed by the learner and their perceptions of themselves and sensory input. The two types differ in that one is exogenous and the other endogenous. The first proposes knowledge exists in the context before the learner absorbs it. Meaning that the stimuli provided to the learner is the primary factor which results in learning. The individuals who maintain this philosophy are referred to as objectivists. Conversely, constructivist believe that knowledge is formed internally and does not exist within the environmental context of one's situation. It is only created after it is internalized and analogized against previous experience by the learner (2020).

The predominant theories that support these beliefs are behaviorism, cognitivism, and constructivism (Ertmer & Newby, 2013). With behaviorism and cognitivism placed within the objectivist belief and constructivism providing the basis for constructivists (Heaster-Ekholm, 2020). Behaviorism is an environmentally pre-dominant theory that focuses on the contextual stimuli and subsequent performance after stimuli has been administered to the learner. This theory gives no consideration to the learner's knowledge structure, or the mental processes utilized to achieve the learning. Cognitivism fills in the gaps of structure and process by emphasizing the "complex cognitive processes such as thinking, problem solving, language, concept formation, and information processing" (2013).

Both behaviorism and cognitivism have been in practice for many decades in the west and the combination of both theories have been predominant since the 1950's (Ertmer & Newby, 2013). Though not a completely new theory, constructivism has become more prevalent in use, particularly since the inclusion of e-learning technologies. Constructivism promotes the idea that learning is synonymous with *creating meaning from experience* (Bednar et al., 1991). Constructivists see the human mind as a *filter* that takes input from the world and then creates their own *unique reality* from that input to create knowledge (2013)

**Learning Taxonomies**

These theories and beliefs drive the form and function of taxonomies as well as design models used to create learning products. The taxonomies and models can be *categorized* on a non-linear spectrum. The first taxonomy described below is an example of a primarily objectivist-centric categorical approach, most popularly known as Bloom's taxonomy (Bloom et al., 1956). This taxonomy provides levels of capability and the required action verbs equitable to evaluate required behavioral result.

Bloom's Taxonomy is a set of domains that focuses more-so on the objective or result of the learning, as opposed to the learner-centric viewpoint of constructivist theory. In 2001 a revision included additional cognitive aspects of design into the model and is the most common version of the model used today (Armstrong, 2016). This taxonomy is considered particularly beneficial within a standard *student-teacher* learning dynamic, to assist the teacher in mapping objectives for performance in learning evaluation. Elements of Bloom's cognitive domain taxonomy are shown in table 1. *Bloom's Learning Domains* are composed of the cognitive domain along with two additional domains: Affective Attitude and Psychomotor Skills (shown at end of Appendix A). Where the cognitive domain sought to characterize the intellectual skills of learning, the Affective domain focused on feeling and attitude of the learner and psychomotor focused on the level of physical skills concerning a task.

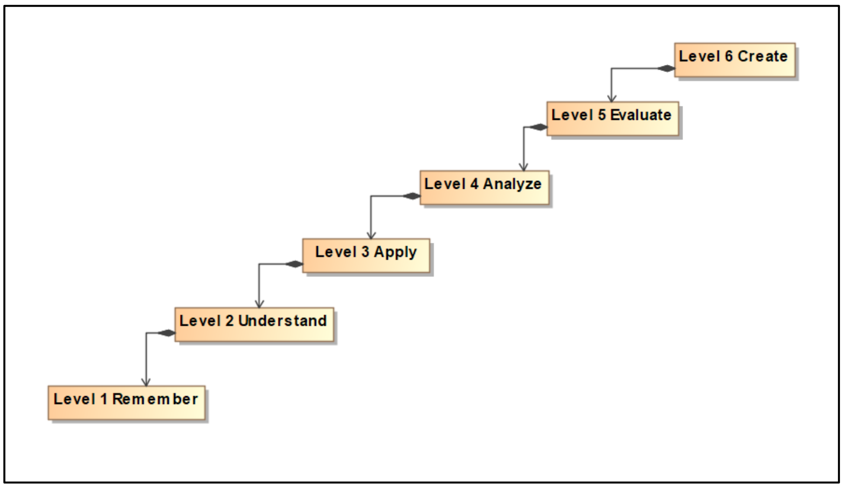



*Figure 1 Bloom's cognitive domain taxonomy, adapted from (Anderson & Krawthwohl, 2001)*

In 2016, the International Civil Aviation Organization (ICAO) published an instructional design taxonomy titled: *Taxonomy to Assist in the Identification of Instruction Methods (E-learning, Classroom and Blended Training)*. This taxonomy added to Bloom's learning domains with an additional interpersonal domain that included socially interactive considerations for learning. Additionally, the ICAO model (figure 1) noted the need for additional perceptual sensory cues. However, these cues were not explained within the ICAO's proposals.

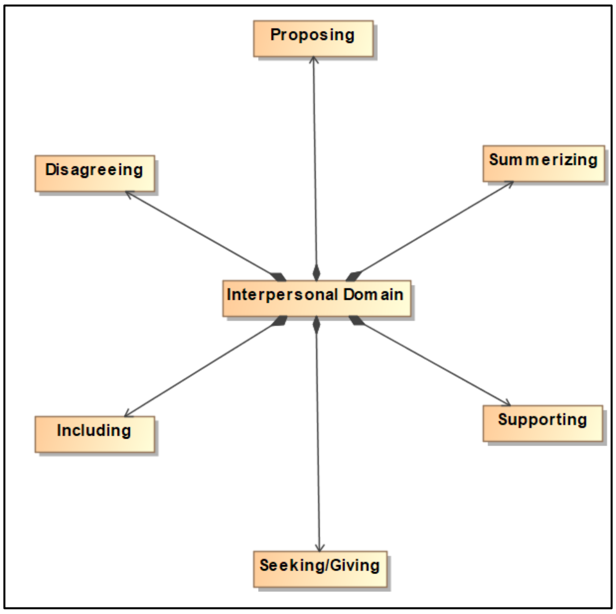


*Figure 2 Block diagram depicting the ICAO taxonomy, adapted from (ICAO, 2016)*

Another consideration of training is safety. There are several methodologies throughout the commercial sector that are used to design-in safety for training purposes. For implementation within this paper, an adaptation of the *Three Levels of Safety* (Table 2) metric will be utilized. The reasoning for the inclusion is that the metric does not only focus on the physical hazard but also takes into consideration the individual and the organization they are a part of and how their dynamic can affect risk along with a hazard's severity (McWhorter, 2021).

| Three Levels of Safety |
|---|
| 1. Emotional |
| 2. Professional |
| 3. Physical |

*Table 1 Three Levels of Safety, adapted from (McWhorter, 2021)*

For the purposes of this thesis, these taxonomy domains give guidance on characterization and help to define factors for analysis. Though behavioristic, it is the proposition of this paper that the taxonomies can be applied from both the task and learner perspective. Appendix A provides a more in-depth description of the domains, towards the end of the appendix.

**Instructional Design (ID) Models**

Popular ID models are numerous and can be both procedural and non-linear. The following section reviews some of the most popular ID methodologies and how they are used.

*Analyze, Design, Develop, Implement, and Evaluate (ADDIE):* Though original concept source is unknown the ADDIE process, shown in Table 2, was developed by Florida State University and has been used to structure training in the US military since. Instead of giving clear direction, this process model provides an abstract linear design method for designing instructional material, although the model may also be envisioned as a continuous loop (Molenda, 2003).

| **ADDIE Process** | | | | |
|---|---|---|---|---|
| Analyze | Design | Develop | Implement | Evaluate |
| Gain deep understanding of process. Identify knowledge & skills gap | Organize info into topics, tasks, and performance objectives | Production of content | Delivery of learning resource to learner(s) | Effectiveness of product in relation to prescribed goals |

*Table 2 ADDIE Model adapted from (Ertmer & Newby, 2013)*

The model is utilized throughout the DoD as a guide, not just as an instructional design model, but also as a training-resource acquisition guide (DoD, 2001). This guidance is provided by DoD handbook 29612-2A, *Instructional Systems Development/Systems Approach to Training and Education.* This guidance follows the original ADDIE model with the exception that it applies a level of evaluation (formative, summative, or operational) at each procedural step. Figure 2 gives a graphical representation of how the DoD utilizes the method. The Evaluate function noted center and linked to the rest to denote levels of evaluations at the end of every process.

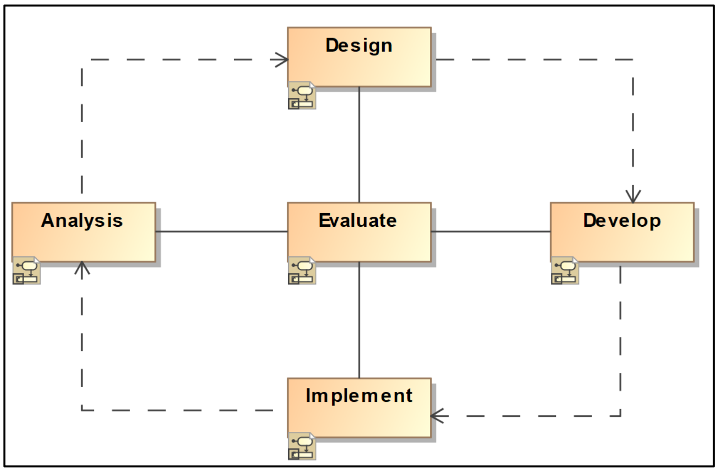



*Figure 3 DoD ADDIE model adapted from (DoD, 2001)*

This model denotes one of the primary designs followed in model creation during this thesis. It is important in the fact that it is DoD regulated guidance and provides understanding of the organizational mindset.

*Merrill's Pebble-in-the-Pond Model:* This model (Table 3) pulls from both theories of behaviorism and cognitivism. It focuses on the content of learning but also identifies the learner's knowledge and skill base. The belief of the designer was that ID could be standardized. However, instructional strategies remain inconsistent and do not change quickly (Heaster-Ekholm, 2020).

| Merrill's Pebble-in-the-Pond Model |
|---|
| 1. Identify content to learn (the pebble) |
| 2. Describe progression of related task/problems (ripple 1) |
| 3. Identify relevant knowledge/skills needed & present with instruction and demonstration (ripple 2) |
| 4. Select appropriate instructional strategy, create functional prototype of task/problem (ripple 3) |
| 5. Refine and finalize prototypes (ripple 4) |
| 6. Collect appropriate data to assess learning & eval design (ripple 5) |

*Table 3 adapted from (Merrill 2013)*

The first stages of Merrill's model focus on task dissection and analysis. A section reflects prevalently on task KSA identification. This reflects well against the beginning phases of the proposed model within this paper.

*Gagn's Nine Events of Instruction:* This model (Table 4) brings key motivators to light that reflect the effectiveness of learner reception of topic content. The event model is set primarily within the theory of cognitivism but has constructivist considerations. It provides key considerations for both external and internal aspects of process learning. It considers the state and responsiveness of the learner (internal) as well as the content imparted (external) (Lina Heaster-Ekholm, 2020). This model takes the related knowledge building process a little farther compared to Merrill's. It also focuses more so on the attention of the learner as well as learning cues that relate to building on required cues. These aspects are representative of the ideals behind the creations of models within this paper.

| Gagn's Nine Events of Instruction |
| --- |
| 1. Gain learner attention to prime them to receive stimuli. |
| 2. Inform learner of objective(s) to establish learner expectations and allow them to focus in on specifics. |
| 3. Stimulate recall of previously learned abilities to encourage the recall of information or skills stored in the long-term memory and provide schemas for the added information to plug in to. |
| 4. Present the stimuli material, share the added information clearly with critical aspects emphasized. |
| 5. Provide learning guidance by offering students appropriate cues to help them connect added information to their existing knowledge and frameworks. |
| 6. Elicit performance by asking learners to do something with the information they have learned. |
| 7. Provide feedback about performance to help learners gauge the accuracy of their work and to reinforce learning. |
| 8. Assess the performance to gauge the accuracy of their work and to reinforce learning. |
| 9. Enhance retention and transfer through instructor-provided opportunities for review and additional feedback. |

*Table 4 Gagn's Nine Events of Instruction, adapted from (Gagne et al, 2005)*

*Universal Design for Learning (UDL):* This model (Figure 3) is the only constructivist-centric model presented within this paper. It stems from the three fundamental principles, listed below, that promote multiple avenues of engagement, representation, and action/expression. This model of learning design is primarily focused on the learner and how they form their process of learning with the variable-structured content provided. Evaluation can still partly be derived from end-result behavior but is also rated from process "reflection and learner evaluation" (Lina Heaster-Ekholm, 2020).

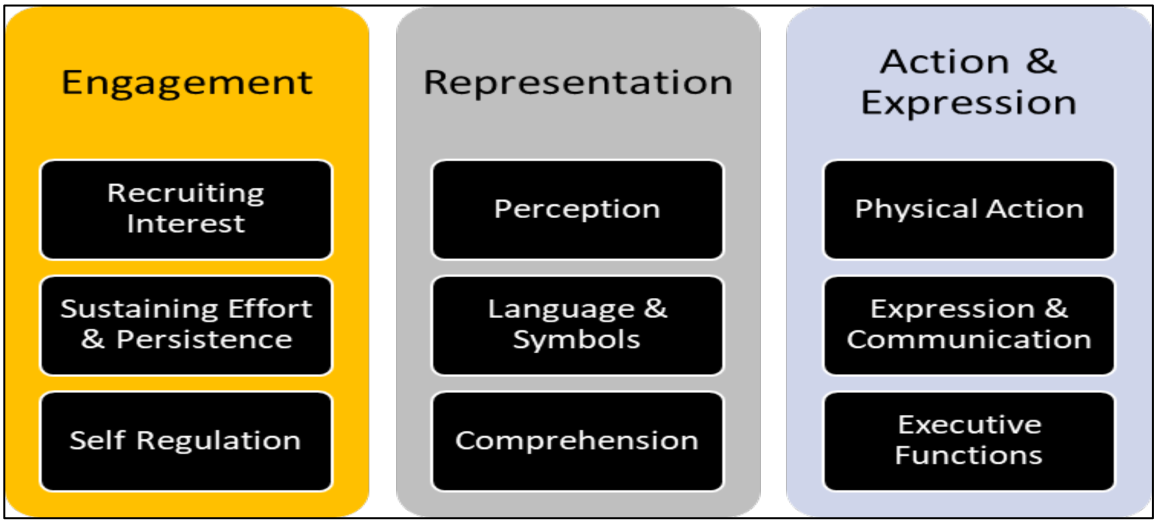



*Figure 4 Three fundamental principles of UDL, adapted from (Lina Heaster-Ekholm, 2020)*

This model provides one of the strongest ideals behind the model creations within this paper. Being that learners should not be required to conform to curriculum, but that curriculum should conform to the learner (Heaster-Ekholm, 2020). This is reflected in the evaluative measures taken within this paper. Additionally, the ideal of UDL stresses dynamic forms of interaction with the learner and the task to learn. It encourages learner analysis, not just task, which is motivating factor within the processes proposed within this paper.

The models provided above give a spectrum-wide view on some of the most popular methods for learning content creation and design built off the theories and beliefs within the field. Though all have been used to create content over the years, some are more flexible and benefit diversity more than others (Heaster-Ekholm, 2020). This increases consideration for some models over others when factoring in the added considerations for e-learning processes, including XR platforms.

**Human Systems Integration (HSI) Training Domain**

HSI, a sub-field of systems engineering, is primarily concerned with the development and integration of human *capabilities and limitations, effectively and affordably* into systems.

The USAF acknowledges training as one of several domains within HSI (Grossman et al., 2015).

**Before Training**

The HSI training domain can be separated into three separate states of training: before, during, and after (Grossman et al., 2015). The before-training state consists of a three-part analysis set that combines to supply the *training needs analysis.* Part one is centered around the analysis of the task to be learned. This involves extracting key cues of the task to better understand what is needed to be conveyed through the training (J. L. Goldstein, 1993). The person analysis evaluates the individual to be tested, whether that individual *should* be trained, and how *effective* the training will be for them (Tannenbaum & Yukl, 1992). Finally, organization analysis gauges how the training itself aligns to the organization's goal sets. If training is not in line with how the organization operates, then effectiveness of the training and the ability of the student to transfer their knowledge to the organization will be diminished (Kraiger, 2008); Morrow et al., 1997). Along with the training needs analysis, another fundamental concern before training begins is assurance that both trainee's motivation and organization support are optimized. Motivation can be increased by increasing the trainees *perceived utility* (Burke & Hutchins, 2007). This is done by ensuring training objectives and operational needs of the task align. For optimized organizational support it is important to align with stakeholders' strategic goals and reflect well on an organization's return on investment ROI (Kraiger, 2008). The before HSI model points out key requirements, such as motivation, to consider. This model is the second most referenced model within this paper and several model tactics are utilized and described in up-coming chapters.

| Training needs analysis | |
|---|---|
| 1. What should be trained (i.e., job analysis) (Goldstein & Ford, 2002) | |
| | a. Identify primary work functions & resources available to facilitate effective performance |
| | b. Delineate specific tasks and contextual factors that compose the job (e.g., high time pressure, potential risks) |
| | c. Specify the task requirements and KSA's that are required for effective performance |
| 2. Who should participate in training (i.e., Person analysis) (Goldstein & Ford, 2002) | |
| | a. Identify ability to understand, reason, adapt to complex concepts (Neisser et al., 1996) test with *Wonderlic Personnel Test* (Wonderlic, 1992) |
| | b. Self-efficacy: *Motivation* (Tziner et al., 2007) Transfer (Burke & Hutchins, 2007) |
| | c. Goal orientation: *Mastery oriented* (positive impact: e.g., (Ford et al., 1997) *Performance* oriented (negative impact: e.g., Tziner et al., 2007) |
| 3. Which organizational factors might facilitate or hinder the effectiveness of the training initiative (i.e., goal orientation analysis) (Goldstein & Ford, 2002) | |
| | a. Identify which KSA's are critical for organization's goal attainment (Tannenbaum, 2002) |
| | b. Identify variables that may hinder effectiveness of training (e.g., organizational receptiveness of training, climate) |

*Table 5 Training Needs Analysis, adapted from (Grossman et al, 2015)*

**During Training**

The *During Training* state is centered around two functions, the first are steps used to *facilitate learning*. The second is centered around the ability to *facilitate transfer*. The former is focused on how the learner subsumes the training during learning, while the latter is concerned with how the learning is applied to the actual real-world task (Grossman et al, 2015).

During the process of facilitating learning (Table 5), information is first presented to the learner through a delivery medium. After the critical cues of the task knowledge are delivered, a demonstration of the actual task is given. This provides further informative context to the task requirements. From a traditional perspective, information and demonstration are *classroom* objectives, where practice is more *field* in execution. Practice pertains to the learner accomplishing the task or a simulated version of the task. This provides a form of empirical observation of the learner to confirm understanding and calculate effectiveness of the first part of facilitating learning. The final part is providing feedback to the learner on observed ability to complete the task with recommendations given, meant to improve task performance (Grossman et al., 2015).

| Facilitating Learning | | | |
|---|---|---|---|
| Information | Demonstration | Practice | Feedback |

*Table Figure 5 Adapted from (Salas & Cannon-Bowers, 2001)*

Facilitating transfer happens beyond the training itself. Table 6 provides four methods that are utilized to increase the efficacy of learning and strengthen cognitive, psychological, and psychomotor learning processes. The first, error-management, deals with how implementing errors into training simulations and focuses on how trainees manage the errors. The second method example lies within the constructivist field of thought and is centered around the trainee taking an active role towards learning. This method provides only the base level of guidance and is focused more on how the trainee adapts within the training context. The third method is embedded training. This method is equitable to OJT and is conducted within the daily work environment utilized by the trainee. The final method example is *guided team self-correction.* This method, like exploration, is constructivist in nature. It is team-based and is monitored by a facilitator. Goal-oriented evaluations are conducted before and after a training exercise. It is primarily driven by member feedback (Grossman et al., 2015)

| Facilitating Transfer |
|---|
| 1. Error-management training |
| 2. Exploration |
| 3. Embedded training |
| 4. Guided team self-correction training |

*Table Figure 6 Adapted from (Grossman et al, 2015)*

**After Training**

The last state of training from the perspective of the HSI process concerns those methods linked to *After Training* functions. Primarily, this state involves the determination of training from two perspectives: whether the training was effective, also if the training has transferred and is sustainable (Grossman et al., 2015).

Though not the only evaluative framework of training, the Kirkpatrick model is one of the most utilized evaluation frameworks in use today (*The Kirkpatrick Model*, 2022). This method is composed of four barometers for evaluation: reaction (how the learner felt the trainee affect them), learning (pertains to the content the learner retained from the training), transfer (behavioral analysis of what was learned to actual performance on-site), and results (impact to workplace/organizational outcomes, i.e., costs analysis (Grossman et al., 2015).

Learning transfer involves ensuring a culture of sustained acceptance of implemented training and the processes learned. This is accomplished by not just having organizational support (through policy and guidance), but also peer-acceptance as well (behavioral support and networking). Additionally, resources must be available in the actual workplace that reflect those taught in training to best facilitate transfer (Grossman & Salas, 2011).

To ensure sustainment of training several actions are necessary: checking on the training system and ensuring that subsequent training sessions are, or are not, necessary. This involves pulling from the evaluation and incorporating the findings into future training sessions. Future reviews of the training are planned where additional factors are considered (Grossman et al., 2015).

Though the *during* and *after* processes of the HSI model are not represented within this paper's methods, it is still appropriate to compare to the other primarily utilized ADDIE model. For instance, the DoD's ADDIE method focuses on stringent adherence of the training system during implementation, where the HSI model provides a variety of measures that can be incorporated at during implementation to *facilitate transfer* of learning (Grossman et al., 2015).

## Model-Based Systems Engineering

In the previous paragraphs of this chapter theories and methods related to both ID an HSI have been described. However, some of these descriptions can weigh on the side of the abstract. To clarify conceptualization, an additional method pulled from the field of systems engineering is used in this document for component representation, MBSE. Previous systems descriptions have relied heavily on documentation, such as system requirements and design standards (Watson et al., 2017) MBSE places representation in the form of highly integrated and interrelated models, providing multi-faceted views to represent the system-as-a-whole (Friedenthal et al., 2014). These models use symbols to indicate various forms of relationships amongst the parts of the system. The symbology used in the modeling in this paper was derived from the unified modeling language (UML) and adapted for use in systems modeling. This symbology is as a toolset is referred to as SysML. Fig. 11 illustrates a taxonomy of diagrams which are commonly used in SysML.

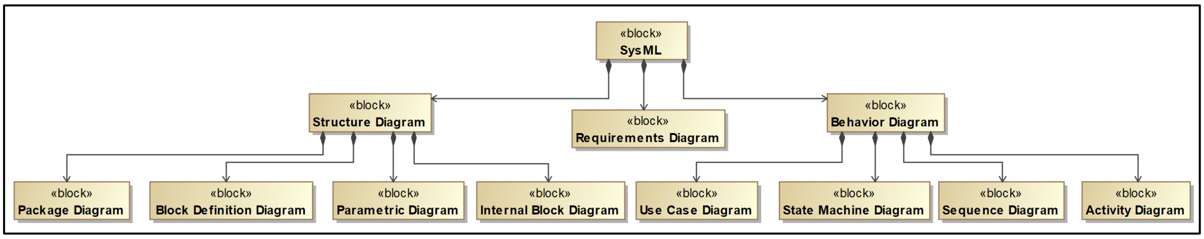



*Figure 7 Taxonomy of SysML diagrams, adapted from: (Friedenthal et al, 2014)*

The intended use of MBSE in this documentation is to produce a useful *artifact* that can provide beneficial guidance in forming a user-centered, instructional design. This design not only accounts for how the content should be learned, but the modes and levels of the content that is conveyed to the learner. These added tiers of consideration have a weighted level of need along with actual content and falls in-line with the added considerations of the taxonomies presented previously in this chapter.

**Chapter Summary**

The methods presented within this chapter along with theories behind them, help to define requirement aspects within a training creation model. Some of the methods demonstrate requirements only from the perspective of the task and how well it must be accomplished. These methods, being behavioristic in nature, view the learner as a non-factor in the equation. Many methods also incorporate learners processing ability. This brings into consideration the cognitive part or learning. However, leaner-centric considerations were limited in the majority of models presented. In the proceeding chapters, this paper will seek to present a modeled representation of all three component theories.

# III. Training Analysis Model Specifications

## Chapter Overview

This chapter focuses on the methods used and models created towards the use case study presented within this paper. It will cover the processes within the *analysis* phase of a con consolidated diagram depicting the components pulled from DoD and HSI guidance. A minor example is provided, and a method breakdown is presented at the end of the chapter.

## Combining Methods

In the last chapter the training design philosophies, beliefs, taxonomies, and design models were reviewed. To further include human-centric factors into DoD training design methodology, this paper proposes a hybrid method with procedures applied in the ADDIE method, which is often utilized by the DoD, being combined with methods utilized in HSI guidance. The proposed method will utilize MBSE processes within a SysML structure. Additionally, the taxonomies implemented using a SysML stereotype structure are applied to certain analysis activities within the proposed hybrid analysis model. This hybrid model will then be applied in a case study that demonstrates task-operator analysis, followed by *gap* evaluation, of a given AFSC task scenario.

Figure 8 shows the proposed analysis process with items from the DoD adaptation of the *analysis* phase of the ADDIE model shown in red and steps from HSI methods shown in blue. Additionally, combined processes are highlighted in green. Application points demonstrated during use case study are noted in yellow. This diagram provides an overview of the proposed analysis process, starting with task training validation, moving to the division of the task in sub-tasks, to KSA evaluation of the tasks, analysis of operators KSAs, noting gaps. Finishing with determining organizational buy-in, identifying hindrance variables, and performing an informative evaluation of the *analysis* process and products. Note that within this thesis, the term *gap* is used to indicate a difference between the necessary level of training and the KSAs an individual within the target career field has before training. Only negative KSAs on the operator's part are noted in reference to required evaluative training measures.

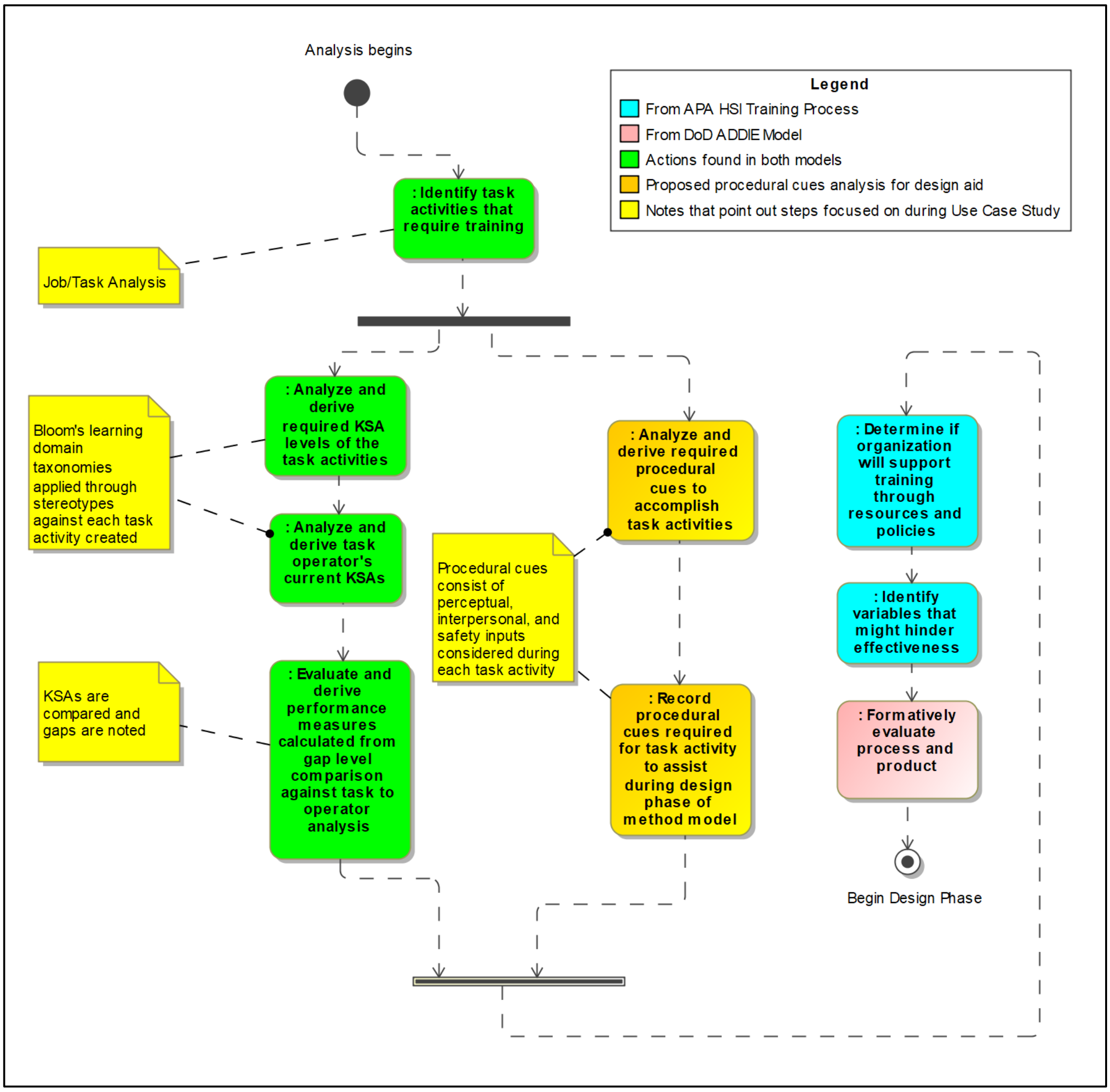



*Figure 8 Activity diagram depicting the combined proposed training analysis process.*

## Initial Task Analysis

Task training design begins with conceptualization of the task to train, including what must be considered and what is already known. The work by Annett et al (1967) state tasks should first be evaluated through probabilities of untrained success. If the task is likely to be accomplished sans training, then training is unnecessary. Secondly, if success of a task is unlikely without training, then what are the probabilities of task failure resulting in inadequate performance of the system? If these two questions cannot be answered clearly, then the task being analyzed must be sub-divided and evaluated in sections.

These decisions fundamentally comprise the initial work towards structuring task training. Using this thought process, training creators can decompose tasks into critical components that facilitate objective component review from perspectives that go far beyond cognitive considerations but include emergent factors that involve sensory and contextual training. Annett et al. noted these considerations as the initial *two rules* for task decomposition (Annett J & Duncan K, 1967).

In the DoD prescribed guidance, analysis precedes design and falls after conceptual planning (DoD, 2001). Analysis provides the understanding of the relevant and irrelevant task components to training design. As soon as a task is deemed necessary for training as described within both ADDIE and HSI models, the task is decomposed into subtasks and prevalent actions. Task decomposition is necessary to ensure all task parts required for training are adequately covered. There are several methods available to support decomposing tasks into key parts. There are methods of task analysis focused more on the task and others which are more on the operator and their requirements for task completion, such as the cognitive ability required.

During formulation of the use case presented in this paper, a hybrid version of task-oriented and worker-oriented methods was utilized. This hybrid approach referenced task analysis methods: *task inventory* (Gragun & Luchman, 1967) and *Fleishman Job Analysis Survey (F-JAS)* (Fleishman & Reilly, 1992). *Task inventory* provided the decomposition of the task into a hierarchy of functions that are processional in nature. However, the primary tasks were determined using two *rules* that were noted by Annette et al. in 1967. First, what is the likelihood that the task can be performed without training for a standard citizen (e.g., using a phone)? Second, what is the cost to the system if the task is not performed correctly? If it is likely that the task can be performed correctly without training or task failure is irrelevant to system operation, training is deemed unnecessary. These two rules guide the use of the *task inventory* methodology.

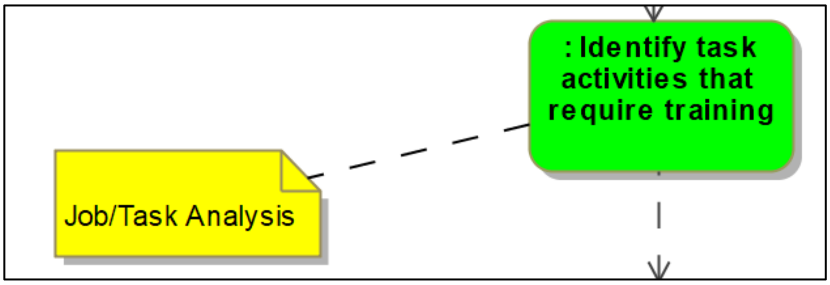



*Figure 9 Task analysis section of consolidated analysis model*

Figure 10 displays a section of a SysML activity diagram from Figure 8 that depicts the second stage in the analysis, i.e., task analysis. The primary purpose of the task analysis is the formulation of KSAs. These KSAs are used to set standards for effective task accomplishment. For this paper, KSA levels are representative of the Blooms', ICAO, Safety, and proposed perceptual cues taxonomies. Task and operator are evaluated and characterized using these taxonomies converted into SysML stereotypes depicted in Figure 14. These taxonomies ensure effective evaluative scope across learning needs domains. The figure represents a profile diagram with two stereotypes: "Task KSAs" and "Operator KSAs". These two stereotypes are annotated with enumeration elements that represent the possible values to assess each item in the taxonomy. When combined, they represent a collection of human-centric factors to consider during evaluation of each required task KSA level and each operator's current KSA level. These proposed stereotypes are intended to represent the task and operators' requirements from both objectivist and constructivist points of views.

*F-JAS* is an example of a similar analysis tool given in the HSI guidance (Fleishman & Reilly, 1992). It provides a survey-type, worker-oriented approach to evaluating possible KSAs that are within each task action. This approach allows a categorical form of analysis that is derived from a standardized list of questions that are key to specifying the required cognitive level of understanding for a task. For this paper, the domain premise that is part of *F*-JAS will be presented. However, to assess the utility of this approach, a brief exercise will be conducted to understand if a group of experts provide similar ratings both for tasks and individuals to be trained. However, the survey questionnaire used in *F-JAS* will be replaced by categories which are derived from the ICAO, Blooms, and safety level taxonomies. This allows the raters to provide ratings using defined scales instead of a sliding scale as is applied in F-JAS. This helps install a definitive level of evaluative requirement if a gap is discovered during analysis evaluation.

Figure 11 gives a SysML representation of the taxonomies described in chapter two. The taxonomies were converted into enumerations that could then be applied to stereotypes. These Stereotypes are then applied to task activities that in-turn apply the taxonomy categories onto the task activity for analysis. This view was developed within *Cameo Magic draw* SysML software (Dassault Systèmes®, 2021).

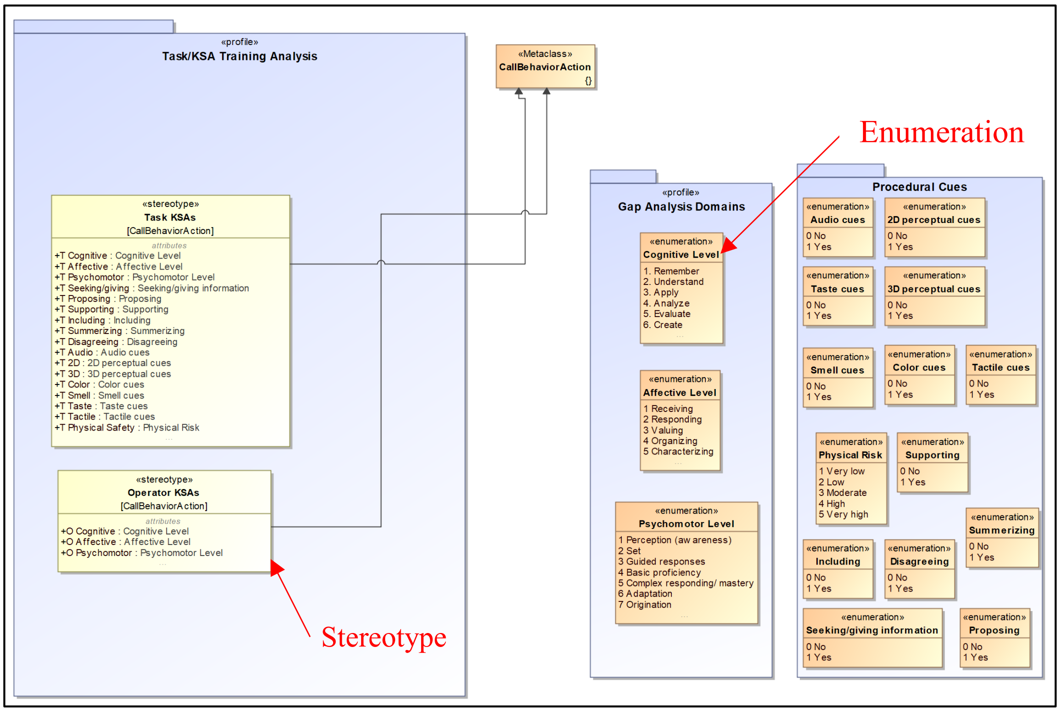



*Figure 10 Profile Depicting Task KSA & Operator KSA stereotype with enumerations defined*

Within the original HSI and DoD analysis procedures, the task analysis is performed by observing and interviewing a current worker as they perform tasks within the career field, then determining KSAs (DoD, 2001; Grossman et al., 2015). For instance, if you wanted to rate operator specific behavioral KSAs of a mechanic's shop, a possible evaluation measure would be to observe a mechanic at work to determine the appropriate KSAs. For the purposes of this paper, the KSA evaluator will be a SME that has accomplished the task and task specific KSAs will be provided by the SMEs based on their prior experience. Similarly, these same SMEs will determine the KSAs possessed by the target worker, who will be defined by a *persona* which represents an individual within a career field with a specific level of training according to the career field's AFSC's Career Field Education and Training Plan (CFETP). Fig 12 shows the two proposed KSA analysis steps, first for task then operator using learning taxonomies. Since taxonomy categories are applied at both steps and are uniformed, evaluative comparison is producible.

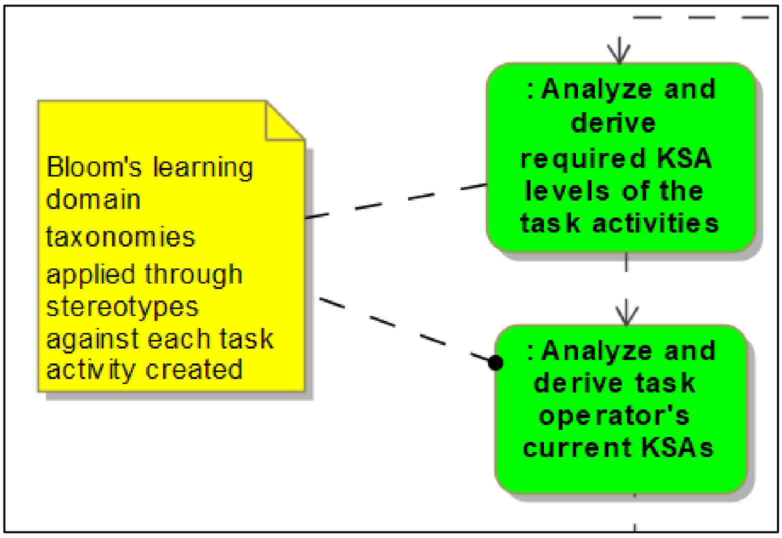



*Figure 11 DoD/I Operator KSA analysis within SysML activity diagram*

**Operator Analysis**

When an individual operator is not available and is purely a hypothetical entity, such as in the purposes of this paper, a type of generic *persona* must be comprised to "stand-in" for evaluation. In agile processes, a *persona* is a "detailed real or hypothetical description of a typical end-user" or operator (Salimi, 2021). With a *persona* the training planner can form an idea of the possible operator's KSAs and rate them per task. Having this information allows us to pull base knowledge from the AFSC's CFETP. This document lists the core competencies of the operator's career field and at the level of competency an operator can be expected to possess to perform career specific operations. Though this document only covers cognitive levels of understanding, an inspection of the processes can help the training analyzer compare similar tasks there-in to the task needs and form analogies between the training requirement for the two-career fields to form ratings for the typical level operator.

These rating are performed in-line with the task's KSAs pulled from the consolidated taxonomy stereotype. This is necessary to apply a quantitative lateral evaluation between the task KSAs and operator KSAs. Once operator KSAs are determined, they are compared to the initial task KSAs to derive a KSA gap, level difference, between the two.

**Gap Evaluation**

Within the consolidated KSA taxonomies used for evaluation, there are factors that are either rated on an ordinal scale or provided through Boolean values. When both the task and operator KSAs have been rated using these taxonomies, a comparison is performed. The ratings are compared (Fig. 13) per taxonomy domain across each task activity and if operator KSA level ratings are lower than task requirement KSAs then domain gap is noted for corrective planning. If no gaps are recorded, then it is assumed that the operator only requires instructional data prevalent to tasks and no evaluative measures need be applied to ensure *gap* correction.

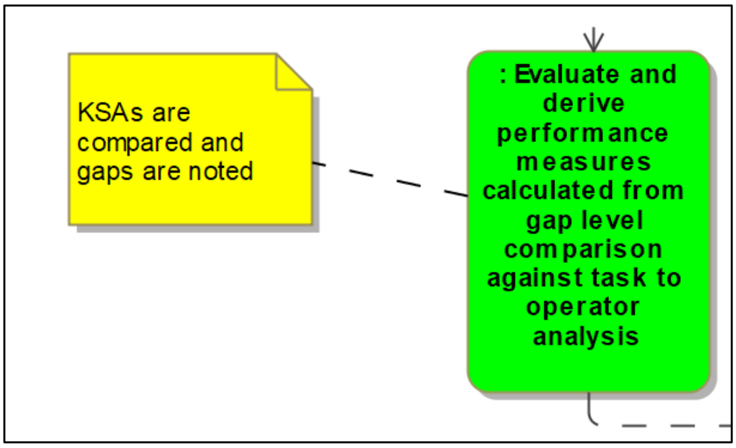



*Figure 12 Gap Evaluation*

The gap between task and operator can be difficult to quantify. However, when considering the factors that are ordinal in rank, such as cognitive, ideas for corrective action can be formed. For instance, if the task and operator have a cognitive gap of one level, then it can be inferred that the operator will only have to accomplish the training required to build cognitive capability by one level. This can be handled well enough in a constructivist-type format, where the information is simply provided to the operator. Alternately, if cognitive ratings are much larger in gap, then additional considerations will have to be noted towards performance levels in training (during analysis phase) and increased time for training will have to be designed (during design phase) and accomplished by the operator. Performance levels can be assigned using the verb method noted earlier for Bloom's taxonomy or through SME subjective rating measure. DoD guidance also provides difficulty of performance and learning time scales to assess SMEs in calculating time for training (DoD, 2001). This along with additional guidance on correcting gaps with implementation of job aids rather than training can be found in chapter 6 of same publication. Since performance measurement on considered during the analysis phase, it is appropriate to consider job aid implements during the same phase instead of waiting until design.

Each factor of evaluation within the operator-oriented taxonomies is planned differently due to the different requirements present in each domain. Affectiveness deals with levels of motivation required for the task and operator. The requirements within this domain differ greatly to that of cognitive capability. Therefore, each domain is evaluated with its own unique parameters. These evaluations facilitate expert inputs, or notes, for training after each task. This results in specialized levels of training requirements keyed to each individual operator. These steps ensure training requirements are valid and appropriate to the individual.

**Procedural Cues**

*Gap* analysis is accomplished for the traditional learning domains (cognitive, affective, and psychomotor). However, the interpersonal, safety, and proposed perceptual domains are noted if they require consideration during training design. It should be noted that the physical safety domain is considered during every task activity. However, the emotional and professional safety levels are considered during the *design* phase, after organizational buy-in has been analyzed and all other determinations have concluded at the end of the *analysis phase.*

These cue domains represent indicators that are important during a task that should be represented in one form or another during training design for the task activity. Figure 14 displays the section of the *analysis* activity diagram that indicates the procedural cue analysis and documentation process.

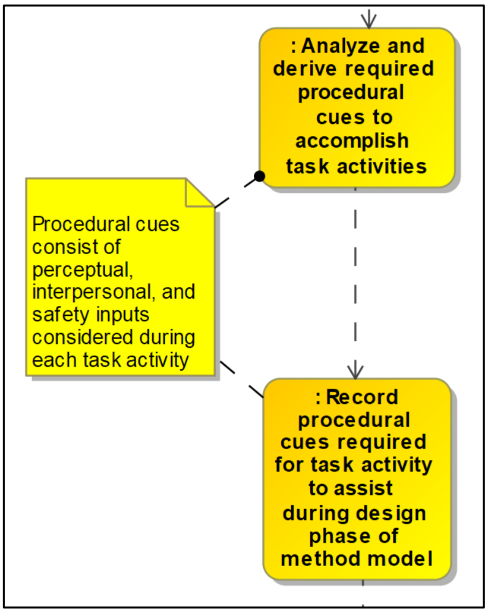



*Figure 13 Procedural Cues*

**Example Of Use**

Figure 9 provides a simple use example of the previous analysis phase activity diagram (Fig. 8). The example task to analyze is *Drive Vehicle*, which is part of the overall process of vehicle operation. The sub-activity window shows two sub-task activities that were dissected down from the drive vehicle task. This represents an example of the first step in the analysis activity diagram *Identify task activities that require training*. After dissection, the parallel operations in figure 5 are processed. The sub-task activity: *Follow Traffic Laws* has been analyzed against the learning domain taxonomies and a cognitive requirement has been noted. From a cognitive perspective, to follow traffic laws one must not only remember laws but also ***understand*** them. Therefore, the cognitive level required per the domain taxonomy is level **two.** It is also prevalent to note that following traffic laws is a task that resides purely in the cognitive realm and therefore has no procedural cues.

Conversely, the task *Observe Surroundings while staying in lane* has both the procedural cues of *3D* and *Audio*. This is due to the 3D visual requirements needed to observe surroundings, in addition to audio cues that could occur during driving. These cues are recorded for later use in the *ADDIE design* phase. Additionally, analysis of the task shows a needed minimum level in the psychomotor domain of ***Basic Proficiency***. Meaning the task has a *muscle memory* difficulty of level **four** according to the psychomotor domain (Fig. 11)**.**

Following task analysis, the operator assigned to accomplish the task is analyzed. For this example, assume the operator is an individual that has just obtained their drivers permit. Performing the same analysis using the learning domains, it is determined that the operator can *remember* traffic laws since they have passed a permit test. However, it is unclear if they *understand* the laws. Additionally, consider that the operator has had no physical driving experience. This indicates that from a psychomotor perspective, the operator is at a base level of *muscle memory* and does not have at least a *Basic Proficiency* needed. Therefore, *Gaps* are present between the tasks and operator in the example.

During the *analysis* phase of the *ADDIE* model, these gaps are noted but corrected. Corrective processes are determined during the *design* phase and are outside the scope of proposed diagram. However, the common corrective actions used to correct gaps in capability for permitted drivers is well known, passenger guidance. Hours of interaction with a certified driver, along with in-seat driving, builds competence and fills the gaps found. Evaluative measures are applied, and the permitted driver is subsequently tested on the gaps.

Though not all-inclusive, this example gives a conceptual understanding of the analysis steps described within this paper. Along with additional procedural steps beyond the *analysis* phase.

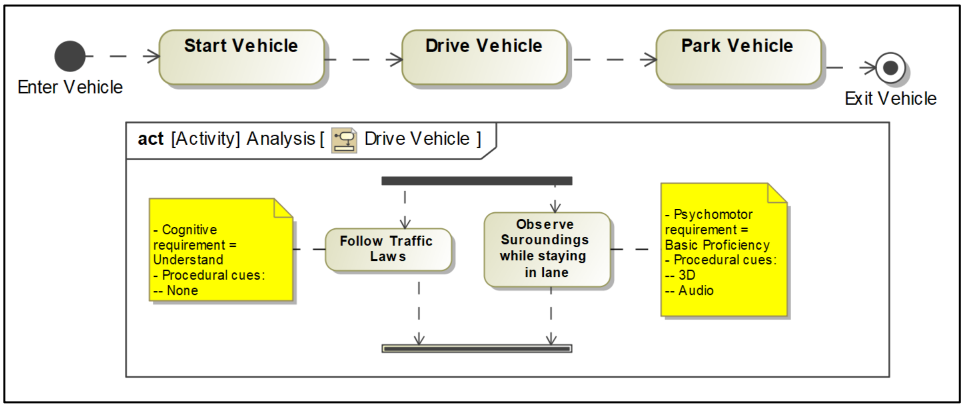



*Figure 14 Example activity diagram*

## Last Steps

Once completed, the last steps within the *analysis* phase of the proposed model seek stakeholder buy-in. From the perspective of the operator, this is already accounted for through the affectiveness factor. Additionally, organizational buy-in can be improved by maintaining lines of communication and providing analysis results that provide findings and solutions that can give a sense as to the likely ROI. Lastly an informative evaluation is conducted of the entire phase that consists of review of the process steps within the phase, ensuring the steps were followed. This is done by comparing the product, and performance measures, against the steps. This then concludes the initial analysis phase, which may or may not be repeated, dependent the formative evaluation results. If good to go, then the *design* phase begins, and training resources dedicated.

## Method Review

This section seeks to review the methods posed during this chapter:

1. Analyze entire process that is considered for training.
2. Decompose process into task activities.
3. Analyzed task activities individually using domain categories provided by Bloom's learning taxonomies pulled from literature review to form the inputs that analyze KSAs.

4. Perform a similar KSA review in reference to operator that is subject to training. Analyze operator KSAs against task activity using taxonomies pulled from literature review.
5. Evaluate and compare task requirements and operator capabilities. Note gaps if operator capabilities are at a lower level than task requirements.
6. Review gaps in reference to the taxonomy they pertain to and evaluative parameters. Pull additional information, if required from DoD guidance on time and performance calculations (DoD, 2001).
7. Simultaneously, record prevalent procedural cues for each task activity and recorded for future use during *design.*
8. Note organizational buy-in along with any other training deficiencies, such as operator motivations pulled from affective review.
9. Conduct a formative evaluation reviewing overall process and recorded products.
10. Conclude analysis phase and begin *design* phase of ADDIE model. Use performance measures created to aid in training design, to include training resource selection.

**Chapter Summary**

This chapter described the methodologies that drove design of models created within this paper. Procedural steps were discussed that made up the consolidated *analysis* activity diagram created. Additionally, information on taxonomy representation by way of stereotypes was given that shed light on how learning taxonomies were applied in SysML and used within the diagram. A simple example was presented to help clarify steps and method review was presented at the end of the chapter. Chapter IV will demonstrate a use case study that implements these proposed processes and methods.

# IV. Case Study

## Chapter Overview

This chapter begins with presentation of a use case task breakdown and information concerning SME professional demographics. Additionally, data resulting from the three analysis observations described in the previous chapter were recorded. Inputs from all three SMEs are documented and subject data is compiled to facilitate factor comparisons and note differences. The statistics software SPSS (IBM Corp., 2021) was used to create descriptive graphs and compute correlations. Along with task and operator analysis inputs, some professional demographic information is also gathered to provide criteria for SME selection. Any gap between task and operator variables is noted and a descriptive analysis is provided.

## Analysis and Results

## Use Case

A case study was used to understand the applicability of the proposed learning analysis model. This case involves the installation of an expeditionary aircraft land anchor known as a *Trim Pad*. The premise of the case study is to first analyze the task from order initiation to final certification. The case study will assume that the typical operators who would typically install a trim pad, specifically civil engineering power production personnel, will not be performing the task. Instead, an operator from an aircraft maintenance career field will be assumed to be trained to perform the task. Utilizing the hybrid process and consolidated taxonomy proposed in this paper, an adequate training plan will have to be formulated from them both.

**Use Case Analysis**

A group of three SMEs with experience with expeditionary *Trim Pads* were each individually presented with the scenario and requested to analyze the process. They then reviewed the task decomposition and evaluated each task action's KSAs as well as the operator's KSA using a character reference, referenced as a *persona*. Afterwards, any dissimilarities in ratings provided by the 3 SMEs are reviewed and assigned appropriate performance measures. The SME's analysis results were compared amongst each other and a descriptive comparison and correlation amongst ratings were performed.

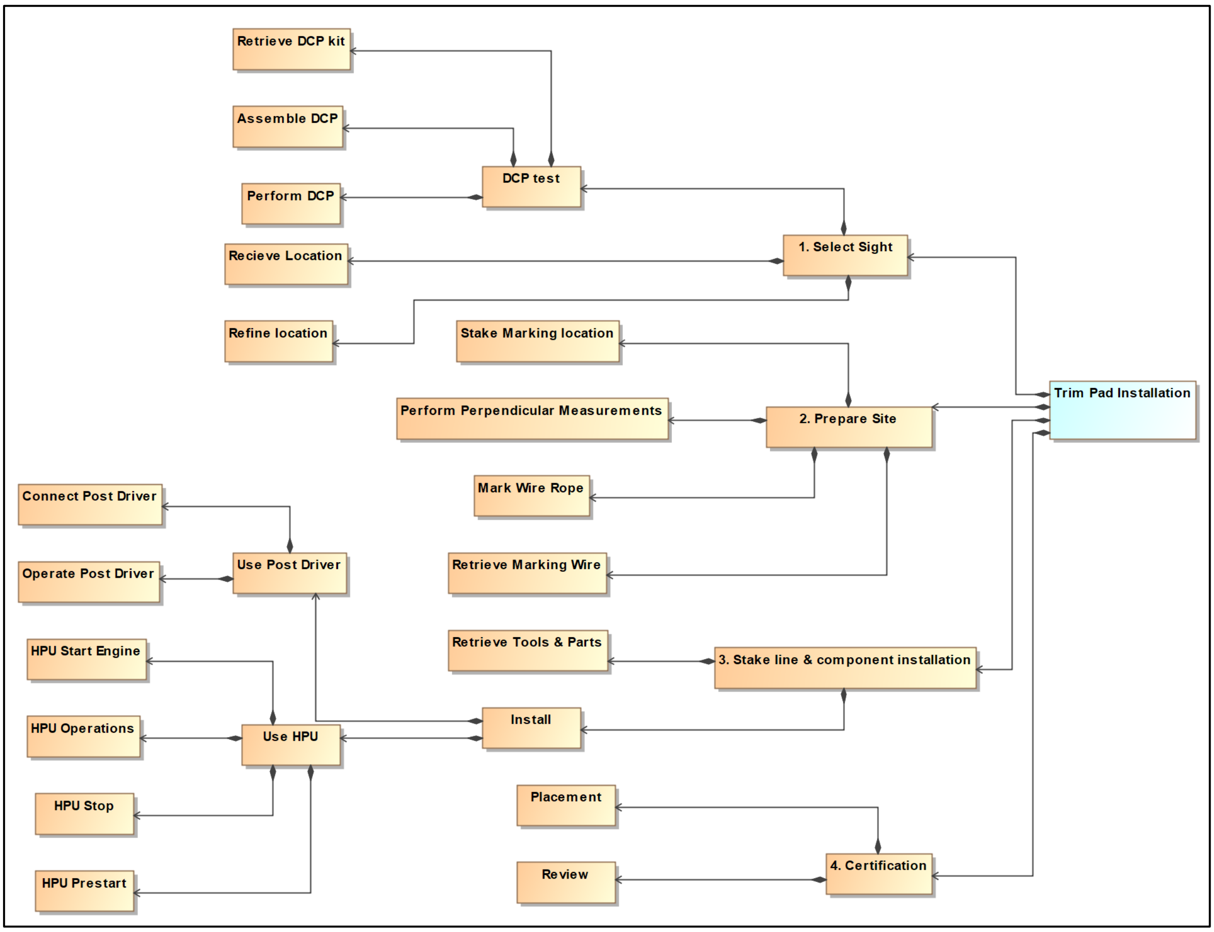



*Figure 15 Hierarchical Decomposition of Trim Pad Installation*

Figure 15 gives the task hierarchical breakdown of the proposed use case scenario. The task inventory process was used, following the basic breakdown criteria of Annette et al's *two rules*. For the purposes of this paper, the decomposition was created to include several task actions that would not normally be considered as primary to task analysis, such as retrieving tools, etc... These elements were left in the decomposition to provide test insight on how taxonomies would be used to evaluate for similar actions. Ultimately, 18 tasks were derived with four primary processes noted: sight selection, alignment & marking, stake line & component installation, and certification. These primary tasks were subsequently decomposed into their respective sub-tasks and actions. The task decomposition was performed in *Cameo Magic Draw*, SysML software by the researcher who was trained as a systems engineer and possessed SME knowledge of the task from previous real-world experience. During decomposition, two documents were referenced to confirm regulatory information. Technical manual 35E8-2-10-1, *Operation and Maintenance Instructions Organizational/Intermediate Levels Mobile Aircraft Arresting Systems* (2021) was utilized to confirm equipment, tool, and operations procedures during install operations. The DoD's *Tri-Service Pavements Working Group (TSPWG) Manual*(2019) was used for clarification on install configuration data and process of execution. To aid the SME during analysis, guidance from both documents were attached to each task element within *Cameo Magic Draw* Software. The examples in figure 16 shows the documentation pane for activity element *1.3 Calculate Correct Layout.* Which provides guidance embedded from the required technical order (TO) (USAF, 2021). Each element within *Cameo Magic Draw* software has a similar documentation panel. This provided a resource to display required documentation to the analyzer that aided in level rating. Note that simple or HTML text graphics can be embedded within the documentation panel (Dassault Systèmes®, 2021).

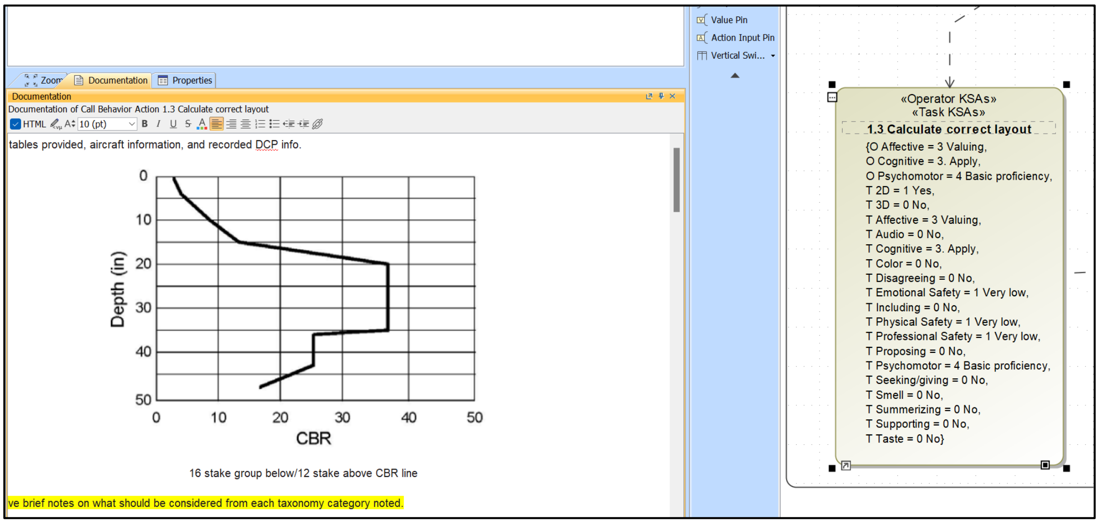



*Figure 16 Embedded Documentation Example within Magic Draw Software*

## Use Case Participants

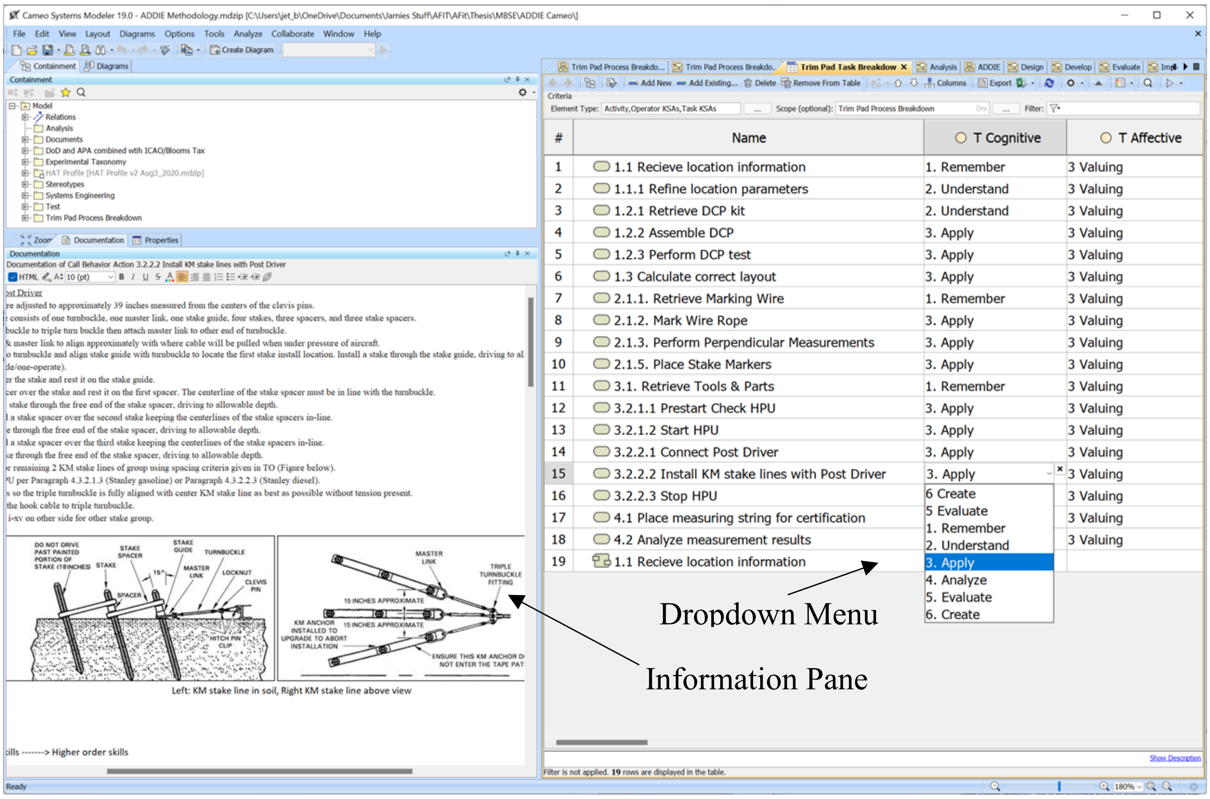
Three SMEs independently conducted the analysis. The individuals had all conducted, and headed, the install of at least two expeditionary *Trim Pad* installations. All three had received the standardized *train-the-trainer* training that is routine in the enlistment track. Furthermore, all three had achieved at least 7-level career field mastery of the AFSC in question. One of the SMEs had also taken AF basic instructor course in preparation for time spent as an expeditionary instructor. Table 6 provides SME demographics.

| **Professional Data** | | | |
|---|---|---|---|
| | SME 1 | SME 2 | SME 3 |
| **Years in AFSC?** | 20.5 | 13 | 18 |
| **# Of times accomplished task?** | 4 | 3 | 2 |
| **7-level certified?** | Yes | Yes | Yes |
| **Instructor experience?** | No | No | Yes |

*Table 6 SME Career Data*

## Use Case Process

Each SME was supplied with information on the analysis process and the scenario provided in the use case (appendix A). A *persona* (appendix B) was provided representing the operator to be trained. To populate a reliable *persona,* the fictional operator within this paper's use case was an airman that was a part of the Tactical Aircraft Maintenance Specialty career field, *AFSC 2A3X3*. Lastly, a brief description of MBSE and SysML was provided by the research facilitator to impart understanding of the analysis layout to the SMEs. Due to limited software availability, the facilitator provided a view of the software in *Microsoft Teams* to the SMEs and inputted the SMEs ratings for each taxonomy category personally. Figure 18 shows the activity diagram displaying one element with the stereotype tags visible and factors evaluated for the *calculate correct layout* step for installing an expedition *Trim Pad* anchor system. The *O* in front of the category refers to an operator analysis point and *T* pertains to a task. Each task evaluation was either carried out by accessing the individual element (like element 1.3 in Fig. 16) or selected from a general table (Fig. 17) scoped so that stereotype columns contained the variable for each taxonomy.




(Figure 17 Generic Table with Information Pane)

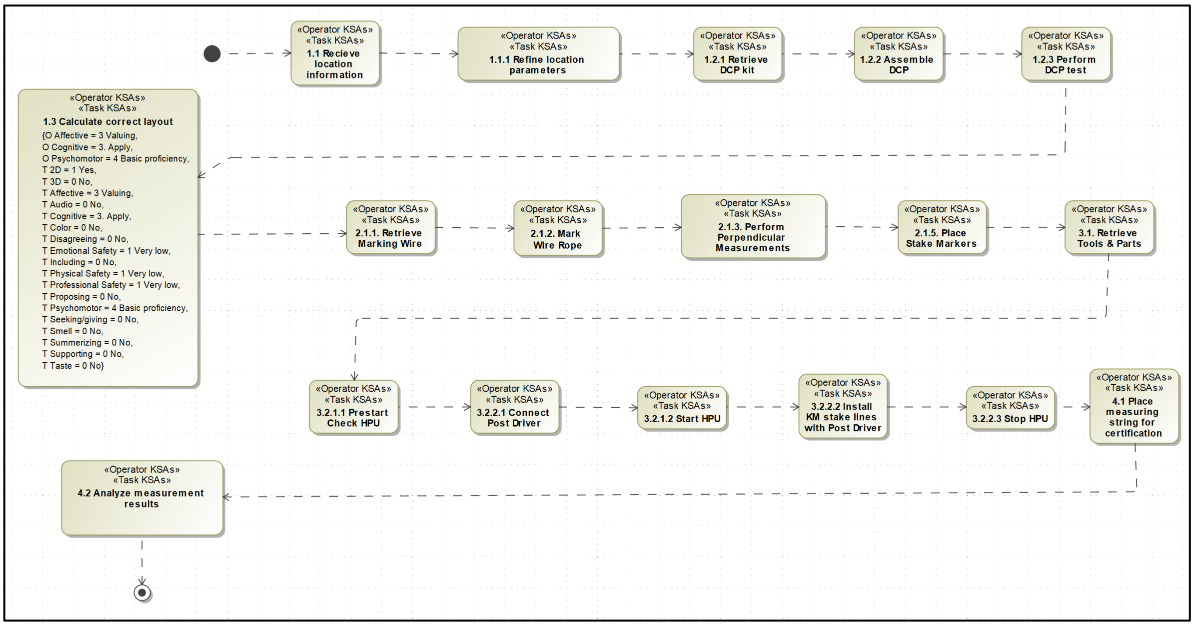



*Figure 18 Activity Diagram displaying Activity 1.1.1 with taxonomy tags visualized*

As described in the previous chapter, the task decomposition was performed by the researcher with SME experience. This was due to time constraints inhibiting both task decomposition and SME task-operator analysis. However, task decomposition was noted satisfactory by all SMEs involved. The task decomposition, which is shown in Table 7 below is composed of eighteen activities. During the experiment, the facilitator displayed each task activity one-by-one and recorded SME inputs for each category within the taxonomy selections windows. As shown previously in Fig. 11, there are twenty categories. Seventeen categories evaluate task levels required for accomplishment of the task activity, and three categories make up the evaluative measures imposed on the operator who is intended to receive training. SMEs used information pulled from the *persona* given and previous knowledge of the career field when selecting categories. All three analysis exercises were accomplished in less than two hours.

| Task Activity |
|---|
| 1.1 Receive location information |
| 1.1.1 Refine location parameters |
| 1.2.1 Retrieve DCP kit |
| 1.2.2 Assemble DCP |
| 1.2.3 Perform DCP test |
| 1.3 Calculate correct layout |
| 2.1.1. Retrieve Marking Wire |
| 2.1.2. Mark Wire Rope |
| 2.1.3. Perform Perpendicular Measurements |
| 2.1.5. Place Stake Markers |
| 3.1. Retrieve Tools & Parts |
| 3.2.1.1 Prestart Check HPU |
| 3.2.1.2 Start HPU |
| 3.2.2.1 Connect Post Driver |
| 3.2.2.2 Install KM stake lines with Post Driver |
| 3.2.2.3 Stop HPU |
| 4.1 Place measuring string for certification |
| 4.2 Analyze measurement results |

*Table 7 Task Activity Decomposition*

This resulted in the accrual of 360 ratings per SME. After completion of the ratings, an analysis of any possible *gaps* between task requirements and operator competency were conducted. This showed no *gaps* between levels for SME two and SME three (Table 8). However, SME one noted three activities where there was a level of cognitive *gap* between the task level and operator's KSAs. Since *gap* was found, subject one noted that evaluative performance measures would have to be created. To create the measures, SME noted that they would reference Bloom's taxonomy and assign an appropriate verb from the designated level of cognition. This provides a testable difference that the operator can be evaluated on. Besides the evaluative measures created, the remaining necessary training would comprise formative levels of knowledge consisting of noted procedural cues pulled during task analysis.

**Use Case Results**

| Gap Observed Among SMEs in Adult Learning Domain | | | |
|---|---|---|---|
| TASK | SME 1 | SME 2 | SME 3 |
| 1 | No | No | No |
| 2 | No | No | No |
| 3 | No | No | No |
| 4 | No | No | No |
| 5 | Yes | No | No |
| 6 | No | No | No |
| 7 | No | No | No |
| 8 | No | No | No |
| 9 | No | No | No |
| 10 | No | No | No |
| 11 | No | No | No |
| 12 | Yes | No | No |
| 13 | No | No | No |
| 14 | No | No | No |
| 15 | Yes | No | No |
| 16 | No | No | No |
| 17 | No | No | No |
| 18 | No | No | No |

*Table 8 Gap found within the Adult Learning Domains*

Cognitive ability was only one of the seventeen task KSAs that were compared to the Operator's KSAs. The other sixteen task KSA inputs showed no gap at all. Meaning according to the information given to the SMEs and their previous experience, the majority concluded that a tactical aircraft maintainer could successfully accomplish an expeditionary *Trim Pad* installation with informative direction only. Informative direction could be represented as minimally as providing the tri-service instructional manual and operation technical order (DoD, 2019; USAF, 2021). However, since procedural cues were also recorded, instruction should also consist of forms that provide consideration for the recorded cues. These findings are used during the *design* phase when training resources, to include XR, are selected and design methods selected (DoD, 2001).

After analysis was concluded, the question was posed to the SMEs if the operator had been from a less mechanical-based AFSC if their rating would show more *gap*. All three agreed that their ratings would show far more *gap* if they were asked to rate an operator from an AFSC with no mechanical core tasks, for instance a paralegal. Meaning far more testable parameters would have to be created and evaluated.

Though gap calculations were low (3 out of 306) the differences of the individual rankings that each SME prescribed to each taxonomy domain and category were higher. For instance, cognitive levels assigned per task were not identical. As shown in the graph below, SME 1 selected *analyze* four times more than SMEs 2 or 3. SME 2 selected the *understand* level five times more than SME 3 and ten times more than SME 1. This presents a varying of analytical opinion among the SME ratings.

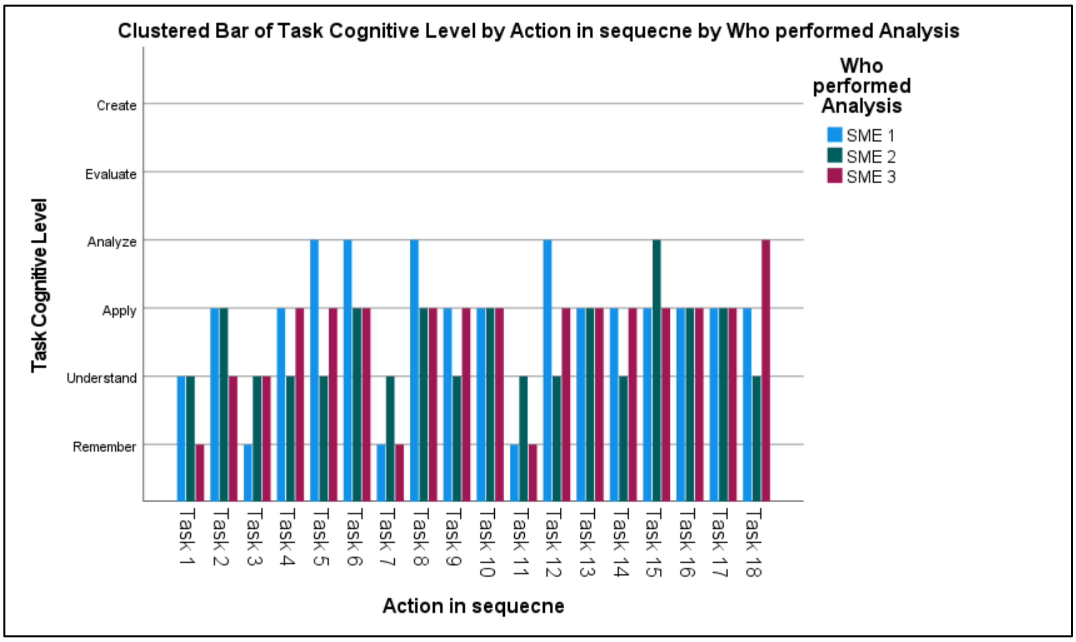



*Figure 19 Task cognitive levels selected*

There is also a difference of ratings between at least one SME for fourteen of the listed actions. However, only a one step difference occurred for most tasks. Meaning a low difference among rankings across SMEs. Tasks 5, 12, and 18 had a maximum rank difference of two among the SMEs. In each of these three tasks, SME 2 rated the task requirement at a *cognitive* level of understanding, while SMEs 1 or3 selected *apply* or *analyze.* During the selection process, each SME was given Bloom's taxonomy and asked to relate one of the verbs to the corresponding level of evaluation required to show the necessary cognitive competence. SME 2's estimation of competence for the tasks focused on the requirement of *interpretating* the data given, an action within the *understand* level of the taxonomy. SME's 1 and 3 saw that the majority of task activities should be held higher on the cognitive spectrum, requiring the operator to have the ability to not just interpret the data but to also *execute* or even *deconstruct* the activity to find error.

Since *gap* observed by SMEs appears limited, positive correlation between task and operator analysis should also appear significant. The data being analyzed is ordinal in type and the distributions of all data sets are non-normal in condition. Thus, a *Spearman's Rho* correlation was chosen to see if any correlation existed between task cognitive analysis and the operator cognitive analysis. Fig. 20 shows the outputs of the *Spearman's Rho* test for correlation. The test gives a coefficient rating of 0.886 between task and operator cognitive analysis. Since the rating is above 0.8 and significance is below the standard alpha of 0.05, indicating a monotonic formation, this leads to the observation that there appears to be a positive relationship between the two factors. This indicates that a tactical aircraft maintainer possesses the cognitive task capability to perform the normally Civil Engineer specific task of installing an expeditionary *Trim Pad* anchor system.

**Correlations**

| | | | T Cognitive | O Cognitive |
|---|---|---|---|---|
| Spearman's rho | T Cognitive | Correlation Coefficient | 1.000 | .886** |
| | | Sig. (2-tailed) | . | <.001 |
| | | N | 54 | 54 |
| | O Cognitive | Correlation Coefficient | .886** | 1.000 |
| | | Sig. (2-tailed) | <.001 | . |
| | | N | 54 | 54 |

*(Figure 20 Spearman's rho correlation between T Cog/O Cog)*

The next area considered in the learning taxonomy is the *affective* domain. Figure 21 shows that many selections are identical across the eighteen actions. Many tasks were assigned the *Valuing* level of affective capability. This indicates that the SME's assessment of the operator's motivational requirements to complete most tasks is that they are willing to endorse the activity and *at least* be seen valuing its purpose.

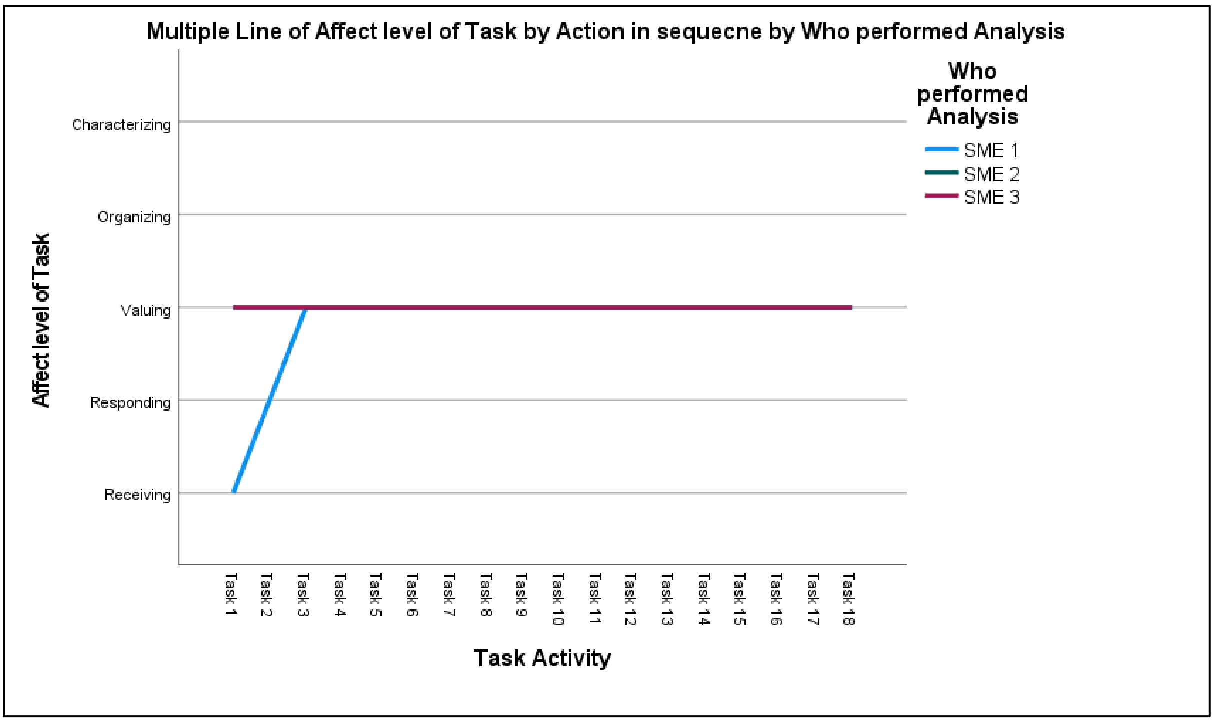



*Figure 21 Affective level to task Graph*

*Spearman's Rho* correlation is pointless to apply to either affective or psychomotor ratings when comparing task to operator ratings. This is because they are same. The correlation coefficient would read 1.00 and there would be no reading for monotonic significance since they are identical. Figure 22 shows the selection the SMEs made during tasks concerning psychomotor ratings. The graph shows that the SMEs fluctuated between *perception* and *basic proficiency* for the tasks, with *basic proficiency* composing most selections. The facilitator noted that at times, an individual SME would conclude that *simpler* tasks, such as retrieving an item, would require at least a *basic proficiency* from the perspective of *retrieving*. However, other SMEs would note cognitive *knowledge* of the item being retrieved and standard *perception* was all that was required to perform the task. This suggests a difference of opinion on domain interoperability.

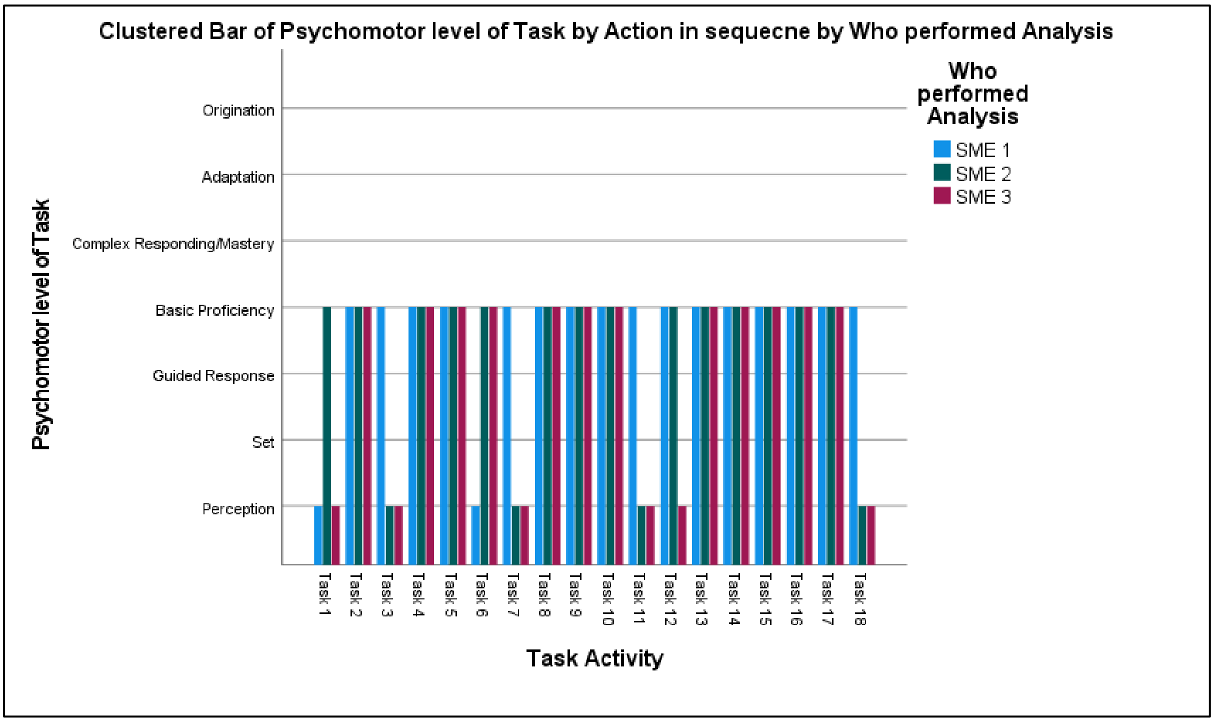



*Figure 22 Psychomotor level to task graph*

**Procedural Cues**

Procedural cues are documented to aid in training design. During analysis, SMEs noted *interpersonal, perceptual*, and physical *safety* inputs-of-note during each task activity. These cues were recorded along with learning domain ratings and exported into an excel spreadsheet. Data recorded showed that most task activities contained important *3D* and *2D* perceptual cues that should be considered during the *design* phase of training. These input considerations primarily involved the understanding of the layout of equipment or the ability to reference manual guidance, such as technical orders. Several tasks were noted for *audio* cues that should be considered. These considerations also involved negative affects to *audio* inputs, such as hazardous noise. Lastly, one task was noted for a *color* cue relating to noting a discoloration of fluids during a pre-operations check for a power unit.

Interpersonal cues were noted for five task activities out of the process. During these activities, operators relied on other team members and leadership to assist in location selection, measurements, and install of the anchor system. SMEs noted that all aspects of the interpersonal domain should be present during the interactive task activities referenced.

Lastly, higher emphasis on safety was noted for four task activities. These distinctions involved noting pinching, noise, lifting, and high-pressure fluid hazards. Table 9 below gives a binary summery of cues included. These inputs would be used during training design.

| Task | Color | Audio | 3D | 2D | Seek/Give Info | Disagreeing | Summerizing | Including | Supporting | Proposing | Safety |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 2 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 10 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 11 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 12 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 13 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 16 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

*Table 9 Procedural cues recorded, 1 = yes, 0 = no*

**Application Overview**

This section is structured much like the methods section provided in previous chapter. However, it is posed from the perspective of application of the use case study:

1. Analysis of the process of installing an expeditionary trim pad anchor system was conducted to include document review for requirements.
2. The process was dissected into primary tasks and further dissected until "two rules" methodology was satisfied (Annett & Duncan, 1967). A task activity hierarchy was created in SysML (Fig. 15).
3. Activities were pulled from created hierarchy and placed in activity diagram, where taxonomy stereotypes were applied to each task activity (Fig. 18)
4. SMEs analyzed created activity diagram and used stereotype *tags* to review and rate each domain category for both task an operator. Procedural *tags* were noted during same step (Fig. 16 or Fig. 17).

5. Completed *tags* are pulled from SysML data and transferred to excel software for comparison evaluation.
6. Gaps are reviewed in reference to the taxonomy they pertain to, and evaluative parameters noted from verb list. Additional information, if required is pulled from DoD guidance on time and performance calculations (DoD, 2001).
7. Simultaneously, prevalent procedural cues were recorded for each task activity and recorded for future use during *design.*
8. Organizational buy-in is analyzed and task evaluations were supplied to organization.
9. All other task-specific variables were recorded for consideration during *design* phase.
10. Digitally created artifacts during the phase was reviewed along with verifying all *analysis* steps accomplishment.
11. Analysis phase is concluded and created artifacts were provided for *design* ADDIE step.

**Chapter Summary**

This chapter discussed the application of an analysis tool as implemented in the SysML programming application to support the use case scenario. Three SME participants separately utilized the proposed SysML tool to analyze the scenario. Results were gathered and described graphically and through correlation. Lastly, a revised method breakdown representing use case processes was given to better convey procedural components of the *analysis* phase.

# V. Conclusion

## Chapter Overview

This chapter presents conclusions and readdresses the research investigative questions posed during chapter 1. These questions aided the creation of MBSE artifacts to support the analyses required to properly calculate appropriate levels of training that are uniquely designed for an operators KSAs. This process proved credible by demonstrating a utility that can reduce training design requirements dependent on the operator, supplying them only the necessary level of training to accomplish a task. Limitations are covered and prospects for future research are addressed.

## Investigative Questions

Initial investigative questions posed in this paper:

1. What KSAs are required to analyze tasks within a job?

2. How would you determine and represent the gaps present in KSAs for individuals who have not been specifically trained to perform the job?

3. How can the integration be best depicted and utilized to promote standards of analysis in training that can be duplicated across training designers?

Question 1 was answered through the research of taxonomies presented in Chapter 2. The combination of Bloom's, interpersonal, perceptual, and safety domains provided the inputs for the stereotype implemented in the SysML model. The consolidation of these taxonomies supplied the framework needed to map the training analysis factors into SysML using stereotyping. Figure 23 gives a final view of the consolidated taxonomy pooled from several sources: (Armstrong, 2016; ICAO, 2016; McWhorter, 2021; Proctor & Zandt, 2008). The number of domains and cues mapped totaled 20. Combined with eighteen task activities, this created a large pool of data to support task analysis and design. Programing this in

MBSE proved helpful. Graphically applying an activity diagram of the process procedures helped to visualize the temporal cadence of the task activities and help keep track of specific data pertaining to the task within each activity element. Additionally, the ability to map out the taxonomies within a profile and create enumerations for the factors, helped to maintain correct values for each factor. Lastly, the ability to take the SMEs' answers and place them within a table, made exporting the data to evaluative software much easier. This aided in an easy transition to evaluation after modeling was completed.

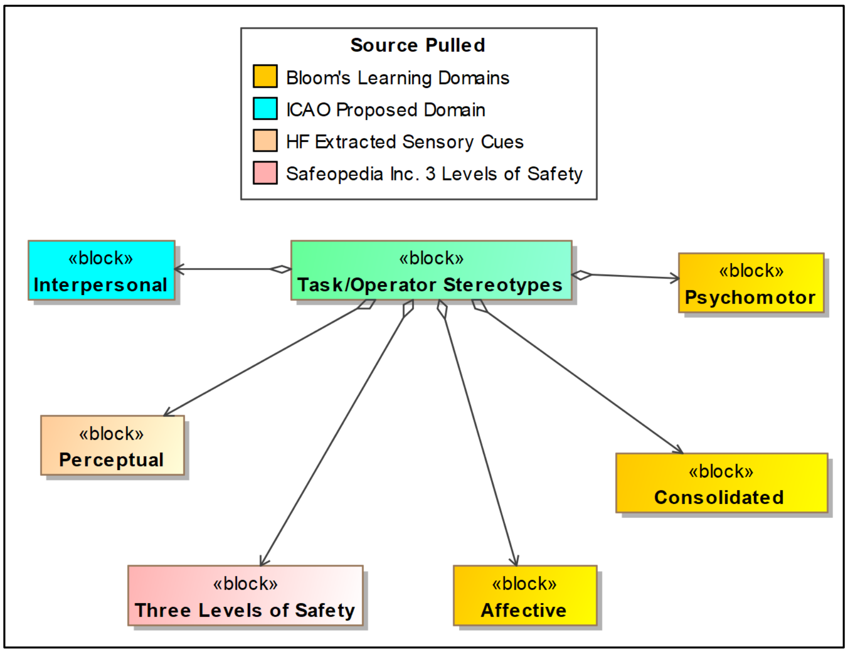


*Figure 23 Consolidated Taxonomy Domains*

Question 2 again pulled from the understanding provided from the taxonomy review. Negative gaps between the task and operator were found and recorded. Subsequently, corrective actions would be created and implemented during the *design* phase of the training creation process. The design itself could take on many forms, dependent on multiple factors. Some factors are represented within this paper, such as learning domain *gap* considerations and procedural cues. The *gaps* found would have a determinant effect on the performance measures created to evaluate the operator for each task activity. Where the procedural cues would seek to fully prepare the operator to accomplish the task activity from a contextual perspective.

Question 3 was answered by proposing and utilizing a taxonomy stereotype during task-operator analysis within SysML for assessing operator training requirements. This showed that using taxonomic stereotypes within SysML can quickly filter through large amounts of decision data. More importantly, it ensures a full-spectrum review of KSAs from multiple perspectives of learning. The use case provides insight into how using the compiled taxonomy, provides similar responses from multiple task authorities. This paper's analysis example demonstrates not just similarity, but efficiency of using digital utilities, with the completion of 306 data inputs within less than two hours.

**Significance of Research**

The significance of this research stems from the utility of more precise evaluation of required KSAs. With more precise evaluations of KSAs across AFSCs, a better understanding of flexibility in training can be realized. This not only improves workforce capabilities, but also improves workforce perspectives. When the workforce perceives good utility from training, their investment in that training is increased (Grossman et al., 2015).

**Limitations and Future Research**

Several limitations were prevalent in the research. Primary would have to be the small number of SMEs who provided ratings. The use case given is unique in nature and the ultimate population of experts that met the criteria for analysis is small (i.e., less than two hundred individuals worldwide). This severely limits availability. Therefore, finding experts that fit the criteria for analysis was difficult. A larger pool of SMEs from a single career field would increase power and permit a better analysis of the consistency of operators in assessing task and operator KSAs when using the proposed tool. A second limitation is in the overall scope of the research, which only proceeded through a portion of the analysis phase of the ADDIE model. The entire methodology was mapped, but time constraints caused a reduction to the analysis model section. Lastly, the lack of SysML tools for each assessor created confusion when MBSE objects could not be accurately represented through internet and camera proxies. A more immersive interface would be more ideal for this type of experimentation over distances, or in-person analysis is suggested.

Future research should be focused on increasing the test model beyond analysis and further into design and development. A prevalent consideration not noted in this paper is resource availability. DoD guidance specifies resource allotment is conducted during the *design* phase and the first item within the resource consideration list is *equipment* (DoD, 2001). XR technologies falls in this category for possible implementation in design. XR platforms have increased in usability and affordability (Kaplan et al., 2021). Demonstrating XR inclusion into a SysML activity diagram, digitally representing the *design* phase could prove a worth-while next step for future research. Lastly, the final phases of *develop, implement,* and *evaluate* could be presented through SysML as well. This would result in field-tested data and additionally results in a use case reference for any XR resources utilized.

From a research evaluative perspective, increased sample numbers would benefit testing and add more significance to findings. Therefore, tasks should be pulled from career fields on hand who can physically participate in the training. This would further improve evaluative results.

**Summary**

Costs of training are quite high in the Air Force. Coupled with stream-lining concepts such as MCA and ACE, finding a means to better supply that training and modulate its use is critical to future implementations. A first step lies within task and operator analysis and finding the best way to satisfy requirements of training for both. Using taxonomies that focus on all considerations towards task training efficiently prepares the training designer to begin the design phase and ensure full accountability of training requirements. Providing efficient and standardized models through methods like MBSE, help to further streamline the process and create dynamic records of use which can then be stored for reuse.  Using taxonomies, during task-operator comparisons, aids in the correct level determination for training design. Which upgrades operator's KSAs in a task beyond their *standard* training.

## Appendix A – SME Analysis Process Script

**Notes to SME:**

- For the purposes of this use case study, we are looking into you using HSI and MBSE practices to help with Training creation. Mainly in the areas of analysis, design, and development. Though we do look at aspects of implementation, up-keep, and retirement of processes too. In this research, we will only be looking at the **analysis** function of the scenario below. During the analysis you will be requested to utilize a consolidated taxonomy to consider key points of the scenario's tasks.
- A research assistant will facilitate use of MBSE tools used during the analysis.
- What is a **taxonomy?**
    - A taxonomy standardizes terms within a field.
    - Helps to reduce confusion among differing sectors of professionals within the field.
    - YouTube Links that can provide more clarification taxonomies used in analysis:
        - Blooms: Bloom's Taxonomy: Structuring the Learning Journey – YouTube
        - Adult Domain: https://www.youtube.com/watch?v=N-ZecFaqcoE
        - Three levels of safety: Safeopedia – What are the 3 Levels of Safety? – YouTube
    - References to the taxonomies will be provided during each analyzed task activity within MBSE tools software. The research assistant will facilitate access to the tools.
    - For the purposes of this use case study, you will use Bloom's taxonomy to calculate required task capabilities and operator current capabilities. The remaining domains represent the procedural cues you will consider as being of note during the task.
- Persona of operator:
    - Tactical Aircraft Maintainer 3-level with a couple of years of experience.
    - Skill sets pulled from CFETP that
    - Basic KSA list pulled from CFETP

**Scenario:**

Involves using a framework (created from taxonomies) to calculate proper Knowledge, Skills, and Attitudes (KSAs) levels to effectively train an operator on selection, installation, and certification of an expeditionary Trim Pad anchor system.

**Scenario:**

"During a standard joint exercise located at RoA 71st Air Base, Campia Turzii, Romania an F-15 is marked for engine swap at location. During previous ADVON visits, the anchor systems on base have been deemed unusable by F-15 maintainers for throttle testing. In an “A-typical” circumstance, an Aircraft Arresting System (AAS) crew would be deployed to assist the maintainers and install an expeditionary Trim Pad anchor system. However, in this scenario, no such crew was dispatched. Instead, an ISU-90 Connex (standard large air-cargo box) is provided containing all required equipment, parts, and tools need for install. The intended operators of the install are tactical aircraft maintainers that have no lower than a 3-skill level within their respective career field.”

In this scenario the focus is how to provide the proper level of training to the tactical aircraft maintainer to accomplish selection, installation, and certification of the Trim Pad. The following assumptions are provided:

- Personnel installing trim pad meet all required KSAs pertaining to acceptance of their respective AFSC
- Joint leadership has discussed need and a viable stretch of taxiway on airfield has been selected to install Trim Pad clear of other vehicles and debris.
- The individuals installing the Trim Pad have unrestricted access/communication to their leadership and the airfield authority (foreign government).
- There are only USAF Operation and Maintenance Sq personnel on site. All other requirements are facilitated by host nation (i.e., forklift & driver).
- Both Mx and Ops personnel arrive on location with standard equipment specified for such deployments.
- Personnel performing install passed all required pre-deployment checklist and were cleared on all accounts (i.e., health statuses)
- Personnel performing install were given pre-deployment brief on joint relations with Romanian government and cursory reasons to need for exercise.
- US Personnel at location have had one or two negative run-ins with host country nationals but overall camaraderie between joint forces is very high.
- Conditions: California Bearing Ratio (CBR) = 39 (throughout), Taxiway = 60 ft wide, F15 = 60,000lbs (thrust), Tools/parts provided in ISU-90 Conex (Standard Air Cargo Box) (with full inventory), cable used: 300ft
- Requirements: Anchor ability for F-15 test capacity. Timeline: ASAP.

Notes on time:

1st Introduction: ~15 minutes

2nd MBSE Taxonomy Evaluation guidance: ~30 minutes

4th SME analysis: ~60 minutes

3rd Closing with feedback: ~15 minutes

Taxonomy tables are referenced within SysML models but are also listed below:

**Bloom's Learning Domains:**

**Cognitive:**

| Lower Order Skills -------------------------------------------------------> Higher Order Skills | | | | | |
|---|---|---|---|---|---|
| **remember** | **understand** | **apply** | **analyze** | **evaluate** | **create** |
| recognizing | interpreting | executing | differentiating | checking | generating |
| ~ identifying | ~clarifying | ~carrying out | ~discriminating | ~coordinating | ~hypothesizing |
| recalling | ~paraphrasing | implementing | ~distinguishing | ~detecting | planning |
| ~retrieving | ~representing | ~using | ~focusing | ~monitoring | ~designing |
| | ~translating | | ~selecting | ~testing | producing |
| | exemplifying | | organizing | critiquing | ~constructing |
| | ~illustrating | | ~finding coherence | ~judging | |
| | ~instantiating | | ~integrating | | |
| | classifying | | ~outlining | | |
| | ~categorizing | | ~parsing | | |
| | ~subsuming | | ~structuring | | |
| | summarizing | | attributing | | |
| | ~abstracting | | ~deconstructing | | |
| | ~generalizing | | | | |
| | inferring | | | | |
| | ~concluding | | | | |
| | ~extrapolating | | | | |
| | ~interpolating | | | | |
| | ~predicting | | | | |
| | comparing | | | | |
| | ~contrasting | | | | |
| | ~mapping | | | | |
| | ~matching | | | | |
| | explaining | | | | |
| | ~constructing models | | | | |

Legend:
"~" Denotes a sub-category verb, related to the first verb above it without an "~".

**Affective:**

| Category | Definition | Description |
|---|---|---|
| Receiving | Developing awareness of ideas and phenomena | Differentiate, set apart, separate, accumulate, select, combine, listen, control, acknowledge, ask, attend, be aware, listen, receive, reply, select show alertness, tolerate, use, view, watch |
| Responding | Committing to the ideas etc. by responding to them | Comply, follow, commend, volunteer, discuss, practice, acclaim, augment, agree (to), answer, ask, assist, communicate, comply, consent, conform, contribute, cooperate, discuss, follow-up, greet, help, indicate, inquire, label, obey, participate, pursue, question, react, read, reply, report, request, response, seek, select, visit, volunteer, write |
| Valuing | Being Willing to be seen as valuing certain ideas of material | Relinquish, specify, subsidize, help, support, protest, debate, argue, accept, adopt, approve, complete, choose, commit, describe, desire, differentiate, display, endorse, exhibit, explain, express, form, initiate, invite, join, justify, prefer, propose, read, report, sanction, select, share, study, work |
| Organizing | To begin to harmonize internalized values | Theorize, abstract, compare, balance, define, formulate, organize, adapt, adhere, alter, arrange, categorize, classify, combine, compare, complete, defend, explain, establish, formulate, generalize, group, identify, integrate, modify, order, organize, prepare, rank, rate, synthesize, systemize |
| Characterizing | To act consistent with internalized values | Revise, change, complete, rate, manage, resolve, act, advocate, behave, characterize, conform, continue, defend, devote, disclose, discriminate, display, encourage, endure, exemplify, function, incorporate, influence, justify, listen, maintain, modify, patter, practice, preserve, perform, question, revise, retain, support, uphold, use |

**Psychomotor:**

| Category | Description |
| --- | --- |
| Perception (awareness) | The ability to use sensory cues to guide motor ability, from sensory stimulation to action. |
| Set | Readiness to act. Becoming ready to respond to different situations. |
| Guided response | Preliminary stages in skill acquisition involving imitation and trial and error |
| Basic proficiency | The ability to perform with some confidence and proficiency but without mastery. |
| Complex responding/mastery | Skillful Performance that is fully integrated and automatic. Implies a high level of accuracy and proficiency. |
| Adaptation | The ability to modify actions to meet different or unusual requirements. |
| Origination | The ability to develop new actions of behavior patterns by adapting already highly developed skills. |

**Interpersonal:**

| Category | Description |
| --- | --- |
| Seeking/Giving Info | Seeking or offering clarification of facts or opinions to / from individuals. |
| Proposing | Putting forward a new concept, suggestions or course of action that can be actionable. |
| Supporting | Conscious and direct declaration of support or agreement with another person or his concepts. |
| Including | Direct and positive attempt to involve another group member. |
| Summarizing | Summarizing or restating in a compact form the content of previous discussions or considerations. |
| Disagreeing | Conscious, direct and reasoned declaration of difference of opinion, or criticism of another person's concepts |

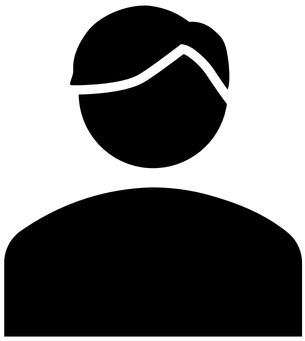
**Perceptual:**

| Category | Description |
|---|---|
| Taste | Task actions decided by the visceral sensor of taste (i.e., chef tasting entrée). |
| Smell | Task actions decided by the visceral sensor of smell (i.e., presence of smoke). |
| Audible cues | Tell-tale sounds that inform task actions (i.e., alarms). |
| 2D cues | Any 2-dimensional cues necessary for task action (i.e. signs, manuals). |
| 3D cues | Any 3-dimensional cues necessary for task action (i.e. objects such as levers, switches, etc.). |
| Color cues | Any signal that uses the color spectrum to convey information or direction. (i.e., alarms flashing red light) |
| Tactile | Any task action where sensation of touch is necessary (i.e., having to locate an object on feel alone). |

**Safety:**

| The Three Levels of Safety | |
|---|---|
| **level** | **Description** |
| Emotional | This is high when the operator perceives themselves a part of the team and are unafraid to not perform a task, they are not confident about. |
| Professional | This is high when the operator is unafraid of losing their position due to leaderships harsh evaluation. |
| Physical | Hazards that can physically affect the operator externally, internally, or both. |

## Appendix B – Tactical Aircraft Maintenance Specialist Persona



**Type:** Human

**Physicality:** Average rating on USAF fitness scales

**Profession:** USAF Tactical Aircraft Maintainer (F-15)

**Total time in profession**: 1-5 years

**Estimated Skill Level:** 5-level

**Specialty Summary.** Maintains aircraft, support equipment, forms, and records. Performs and supervises as a section chief, production superintendent, flightline expediter, crew chief, repair and reclamation technician, quality assurance inspector, and maintenance support functions.

**From Special Training Standard:**

**Basics**

- Housing keeping that coincides with safety standards
  - Sound, intake/exhaust safety, High pressure equipment, and ground handling an aircraft
- Understands and is capable of simple instruction out of TOs, AFIs, manuals. Knows system in general
- Is partially proficient on “pre-use” inspections of equipment
- Knows the basic functions within maintenance functions

**Maintenance Materials/Tool handling**

- Understand the concept of tool control
- Is partially proficient on the procedures to Remove/Inspect/Install
- Is partially proficient on electrical connection process, understand their purpose
- Is partially proficient on use of safety wire, cotter pins, and understand most safety items
- Is partially proficient on the use of hand tools to include torque wrenches, rulers, and micrometers.
- Understands and can perform airfield hand signals
- Understands the concepts of towing and jacking aircraft vehicles
- Can install and inspect aircraft panels supervised

- Understands and can work on brake assemblies
- Can operate flight controls with supervision
- Understand the fundamentals of hydraulic systems
- Understands fundamentals of electric and lubrication systems
- Can operate maintenance stands, aircraft jacks
- Understands diesel air compressors
    - Can pre-op
- AGE Generators:
    - Understands and can operate
- Understands Engine Stands and Dollies
- Operator rates at least "2b" on most stated tasks and possesses at least an "A" subject knowledge level. The "2b" and "A" designators are pulled from the CFETP Proficiency Code Key and mean that the operator "can do most parts of the task listed and needs only help on the hardest parts". Also, "A" denotes that the operator's knowledge is at least factual on all topics covered. Meaning the operator can "identify basic facts and state general principles" of the tasks described above.

| Proficiency Code Key | | |
|---|---|---|
| | Scale Value | Definition: The individual |
| Task Performance Levels | 1 | **IS EXTREMELY LIMITED** (Can do simple parts of the task. Needs to be told or shown how to do most of the task.) |
| | 2 | **IS PARTIALLY PROFICIENT** (Can do most parts of the task. Needs only help on hardest parts.) |
| | 3 | **IS COMPETENT** (Can do all parts of the task. Needs only a spot check of completed work.) |
| | 4 | **IS HIGHLY PROFICIENT** (Can do the complete task quickly and accurately. Can tell or show others how to do the task.) |
| *Task Knowledge Levels | a | **KNOWS NOMENCLATURE** (Can name parts, tools, and simple facts about the task.) |
| | b | **KNOWS PROCEDURES** (Can determine step-by-step procedures for doing the task.) |
| | c | **KNOWS OPERATING PRINCIPLES** (Can identify why and when the task must be done and why each step is needed.) |
| | d | **KNOWS ADVANCED THEORY** (Can predict, isolate, and resolve problems about the task.) |
| **Subject Knowledge Levels | A | **KNOWS FACTS** (Can identify basic facts and terms about the subject.) |
| | B | **KNOWS PRINCIPLES** (Can identify relationship of basic facts and state general principles about the subject.) |
| | C | **KNOWS ANALYSIS** (Can analyze facts and principles and draw conclusions about the subject.) |
| | D | **KNOWS EVALUATION** (Can evaluate conditions and make proper decisions about the subject.) |

**Explanations:**

* A task knowledge scale value may be used alone or with a task performance scale value to define a level of knowledge for a specific task. (Example: b and 1b)

** A subject knowledge scale value is used alone to define a level of knowledge for a subject not directly related to any specific task, or for a subject common to several tasks.

- This mark is used alone instead of a scale value to show that no proficiency training is provided in the courses or CDCs.

/ This mark is used in course columns along with proficiency codes to show that training is required but not given due to limitations in resources (3c/b, 2b/b, 2b/- etc.).

**Note:** All tasks and knowledge items taught in the initial skills course are trained during war time.

(Proficiency Code Key – pulled from CFETP material)

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