Modernizing High-End Flight Training for the Contested Fight

JJ Walcutt, Ph.D.	Lt. Col. Thomas Harley	Col. Jay Spohn	Patricia Bockelman, Ph.D.
SAIC	HAF AF A3/T	SAIC	SAIC
Orlando, FL	Washington, DC	Alabama	Orlando, FL
Jennifer.walcutt@saic.com	Thomas.harley@us.af.mil	Jay.r.spohn@saic.com	Patricia.s.bockelman@saic.com

ABSTRACT

Historically, flight training has focused on creating pilots who can master the ability to handle a variety of environmental, human, and technological risks to complete pre-planned missions. Yet, as technology advances have become shared across both allied and adversarial forces, the contested fight is being realized. To be specific, the additional skills and competencies needed to be effective in the future fight are categorically different than the primarily flight-focused skills previously required. Accordingly, the USAF has created the opportunity for instructors to define readiness independently, differing from the Ready Aircrew Program (RAP) Tasking Message historical requirements. While this is a first step to recognizing that current metrics and matrices are not representative of all the nuances of the skills required for aircrew readiness, there needs to be a definition and associated assessment method that targets these new, and more complex, competencies.

In response, the USAF completed a learning engineering study for one airframe to determine how to modernize learning practices and inform technology requirements. Subjective data was gathered to first understand the competencies needed to be ready for the "Night One" future fight. Second, these findings were translated into a five-stage model of development which was then used to create an updated set of learning goals and metrics that can influence training content, pathways, and technology procurement decisions. This paper provides an example for how to modernize training for the contested fight. It focuses on determining when and how to use live-fly or simulation-based training as well as what devices, environments, and other training elements are needed from industry.

ABOUT THE AUTHORS

JJ Walcutt, Ph.D. is a learning scientist for large-scale learning programs. Her current work focuses on optimizing USAF pilot readiness and modernizing learning across the US DoD. Dr. Walcutt has over 25 years of experience in research and development for training and education with specific interests in improving educational systems nationwide as well as internationally.

Tom Harley is a Lieutenant Colonel in the United States Air Force having served over 21 years. He is a Command Pilot with over 2,400 flight hours in the HH-60G, with 440 combat hours over six deployments in support of OEF and OIF. He is assigned to the Combat Air Forces Division within the Training and Readiness Directorate in the Air Force Headquarters.

Jay Spohn, Col, USAF, is a career fighter pilot and Graduate of the United States Air Force Weapons School. Col. Spohn has commanded Airmen at the Squadron and Group level and was a board-selected member of the USAF's F-35 Initial Training Cadre. He is currently an Instructor Pilot (IP) and Stan Eval Flight Examiner (SEFE) in the F-16C and was previously an IP/SEFE in the F-35A and A-10 and a Mission Pilot in the F-15C.

Patricia Bockelman, Ph. D., is a Learning Engineer emphasizing human performance in synthetic systems. Her research has supported work for US Army, US Navy, USMC, USAF, FAA, and DHS partners as well as private sectors including healthcare, energy, and cyber/information security. Dr. Bockelman launched her career in public education, which has provided an anchor for over 20 years of teaching, research, and learning design.

Modernizing High-End Flight Training for the Contested Fight

JJ Walcutt, Ph.D.
SAIC
Orlando, FL
Jennifer.walcutt@saic.com

Lt. Col. Thomas Harley
HAF AF A3/T
Washington, DC
Thomas.harley@us.af.mil

Col. Jay Spohn
SAIC
Alabama
Jay.r.spohn@saic.com

Patricia Bockelman, Ph.D.
SAIC
Orlando, FL
Patricia.s.bockelman@saic.com

INTRODUCTION

Readiness for the high-end contested fight is expected to increase while the time to acquire these skills, decrease (Modernizing Learning, 2019). Consequently, a different approach to training is required since the standard linear method of simply adding more courses or sorties cannot be sustained under these circumstances. Resources are already exceeded (data gathered through interviews and observations, 2022) making expansion in this manner untenable. Rather, utilizing a deliberate planning guide, or a Learning Engineering approach, for determining when and how to optimize the use of training environments and embedded techniques as well as personalized pathways will help improve readiness through several mechanisms. Specifically, it matches environments to training for each capability rather than using a one-size-fits-all approach. This clarification means the brain is more likely to understand information, hold it in long term memory, and retrieve and apply it in the real world most effectively and efficiently. Structuring training pathways by training modality can increase knowledge capture and appropriate use and most importantly, can clarify where to make approvals and investments today. Further, the cost to train is necessarily reduced when technology apparatus are used efficiently by connecting their capabilities to trainee needs and knowledge type to be learned.

A learning engineering design is a new-ish concept that recognizes non-linear learning pathways which incorporate extensive technology enhancements. The rationale is that the demands of the 21st century exceed what the human mind can endure. For defense, this is especially true. Accordingly, various data capture, analytical techniques, instructional interventions, and technology supports have been studied across the learning enterprise. It is important to recognize the use of these elements by adversarial nations because the U.S.'s learning modernization plan has been translated to multiple other languages and is being used by large and small nations alike. Avoiding the implementation of these principles is therefore no longer avoidable.

Thus, a learning engineering design demonstration for the USAF has been commissioned for the F-35 to clarify the process and impact this approach to training can have on readiness. It involves a systematic review of all capabilities needed today and in the future – including the intangible skills such as admin and other basic airmanship skills, emotional modulation, and cognitive agility. These general capabilities are paired with content-specific skills (e.g., platform and maneuvering skills) to create a clear map of the total skills need. Capabilities are then connected to determine which platforms or skills are similar and this map is used to design personalized learning pathways informed by individual inherent traits, experiences, and capabilities. Connected to sensors and technology, these frameworks lead to investment plans and timelines that lead to heightened efficiency of fiscal spend, development time, and pathways to achieve individual and total force readiness. It is important to note that while an effort like this appears overwhelming to create because it requires access to and expertise in multiple disciplines, the extensive modeling and developing of these communities has significantly reduced the time and cost to develop a plan.

Accordingly, this paper reports the results of the initial stage of a customized Learning Engineering (LE) process, the capabilities analysis phase. First, this paper presents a brief explanation of the LE process then how it is applied to the F-35 training, including a model blending 5-steps of mastery for knowledge, skills, and abilities (KSA) categorization then provides recommendations and next steps to harden this process for use.

METHOD

Learning Engineering (LE) Process

LE is a modernized instructional design process that incorporates best practices from the fields of learning science, technology, and analytics to create competency-based learning pathways (Schatz & Walcutt, 2022). Core knowledge areas for LE include software engineering, instructional design, learning environment engineering, educational and training professional practices, assessment, subject matter expertise, learning sciences, and data science (Goodell et al. 2020). By combining all these elements in the design process simultaneously, it allows for an optimized use of the combination of their affects.

Accordingly, the LE process follows five key steps: Capability Assessment (identify the key competencies to be achieved), Competency Modeling (five-stage model development), Instructional Technology and Resources Review (determine available elements), Framework Design (organize the model and current instructional elements; identify gaps in materials and technologies), Recommendations (define content and technology that needs to be developed), and Assessment and Personalization (define what to measure and how to personalize learning pathways for efficiency).

STEP I: Capability Assessment

The primary goal of the capability assessment is to determine the key competencies a pilot needs to be ready for the contested fight. Traditionally, this is established by asking expert pilots to outline skills and associated tasks or through an interview process called cognitive task analysis. In the learning engineering process, the goal is to understand the operational environment, challenges that will be met, and supporting skills that are needed. The result is a set of cognitive, physical, and self-regulatory competencies that once learned will allow the individual to operate successfully in the designated environment. Consistent with USAF Handbook 36-2647, the following steps should be followed:

1. Complete preliminary research on the career field. Resources to aid in this endeavor may consist of the AF Officer/Enlisted Classification Directory (AFOCD/AFECD), career field education and training plan (CFETP), operating instructions/guides/regulations, occupational analysis report (OAR), and/or competency dictionaries.
    a. Questions to ask: What are the expectations/outcomes? What are the targeted jobs (e.g., key developmental positions, all positions, etc.)?

2. Develop an occupational competency model: Collect the data necessary to build the model through a combination of research methodologies. A review of existing data (e.g., behavior and competency catalogs, lists, or models; existing task and mission analyses) should be supplemented by personal interviews, focus groups, surveys/questionnaires of SMEs, expert panels, job/task function analysis, and/or observations.
    a. Identify those individuals or organizations who may be involved in developing, or will be affected by, the competency model (stakeholders, SMEs, analysts, outside consultants or organizations, etc.).
    b. Identify SMEs and high performers within the career field. These SMEs should:
        - Have extensive experience and knowledge of the United States Air Force specialty (AFS).

- Have diversity in perspectives, experiences, and familiarity with the different work positions/functions (tactical, operational, and strategic).
- Be highly productive/superior performers who are currently doing the work and/or have been promoted into leadership/managerial positions.
- Be managers/leaders who supervise highly productive/superior performing individuals.

c. Use a combination of qualitative and quantitative analysis methods to identify categories, patterns, or themes. The goal is to quantify major behavioral categories, patterns, or themes outlining a model.

3. <u>Assign foundational competencies to different categories</u> (e.g., developing self, developing others, developing ideas, and developing organizations). Identify each competency by label, definition/description, proficiency level and criteria, and observable behaviors.

Step II: Competency Modeling

Once the data is collected, analyzed, and key competencies are identified, five stage models have to be developed. These models clarify and describe what a person can do at each stage of development. The purpose of these models is to: a) understand at a deeper level how well someone can perform a skill or how deeply a person understands certain information, b) to use the capability measurements per competency to drive personalized learning interventions, and c) to measure more accurately the difference between the capability needed to perform a job adequately and already learned skills or knowledge. These models can therefore be translated to data to drive individual assessment, training efficiency, and team or fleet level aggregated readiness measurement. Consistent with USAF Handbook 36-2647, the following steps should be followed:

1. <u>Create Developmental Models</u>: Once sub-groups have been named and defined, team members must describe the ideal behaviors associated with each sub-group. These ideal behaviors should be separated into distinct proficiency levels (e.g., basic, intermediate, advanced, and expert). Ideal behaviors are observable, measurable, and learned; they describe what a person can already do at a specified proficiency level. Once the ideal behaviors have been identified, the competency model's basic structure is complete.
2. <u>Validate the Competency</u>: After the model is diagramed, it should be validated. Validation can consist of conducting interviews with other subject-matter experts (SMEs), observations, focus groups, and/or surveys.
3. <u>Finalize the Model</u>: Once the data has been collected and analyzed, the existing competency model may need to be adjusted. To finalize the model, the stakeholder(s), the career field SMEs, and competency division experts should meet to address and approve changes.

Step III: Instructional Technology and Resources Review

The goal of this step is to identify resources and technological capabilities already available that can be used to train individuals and teams through each developmental stage. The process to achieve this involves a procurement, research, and development review. For each of these reviews, interviews and a review of program and research reports are the primary methods of data gathering. Once the resources are identified and described, the next step is to organize them by both instructional content and delivery method. The goal is to connect this information to each stage of development and to determine which resources can be reused for other content.

Step IV: Framework Design

Once all the data is collected and organized from interviews, the review of resources, and the models are developed, the next task is to organize all the information into a framework that can define training goals, sequencing of materials and experiences, and in digital environments, drive personalization decisions. Gaps in materials and technologies will also be determined during this step.

Step V: Recommendations

Based on the framework design, a modularized set of lessons and experiences can be designed and the optimized delivery methods defined. Typical delivery methods include self-study, classroom learning, practical live applications, virtual experiences, and live practice. Much of the current training program and technologies used for delivery can often be reused in this new structure. However, through this process, many more are typically identified and must be created or procured.

Step VI: Assessment and Personalization

Once the content elements are created and the delivery technologies procured, it is necessary to define *what* to measure and how to personalize learning pathways for efficiency. Assessment focus and delivery methods are also determined in this step. These elements define the unique pathways of each trainee. Essentially, individuals are initially assessed to determine what capabilities they possess at the start of the course and to what level of mastery. Based on the initial assessment, the most needed areas to focus on can be identified and used to determine which lessons and experiences need to be applied to the personalized pathway. Assessments can focus on content knowledge, skills, or capabilities but can also include neuro-physiological metrics. Whole body assessments can help determine how much information a person can handle as well as their depth of understanding.

The result is a repository of content elements combined with recommended delivery methods or technologies, a set of knowledge, capability, and whole-body assessments, and an algorithm for personalized training pathways that maximize individual capabilities, speed of learning, and mission requirements for readiness.

CURRENT FINDINGS

Steps I and II were completed which looked at three key elements: (1) current training practices and focus areas, (2) conducted interviews to understand key competencies of interest to the F-35 instructor community, and (3) five-stage developmental models were developed for these key focus areas.

Step IA: Current Training

The initial analysis focused on the training undertaken by a neophyte F-35 pilot. It begins with the F-35 Initial Qualification Course (B-Course) and proceeds through Mission Qualification Training (MQT), Flight Lead Upgrade (FLUG), Instructor Pilot Upgrade (IPUG) and F-35 Weapons Instructor Course (WIC). Each of the five courses were analyzed by first providing a brief description of the course, followed by interviews with F-35 Instructor Pilots (IPs) for the course in question. The analysis then compares the existing course content with any training gaps gleaned from the interview results.

Within 3 years and 7 months (see Figure 1. F-35 standard training timeline), F-35 pilots receive training aimed to advance their skills by applying classroom instruction, scenario-based learning (with various degrees of immersion and fidelity) and live flight practice. Brief summaries of the four primary training phases follow, providing context for the present capabilities assessment.

Figure 1. F-35 standard training timeline

B-Course
The F-35 B-Course is a 190 training day formal course designed to train a recent USAF pilot training graduate to fly and employ the F-35 across various mission sets, day or night and in all weather conditions. The B-Course is only conducted at Air Education and Training Command (AETC) Formal Training Unit (FTU) squadrons which are, as of 2022, located at Eglin AFB, FL and Luke AFB, AZ. The B-Course is comprised of four phases of training: Transition (training days 1 thru 41), Air-to-Air (training days 42 thru 74), Air-to-Surface (training days 75 thru 88) and Missionized (training days 89 thru 129).

Mission Qualification Training (MQT)
MQT is accomplished at the student's gaining Combat Air Forces (CAF) F-35 squadron. MQT is the process by which the CAF squadron commander certifies that the recent B-Course graduate is qualified to perform the unit's Designed Operational Capability (DOC) Statement tasking (i.e. expected types of combat missions to be flown) in the anticipated Area of Responsibility (AOR) or theater of operations. The eleven core instructional events take approximately two months for the recent B-Course graduate to complete at the standard CAF execution rate.

Flight Lead Upgrade (FLUG)
FLUG training is accomplished at a pilot's CAF squadron. FLUG trains an F-35 wingman to lead combat missions in the F-35. The syllabus focuses on two key skills: 1) FLUG Flying Training: Leadership of a flight of two to four aircraft in the conduct of non-missionized F-35 missions (BFM, BSA, ACM, TI) and missionized DOC-Statement missions (OCA, DCA, SEAD). This includes mission planning, briefing content/presentation, in-flight decision making/execution and debrief content/presentation. The training also includes, on missionized sorties, execution in concert with additional flights of F-35s and other strike-package aircraft: 2) Functional Team Lead: Duties required of a Continuation Training (CT) team-lead to coordinate and execute up to a 4+4vX OCA effectively. This includes coordination among other flights and entities (Red Air, Strikers, Command and Control (C2), Tankers), planning IAW 3-3.IPE, execution IAW F-35 Tactics, Techniques and Procedures (TTPs) and debrief facilitation among the varied entities. The twenty-five academic, FMS, and flight events typically require ten weeks to accomplish.

Instructor Pilot Upgrade (IPUG)
IPUG training is accomplished at a pilot's CAF squadron. IPUG trains an F-35 flight-lead to instruct all missions in the F-35. Like FLUG, IPUG uses a building-block approach to developing the requisite CAF Instructor Pilot (IP) skills in the IPUG student. The CAF-standard IPUG syllabus has eleven, one-hour

academic lessons that provide instructor guidance and techniques for each sortie type in IPUG, much like the academic layout of the FLUG. The composition of IPUG academic lessons differs from those of MQT and FLUG, however, as the IPUG academics are focused on how the Upgrading IP (UIP) should teach the skills required for the mission at hand. There are twenty-six academic, FMS, and flight events typically taking ten weeks to accomplish.

Weapons Instructor Course (WIC)
The F-35 WIC is a one-hundred and sixty day long (one-hundred and eight training day), graduate-level course taught by the 6th Weapons Squadron (WPS) at the United States Air Force Weapons School (USAFWS), Nellis AFB, NV. The purpose of the Weapons School, in all of the Mission Design Series (MDS) across the USAF, is to train expert instructors at their given MDS (F-35, A-10, C-17, Intelligence, Space, etc) who are capable of not only being superb at the art of instruction but also of serving as their assigned unit's chief instructor (the teacher of the teachers) and as Subject Matter Experts (SMEs) on their MDS and advisors to squadron, group, wing and senior leaders across the USAF. Far from being the "next step after IPUG", WIC attendance is very selective and the course is focused on young officers that are new instructors. Candidates are identified by their CAF units starting as early as MQT and are monitored through MQT, FLUG and IPUG for the aptitude to be a Weapons Officer. Candidates that do not excel in those upgrades or fail to display the temperament and maturity required of a Weapons Officer will be removed from consideration as they progress through their first CAF assignment. F-35 WIC is comprised of nineteen aircraft sorties (with five more optional flights), six FMS sorties (with four optional FMS missions) and two-hundred and forty-nine hours of classroom academic training.

Step IB: Interviews

Eleven F-35 pilots and instructors participated in semi-structured interviews focused on determining how training is operating currently, identifying where gaps or issues exist, and beginning to describe the true competencies and developmental learning that needs to occur to create optimal F-35 readiness.

Interviewees were chosen by their commanders or self-selected to participate in interviews focused on understanding their experiences during, creating, or delivering training to develop both pilots and future instructors. Questions were focused on understanding how training is conducted currently and where there are gaps in focus are or where support is needed. Understanding how training is conducted involves more than knowing the mechanics of how many lessons a trainee needs to experience or how many sorties they have to complete to be considered qualified and ready for the operational environment. Rather, it involves deeply understanding the mindset of instructors, the goals of each training experience, and the depth of understanding that trainees acquire through these experiences. The reason we need to better understand these elements that are not reflected in policy, doctrine, or formal training programs of instructional guidance is because while the requirements to attain readiness previously were more procedural in nature (e.g., how to fly the aircraft, how to complete a planned mission, or how to evacuate), in the future contested fight, the expectations of decision making under stress, creativity of solution development in real time, ambiguity tolerance, and more competencies will be required for readiness to be attained. Accordingly, the design and intent of training must alter to focus on additionally developing these skills beyond the current focus. Instructors already demonstrated success in teaching these skills can help inform policy and other instructional design requirements for the future to better meet the demands of the Air Force.

Through these interviews, substantive concepts, issues, concerns, and needs were noted. Specifically, five major concerns were reported: 1) **sorties** are tied to missions to learn but not necessarily explicitly tied to the competencies needed for the contested fight, 2) procurement of **technology** to enhance training is challenging due to security issues, 3) **what** to teach rather than how to teach is the focus of instructor training leaving instructors to devise their own strategies, 4) maintenance issues and collateral **duties** make training challenging and reduce readiness, and 5) **policy**, doctrine, and training aids don't provide the full range of authorities and guidance needed to be optimally successful.

Primary wins included the ability to train and maintain skills in both original F-35 pilots (those without other platform experience) and transfer pilots (those who learned to fly initially with another platform). Primary concerns were varied and include: 1) need to explicitly train meta-competencies that transcend skills-based learning (e.g., decision making processes), 2) need to train to fight versus focusing primarily on flight tactics and individual mission sets, and 3) need to create a more fluid and clear training pathway for each student-pilot. Primary requests included better training for instructors on how to help people learn most effectively, incorporate learning engineers in the training development cadre to improve train-the-trainer assets (programs of instruction) and pilot training elements, and expand the use of technology. The ability to better assess and understand the capabilities of individual airmen was also noted as important.

Step II: Competency Modeling

Robust competency models deliver objectively measurable levels of mastery across the three critical performance domains: knowledge, skills, and abilities (or "attitudes" in some training/learning literature). Therefore, the model must be structured to accurately reflect the relationships between each domain as well as the degree of mastery to which the learner predictably performs a task. In this type of model, students advance through mastery stages not by some subjective "better" performance, but by an objective progression of observable and measurable actions.

For example, figure 2 shows Bloom's revised taxonomy domains of cognitive, psychomotor, and affective learning (Bloom, 1994; Bloom et al., 1956) informed by Dreyfus & Dreyfus' (1980) five-stage mastery model (novice, competence, proficiency, expertise, mastery). Hanson, Spark, & Bockelman (2019) placed these constructs on a circumplex, allowing the KSAs to be measured toward advancing mastery, placing the basic performance levels centrally and extending outward in complexity. It is in the outer edge of the KSA circumplex that the most agile performance occurs, with the capacity to integrate new information and apply in novel contexts.

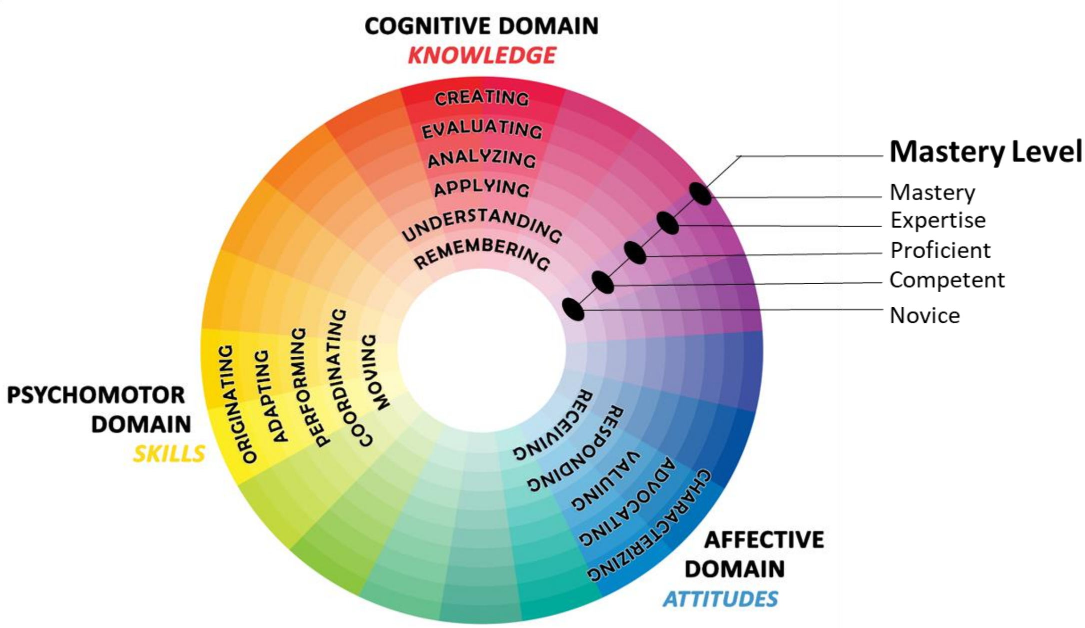

Fig. 2 KSA Circumplex (Reprinted with permission; Hanson, Spark, & Bockelman, 2019)

Initial Model Development: F-35 Competencies

Based on interviews and the review of the current training curriculum, 9 competencies were identified as necessary for the high-end contested fight of the future. In the next stages, these will be broken down into the KSAs needed to demonstrate these competencies. For the purposes of this paper, the initial model will be the focus. This is a substantive deviation from current training development practices that focus on mission rehearsal and task-based learning experiences. Rather, with this shift, we move the overall readiness measurement and associated training to be focused on the end goal of being able to navigate successfully with an overload of incoming data within a complex yet ambiguous and novel Night One. Table 1 provides the initial developmental breakdown of these competencies.

Through analysis of the data provided, five primary competencies and three sub-competencies focused on knowledge and capabilities were noted including airmanship skills (the ability to fly the aircraft in any time of weather or terrain), weapon system knowledge (Knowing your weapon system and how to employ it), emotional/physiological regulation (the ability to manage the self and body in flight), professionalism and the sub-competency of motivation (understanding what it means to be a professional pilot), and procedural effectiveness (Execute specific tasks correctly) and two sub-competencies: reaction time (aggressiveness/lack of hesitancy) and attentiveness (ability to maintain attention and awareness of surroundings).

At the next level of cognition, four primary and four sub-competencies were noted. Specifically, Strategic Awareness (Understanding both the big and the small picture) with two sub-competencies: Understanding commander's intent (knowledge of commander's goals and intentions) and Adversarial awareness (Know thy enemy); Cognitive Efficiency (Thinking quickly) with the sub-competency Cognitive Processing (Take in/process information); Decision making capability/Risk assessment (Deciding actions under high stress and ambiguity) with the sub-competency of critical thinking (ability to analyze data based on commander's intent and low bias), task prioritization (selecting task order based on mission goals while balancing risk and second-order effects).

Table 1. Competencies by Expertise Level

	Competency	**Expertise Level**				
		(1)	**(2)**	**(3)**	**(4)**	**(5)**
Knowing what to do	Airmanship skills	Imprecise and slow action	Recognizes aircraft capabilities and limitation; Memorizes terrain differences	Anticipates issues 50% of the time; Plans ahead	Works well with others; Coordinates for self and team; Flies with automaticity even under stress	Tight planning, tight action, accuracy and anticipating
	Weapon system knowledge	Awareness of the system	Memorizes how instruments work together; Aware of incoming data	Proficient in system knowledge; Can teach others basics	Fluid with the system; Connected with the aircraft in understanding and action	Knows every element of the system; Knowledge like a book
	Emotional/ physiological regulation	Surprised by physiological and emotional responses; negatively affects ability to focus, process, and make decisions	Aware of phys/emo responses; Reacts and adjusts to body's reactions but there is a delay	Anticipates affects; Takes anticipatory action to ensure continued safe flight	Includes phys/emo effects in planning process and instruction	Anticipates personal responses to situations and events; Compensates pre-emptively; Maintains clarity under stress

	Professionalism	Distracted; Unaware of risks; Focus can suffer; 'wings it'; talks versus listens	Follows orders but lacks seriousness and personal curiosity	Treats training and planning as a job; Balances work and home time; Treats training as mission preparation	Collaborates and leads as needed; Focuses on learning to ensure readiness for mission	Hungry to complete the mission; Focused; Serious
	Procedural Effectiveness	Follows procedures; Many errors; Slow to react; Slow processing	Follows procedures with confidence; Knows the actions to take but hesitates	Knows procedures well and completes them with speed and assurance; makes few errors	Follows flight procedures fluidly and also follows personally developed procedures to enhance effectiveness	Anticipate issues; Act before problems occur; Reduce negative impact
Knowing how to do it	Strategic Awareness	Operates in a personal bubble; Lack awareness of surroundings	Follows a pre-planned script; Struggles to deviate even when mission is threatened	Understands the field and mission intent beyond procedures; Adjusts with some hesitation as needed	Recognizes what's missing as well as observable problems	Constantly processing; Anticipates problem variables; Plans ahead; Acts efficiently and effectively
	Cognitive Efficiency	Assess all information and surroundings equally; slow to react; much "fog"	Memorizes what information is important and acts automatically based on preplanning reactions; reaction time quicker but adjustment hindered	Recognizes differences in importance and adjusts based on personal rubric; processing speed enhanced further and adjustment to unexpected events effective	Distinguishes important variables and processes quickly to act swiftly	Fluidly assesses current situations and compares them to past experience, mission goals, and strategic plans to act efficiently
	Decision making capability/Risk assessment	Reacts without a plan	Preplans missions; struggles to adjust when issues emerge	Preplans mission but includes contingency plans	Fluidly adjusts to unexpected issues but pulls from a limited set of experiences rather than creating solutions	Combines experience, strategic understanding, and level of risk to determine action and does so efficiently
	Task prioritization	All priorities are equal	Tasks are prioritized based on preplanned decisions	Tasks importance is decided in the moment but based on a preplanned rubric	Uses personal experience to determine priorities but is also limited to only book knowledge or personal experience	Knows when system, or mission, or safety takes precedence based on personal and others' experiences

NEXT STEPS

The next steps in the learning engineering process focus on breaking down these competencies into KSAs and then further into specific learning objectives. Based on that information, learning tasks, missions, and experiences can be designed and technology selected for enhanced learning and presentation modality. The benefit of this process is the clarity achieved in understanding not only what a trainee has seen or experienced but also understanding what they are capable of performing in a novel situation and their relative to self and others level of expertise in each area.

It is imperative that the instructional sequence allows for transfer of lessons learned to new environments, by scaffolding knowledge and skills to challenge learners to apply important tactical maneuvering principles in more complex situation. Further, the thresholds of "proficiency" need to be clear, consistent, and measurable. To prepare trainees for air-to-surface engagement it is imperative that the instructional tools support the capture and measurement of observable behaviors. To do so, the level of mastery (from novice to master) should be captured across each learning domain (KSA), providing accountability beyond vague objectives (such as “familiarity”). To ready instructors, advisors, and planners, the curriculum must include opportunities for trainees to demonstrate the appropriate mastery level in instruction, advising, and planning. The above mentioned efforts will fall short of maximum impact without investment in recruiting, developing, and placing expert instructors. The criteria for instructor pilots should be based both on the mastery of aviation as well as the mastery of instructional methods.

In complement, simulation training should be more broadly employed in a manner that (1) promotes cross-capabilities and multi-skilling, (2) captures formative and summative assessment data to drive personalized learning interventions, (3) targets decision-making during learning acquisition as well as evaluation, and (4) provides application of KSAs to various contexts and parameters. This would provide more robust instructional resources for training personnel as well as higher rates of learning transfer from classroom to air missions.

CONCLUSION

The present research highlights a shift in approach to training design and development. The learning engineering method focuses more on the end-state of the pilot-trainee and which competencies the airman will need to be successful in the future fight as opposed to completing a series of simulated missions with the assumption that they will be replicated in theater. As the USAF adjusts to this process, editing policy will be a high priority. Without such prioritization, resources cannot be allocated appropriately. A program of record would allow for immediate and productive cross-program coordination among data science, infrastructure, cybersecurity, learning science, and instructional design. Failure to establish this would maintain status quo, continue silos of disparate and finite information, and fall short of integrating instructional lessons learned.

REFERENCES

Bloom, B. (1994). Reflections on the Development and Use of the Taxonomy. In Anderson, L. Sosniak, L (Eds.) Bloom’s Taxonomy: A Forty-Year Retrospective. Chicago: The National Society for the Study of Education, pp.1-8.

Bloom, B., Engelhart, M., Furst, E., Hill, W., & Krathwohl, D. (Eds.) (1956). Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain. New York: David McKay.

Dreyfus, S. E., & Dreyfus, H. L. (1980). *A five-stage model of the mental activities involved in directed skill acquisition*. California Univ Berkeley Operations Research Center.

Goodell, J., Kessler, A., Kurzweil, D., Koldner, J. (2020.) Competencies of Learning Engineering Teams and Team Members. In IEEE ICICLE proceedings of the 2019 Conference on Learning Engineering, Arlington, VA, May 2019.

Goodell, J., Kessler, A., Wiltrout, M. E., & Avello, M. (2021, June). Learning Engineering@ Scale. In Proceedings of the Eighth ACM Conference on Learning@ Scale (pp. 5-7).

Hanson, R., Spark, S., & Bockelman, P. (2019) Strategies for Tackling Learning Modernization Challenges. DevLearn 2019, Las Vegas,NV.

Naeve, A., Nilsson, M., Palmér, M., Wessblad, R., Lindegren, M., Lytras, M., ... & Pappa, D. (2005). A Conceptual Approach to Studying the Learning Process-with a Special Focus on Knowledge Creation.

Pope, C. (March, 2022) *Kendall details ‘Seven Operational Imperatives’ & how they forge the Future Force*. https://www.af.mil/News/Article-Display/Article/2953552/kendall-details-seven-operational-imperatives-how-they-forge-the-future-force/

Schatz, S. & Walcutt, JJ (2022). The Future World with Learning Engineering: A Story in Goodell, J., & Kolodner, J. (Eds.). (2022). Learning Engineering Toolkit: Evidence-Based Practices from the Learning Sciences, Instructional Design, and Beyond (1st ed.). Routledge. https://doi.org/10.4324/9781003276579

Walcutt, J. & Schatz, S. (2019). Modernizing Learning: Building the future learning ecosystem. Office of the Secretary of Defense.