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Operational Camouflage Pattern Case Study

3 July 2018

Dr. Robert F. Mortlock, Lecturer

Graduate School of Business and Public Policy

Naval Postgraduate School

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Acquisition Research Program
Graduate School of Business & Public Policy
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Table of Contents

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List of Figures

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Executive Summary

The protection of American soldiers in combat was a top priority for senior leaders in the U.S. Army, the DoD, and Congress. Camouflage on combat uniforms remained the most important contribution to the overall concealment of individual soldiers on the battlefield. Post-combat surveys from soldiers in Iraq and Afghanistan indicated that better camouflage on combat uniforms contributed to increased combat effectiveness. Soldiers recounted combat missions in which they were close enough to the enemy to hear conversations without being seen. This contributed to the tactical combat dominance of U.S. soldiers. Basically, the enemy cannot kill what they cannot see. Effective combat uniform camouflage remained a significant combat multiplier for soldiers—increasing mission accomplishment.

Army soldiers in Afghanistan faced diverse battlefield operating environments in combat operations. During a single mission, soldiers faced different terrains across various environmental backgrounds. Soldiers who wore combat uniforms and equipment with the universal camouflage pattern (UCP), a three-color digital pattern adopted by the Army in 2005, did not effectively blend into the diverse backgrounds that were typical during combat missions. The UCP colors were not earth tone and were generally too bright, making soldiers easy to detect and providing ineffective concealment. To specifically address combat operations in Afghanistan, the Army selected a commercially available camouflage pattern called MultiCam© to be used on uniforms and equipment for deploying soldiers to Afghanistan. The Army named the commercially available MultiCam© pattern as the Operation Enduring Freedom Camouflage Pattern (OEF CP). In the meantime, the Army focused on a long-term camouflage strategy for soldier uniforms and equipment that would be effective across the diverse military operating environments and considered a family of three camouflage patterns—one suited for the woodland/jungle environments, one suited for desert/arid environments, and a transitional pattern suited for most other environments.

This combat uniform camouflage case study encourages critical analysis of the Army's combat camouflage uniform project at two key decision points. The case focuses on the development, testing, and procurement (also referred to as acquisition) of combat camouflage uniforms and equipment for U.S. Army soldiers. The case is interesting not only to project management (PM) professionals but also to warfighters who appreciate the importance of effective concealment for mission accomplishment and safety. Key project stakeholders are passionate about camouflage because it saves lives in combat, and all soldiers consider themselves subject matter experts on uniforms and camouflage—resulting in wide applicability. Decisions involved with the Army camouflage uniform effort involve a complex acquisition environment—requiring decision-making under uncertainty with consideration for performance, schedule, cost/affordability, legal risk, public perception, and congressional oversight. The combat uniform case study reinforces critical thinking in uncertain environments, documents lessons learned for sound PM for future application, and provides wide private-sector exposure to the complexities of public-sector acquisition and camouflage uniform development, testing, and manufacture in particular.

The case study data enables readers to become familiar with the history of Army combat camouflage uniforms, the basics of combat uniforms in general, and camouflage testing in particular. Readers of the case analyze alternative strategies for the Army path at two critical decision points. Both decisions involve critical thinking, stakeholder management, decision-making with uncertainty, and strategic leadership by focusing on the development of recommendations that decision-makers can use to make the most informed decision possible.

This case study centers on the U.S. Army's decision to change the camouflage patterns on combat uniforms and equipment not only for soldiers stationed in war zones around the world but also for soldiers in daily garrison operations stateside. The case is in two distinct parts. Part I allows PM professionals to analyze how to recommend a path forward to senior leaders with an increased chance of success in meeting desired objectives. Part II allows PM professionals to

analyze how to recommend a set of options or courses of action for senior leaders to enable an informed, knowledge-based decision.

The case study has the following learning objectives:

- Develop the ability to critically analyze a project at key decision points by identifying advantages and disadvantages of various courses of action—**critical thinking**.
- Identify key stakeholders and understand their perspectives—**stakeholder management**.
- Develop a method to compare alternative strategies or courses of action for the decision-maker and defend a recommendation—**decision-making with uncertainty or ambiguity**.
- Compare alternative strategies and identify decision criteria used for the comparison—**decision-making with uncertainty or ambiguity**.
- Identify second-order considerations or consequences of the recommended strategies—**strategic management/leadership**.

Additionally, the case study emphasizes the following project management knowledge modules that are based on best practices from commercial industry and form the basis for the project management book of knowledge (PMBOK):

- Project Management Principles
- Project Phases and Processes
- Project Resource Management
- Project Scheduling
- Opportunity and Risk Management
- Business Analysis & Requirements Management
- Project Leadership
- Identifying and Engaging Stakeholders
- Business and Commercial Aspects of Projects
- Governance in Projects

Part I (Path Forward, Development of a Strategy, Fall 2013) of the case study focuses on the Army program manager as he prepares for meetings in the Pentagon

after learning that the original Army contracting strategy has hit a roadblock. The following are key questions to be addressed:

- Who are the key stakeholders in combat camouflage uniforms?
- Who is the ultimate decision-maker?
- How relevant was the test paradigm shift in this decision?
- What is a realistic test and evaluation strategy and schedule leading to decision in terms of key program and testing events planned by quarter?
- What options should the Army consider?
- What criteria should the Army use to compare options and then select the best path forward?

A key program management fundamental lesson learned from this part of the case includes not rushing to failure. Senior leaders and PMs must try to avoid the pitfalls of making rash decisions because the situation seems urgent. In this part of the case, it is probably best for the Army to take a strategic pause to let the Congressional language become final, and allow time to test additional patterns for which the government has data rights to avoid long-term affordability challenges.

Part II (Camouflage Decision, Winter 2013/Spring 2014) of the case focuses again on the Army PM as he presents the testing results to Army senior leaders to support a path forward. The following are key questions to be addressed:

- Was the $10 million spent over six years in the research, development, and testing of camouflaged uniforms a wise investment for the Army?
- Were the options considered by the Army appropriate? Were other viable options not considered?
- Was the source of funding (contingency funds or base budget funds) an important consideration? Why or why not?
- What were the affordability considerations for the Army in this decision?
- What were the important contractual and legal considerations in this decision?
- How should the Army compare the options and select the best path forward?

Some of the key program management fundamental lessons learned from this part of the case include the realization that even though performance and

schedule are important, sometimes the preferred path forward must be decided by other criteria. PMs must bring together the information for the most informed decision possible. In this case, the PM has to understand the affordability/cost implications, legal risk, and the perspectives of key stakeholders including Congress, soldiers, U.S. Marine Corps, and the media.

"The rest of the story," or what the Army actually did, can be studied not to provide the "right answer," but to provide closure for readers. Many paths often lead to similar end results for acquisition development programs. The case study itself provides the epilogue to the first key decision on how the Army proceeded when the strategy hit the contracting barrier. For the second key decision point, the Army selected a pattern and named it the Operational Camouflage Pattern (OCP) to emphasize that the pattern's reach extends beyond Afghanistan to other Army military operating environments. Because the alternative camouflage patterns all tested similarly, the decision came down to other considerations. The digital patterns that were based on the U.S. Marine Corps patterns (MARPATs) were never seriously considered because Army senior leaders were concerned about the following three things: strict literal compliance to the restrictions in the Fiscal Year (FY) 2014 National Defense Authorization Act (NDAA), the backlash from the U.S. Marine Corps leadership (who did not favor the Army leveraging the MARPATs), and the soldier/public perception of the Army choosing another "digital" pattern after the tepid response to the UCP adoption. The OEF CP pattern was not chosen because of affordability concerns. The Army accepted the 10% licensing fees on all camouflaged uniforms and equipment for Afghanistan in OEF CP because funding for Afghanistan operations came from overseas contingency operations accounts and not from the Army's base budget funding. Transitioning the entire Army to a different camouflage pattern for use in both garrison and deployments is a completely different effort (orders of magnitude larger in scale) than fielding uniforms and equipment to soldiers for one particular operation. The Army spends approximately $39 million per month maintaining uniforms and equipment of approximately one million active duty, reserve, and National Guard soldiers. Ten percent licensing fees of $3.9 million per month in perpetuity were obviously

unacceptable and unaffordable. The camouflage pattern vendor claimed that they did not control the 10% premium paid by the Army for OEF CP patterned uniforms and equipment. At the same time, they claimed they could reduce the fees to the 1% level. The Army could not trust the vendor—if they didn't control the fees, how could they reduce them? Choosing OCP resulted in soldiers' benefiting from an effective camouflage pattern and the nation benefiting from the best use of limited resources. The Army continues to work on improving the force protection and concealment of soldiers through more effective camouflage for uniforms and equipment. Specifically, the Army is considering camouflage tailored for woodland/jungle and desert/arid military operating environments.

Current Situation, October 2013

Colonel Bob Smith sat in his office at Fort Belvoir in total disbelief as he read an email from the contracting officer stating that a contract for the Army to purchase the camouflage pattern had never actually been accepted by the contractor. The email came after Colonel Smith asked the contracting officer to send a copy of the signed contract. The contracting officer's response was delayed by several weeks because Department of Defense (DoD) agencies were resuming normal operations after being shut down October 1–16, 2013, with most federal employees furloughed, because neither an appropriation act nor a continuing resolution had been enacted for FY 2014. On the Friday afternoon before the shutdown, the contracting office reported the successful award of a contract to Crye Precision LLC for their camouflage pattern, commercially known as MultiCam©. Because of significant Army senior leader and congressional interest, notification of the contract awarded was documented in significant activities reports to the chief of staff of the Army (CSA) and secretary of the Army (SecArmy) levels.

Now, Colonel Smith thought about how to notify the Army senior leaders that the contract had not been awarded and that his team would have to develop options for the Army to consider going forward—both of these tasks were significant events considering the importance of the Army combat uniform camouflage decision. The Army had completed the extensive combat uniform camouflage testing—testing that began in 2009 with reviews and a decision process that finally resulted in the selection of an acceptable camouflage pattern for Army combat uniforms. Colonel Smith started to consider all the information needed to help Army senior leaders make an informed decision: the importance of camouflage to soldier force protection and mission effectiveness, camouflage testing basics, the history of the testing program, the status of soldier combat uniforms, and the affordability aspects of the decision. First things first—Colonel Smith asked his deputy to immediately draft a notice to inform senior leaders that the previously announced award of the contract was premature.

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Background

It's Only Camouflage—How Important Can It Be on the Modern Battlefield?

The protection of American soldiers in combat was a top priority for senior leaders in the U.S. Army, DoD, and Congress. The DoD had committed considerable resources and funding over the years in research and development, resulting in advanced materials and manufacturing processes. These investments increased the combat effectiveness of the soldiers and their units. The force protection of soldiers was considered as a layered approach. The outer force protection layer for soldiers was situational awareness. The inner force protection layer was personal protective equipment, like helmets and ballistic vests with ceramic plate inserts. The middle force protection layer was concealment. Camouflage on combat uniforms remained the most important contribution to the overall concealment of individual soldiers on the battlefield. Reinforcing the importance of camouflage was the result of post-combat surveys from soldiers from duty in Iraq and Afghanistan, in which the majority of soldiers indicated that better camouflage on combat uniforms contributed to increased combat effectiveness. Anecdotal evidence from soldiers on the importance of camouflage came from recounted combat missions in which they were close enough to the enemy to hear conversations without being seen—particularly during night operations. This contributed to the dominance of U.S. soldiers and the "we own the night" tactical advantage of U.S. forces. Basically, the enemy cannot kill what they cannot see. Effective combat uniform camouflage remained a significant combat multiplier for soldiers—increasing mission accomplishment.

Army soldiers in Afghanistan faced diverse battlefield operating environments in combat operations (see Figure 1). During a single mission, soldiers faced many different terrains across various environmental backgrounds. Each of these environmental backgrounds contained different earth-tone colors, which required different matching earth-tone colors in the combat uniform for it to effectively conceal

a soldier from detection and/or observation. Soldiers who wore combat uniforms and equipment with the universal camouflage pattern (UCP), a three-color digital pattern adopted by the Army in 2005, did not effectively blend into the diverse backgrounds that were typical during combat missions. The UCP colors were not earth tone and were generally too bright—making soldiers easy to detect and providing ineffective concealment.

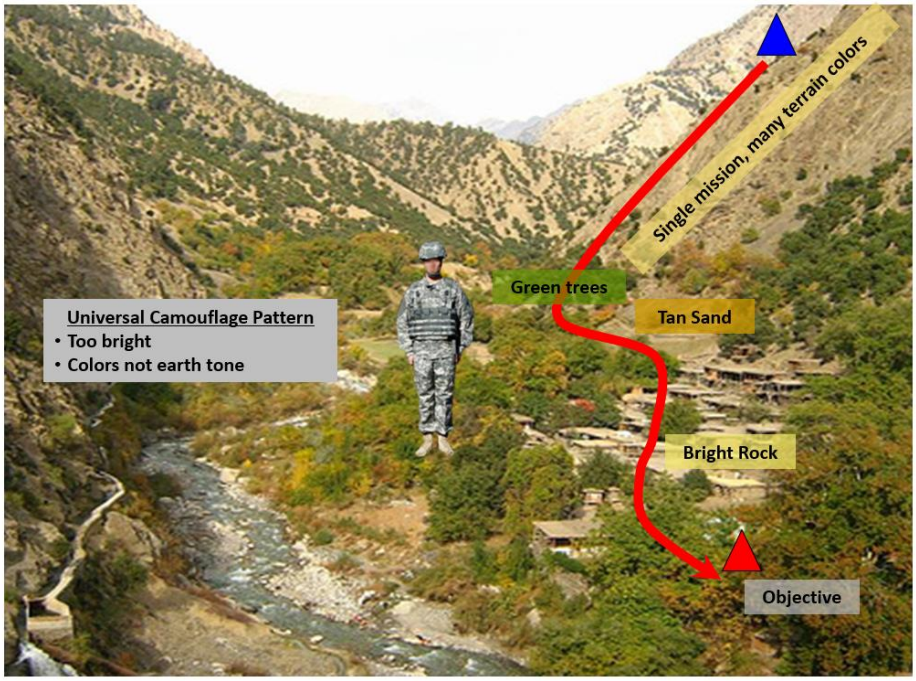


Figure 1: Why the Army Needed a Different Camouflage Pattern

The Army faced a critical question with respect to providing soldiers with effective camouflage on combat uniforms and equipment—how many camouflage patterns should be adopted? Soldiers operating in diverse operating environments have proven that the most effective camouflage pattern matches the colors of the background environment. A “chameleon” camouflage pattern eluded the Army due to low technological maturity level—basically it was just not feasible to have a combat uniform with chameleon camouflage that would change color on its own to fit into its environment. Logistical and affordability considerations limited the Army from adopting a specific camouflage pattern for every combat environment. The Army settled on a strategy considering three camouflage patterns—one suited for the

woodland/jungle environments, one suited for desert/arid environments, and a transitional pattern suited for most other environments. In support of the combat uniform camouflage effort, the Army initiated an assessment of terrain throughout the globe. The Army Corps of Engineers classified the Army military operating environments across the combatant commands as 44% transitional, 37% woodland/jungle, and 19% desert/arid environments. A woodland camouflage pattern would be very effective against backgrounds of darker brown and green colors and ineffective in dry arid regions (see Figure 2). On the other hand, a desert camouflage pattern would be very effective against backgrounds of lighter tan/sand colors and ineffective in woodland/jungle terrains. Finally, a transitional camouflage pattern would provide reasonable concealment against a broad range of environmental backgrounds. Seasonal considerations break down the woodland/jungle and transitional backgrounds even further to dormant (without leaves on trees) and verdant (with leaves on trees) classifications.

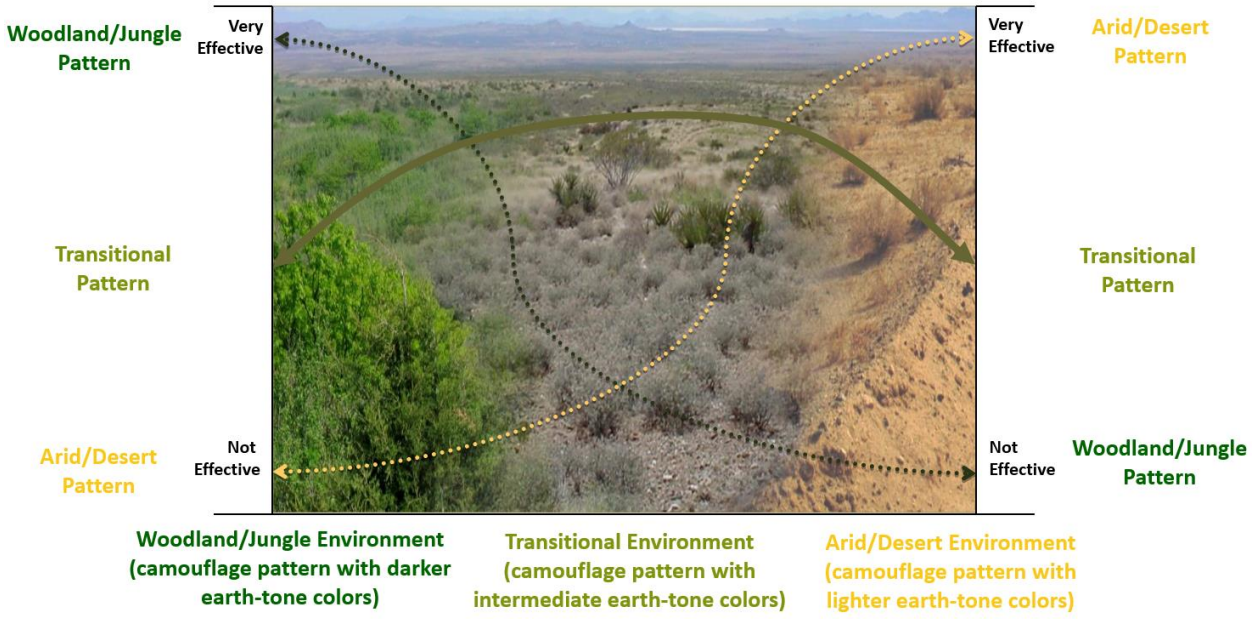


Figure 2: Effectiveness of Camouflage Patterns in Different Environments

Camouflage Testing Basics

The Army recognized that advancing the science of combat uniform camouflage testing was vitally important to enabling knowledge-based decisions on the most effective camouflage pattern. It was acknowledged that it was unaffordable to field-test various camouflage patterns in every possible environment and background. To gain a statistically robust data set to support decision-making, the Army developed a test and evaluation strategy that involved a paradigm shift (see Figure 3). The strategy leveraged four mutually supporting lines of effort. Technical development testing consisted of photo simulation for pattern selection and spectral reflectance measurements for performance insights. Operational field-testing with soldiers consisted of static observation tests for pattern performance confirmation and maneuver tests for both pattern performance confirmation and operational insights.

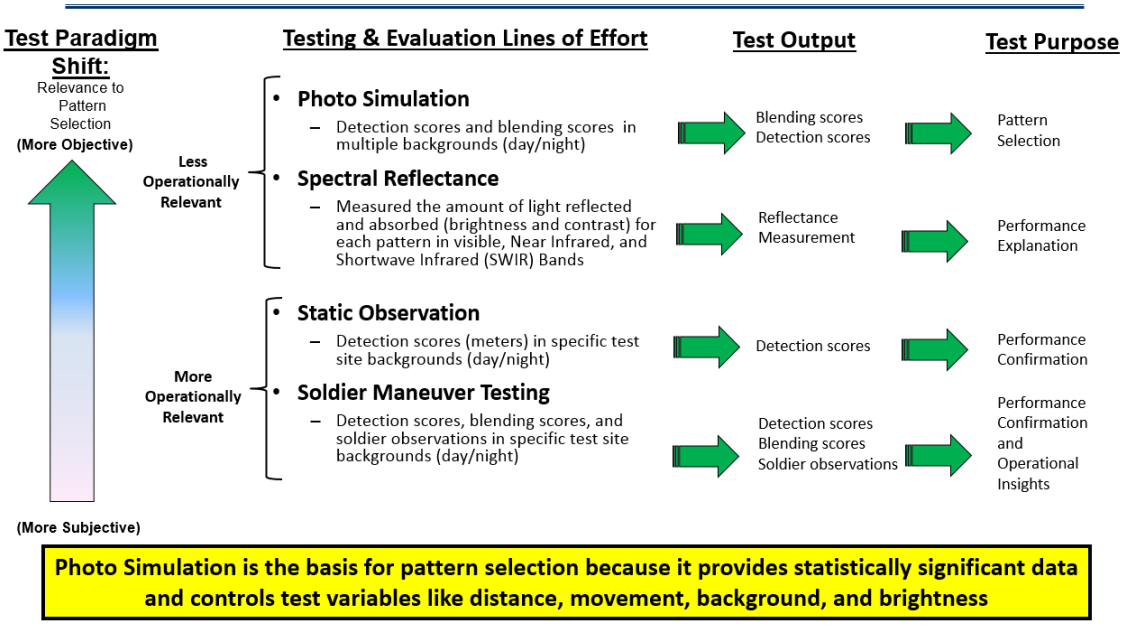


Figure 3: Camouflage Test and Evaluation Strategy

Normally, operationally realistic field-testing carried the most weight in decision-making over less operationally realistic developmental testing, which might rely on modeling and simulation. For camouflage testing, however, a much more extensive data set could be obtained if computer-based testing techniques were used in which soldiers observed photos of soldiers in camouflaged uniforms in many different backgrounds representing the Army's diverse military operating environments. The main effort for the test and evaluation strategy centered on the use of photo simulation to compare the effectiveness of camouflage patterns.

Two different criteria existed to compare the effectiveness of camouflage: detection and blending. Camouflage testing determined detection and blending scores for various camouflage patterns in relevant military operating environments. Detection is the ability to pick out the camouflage pattern measured at different distances, and blending is how well the camouflage pattern matches the background once detected at a specific range. Photo simulation evaluations allowed for collection of significant data in many backgrounds and controlled variables (such as distance, movement, background, and brightness) so the difference in detection and blending scores could be attributable to different camouflage patterns. The word *simulation* referred to the fact that the technique simulated soldiers being outside at the various sites by looking at computer screens of photos of soldiers in camouflage uniforms. Camouflage pattern selection criteria was based on both detection scores (at ranges to 450 meters during the day and to 250 meters at night) and blending scores (at 50 meters during the day and at 25 meters during the night). (Refer to Appendix 1 for a more detailed explanation of combat uniform testing basics.)

A Basic Overview of Army Combat Camouflage Uniforms

After basic initial entry training, the Army issued to soldiers uniforms and other essential combat equipment, classified as organization clothing and individual equipment (OCIE) and generally referred to as the soldier's clothing bag. Part of this issue to soldiers was the army combat uniform (ACU). The ACU was the uniform that soldiers wore in daily garrison operations when not deployed to combat operations. The ACU fabric was a 50-50 mix of cotton and nylon, and came with the

universal camouflage pattern (UCP), selling in the Military Clothing Store for about $90 for a coat and trouser set. After they wore out, soldiers used their clothing replacement allowance to buy new sets of uniforms. Examples of OCIE included the seven-layer Generation III Extended Cold Weather Clothing System (ECWCS), the field pack or rucksack (part of the modular lightweight load-carrying equipment [MOLLE]), and the ballistic vests (part of the improved outer tactical vests [IOTV])—all issued with the UCP.

Beginning in mid-2005, the Army recognized the importance of protecting soldiers from battlefield hazards and included specific uniform requirements for protection against insects (resulting in permethrin treatment) and fire or flame (resulting in flame-resistant fabrics).

When soldiers deployed to combat, the Army issued soldiers the Flame Resistant Army Combat Uniform (FRACU) with the UCP. The FRACU was made of 65% rayon, 25% para-aramid, and 10% nylon. The price of a FRACU set of coat and trousers averaged about $180. Additionally, soldiers received the Flame Resistant Environment Ensemble (FREE)—the FR version of the ECWCS. Soldiers did not normally deploy with the clothing bag–issued ACU and ECWCS—those were for daily wear in garrison operations and in training. In 2011, the Army issued to soldiers deploying to Afghanistan for Operation Enduring Freedom (OEF) the FRACUs and OCIE with the OEF Camouflage Pattern (OEF CP).

Figure 4 displays a pictorial representation of the uniforms soldiers would typically have worn in the summer of 2013 around the world. Soldiers wore the ACU with UCP in most regions of the world, except in the Middle East. Soldiers wore the FRACU with UCP when deployed from combat operations in Iraq and Kuwait, while soldiers supporting combat operations in OEF wore the FRACU in OEF CP.

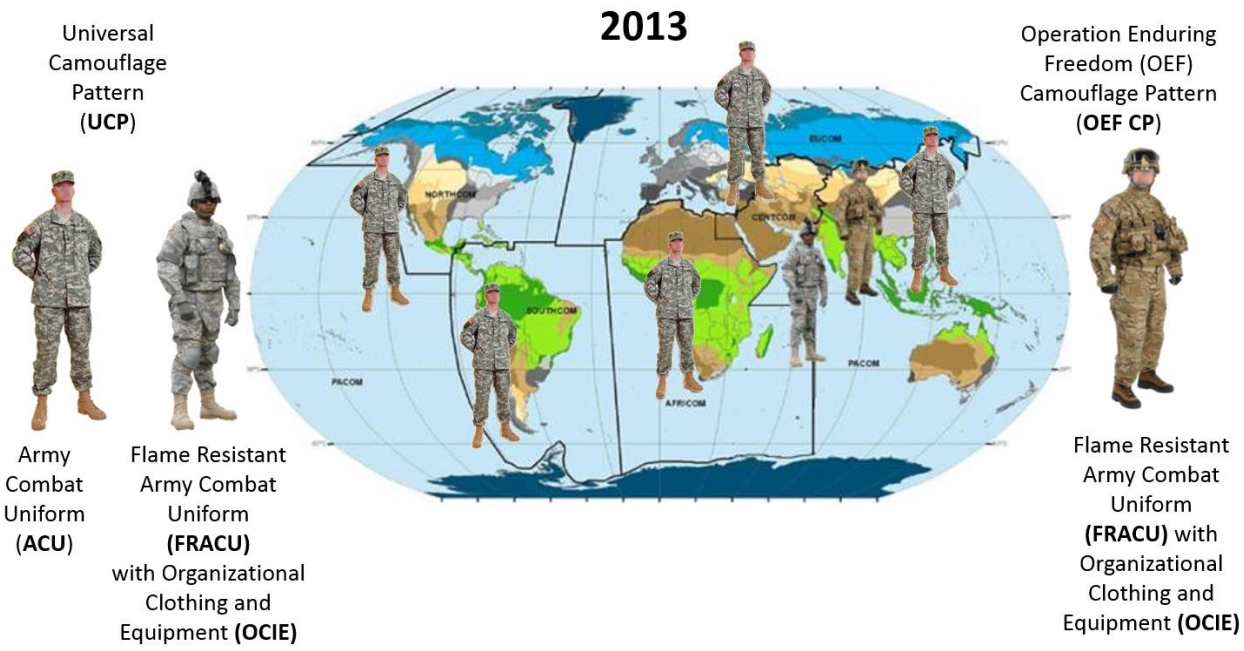


Figure 4: Common Operation Picture for Army Combat Uniforms

The Army remained very cognizant of the value of the combat uniforms and OCIE worn by soldiers and in the inventory. For example, based on the number of active, reserve, and National Guard soldiers both non-deployed and deployed, the ACUs worn by soldiers in their clothing bag valued about $131 million and turned over every year. The value of OCIE worn by soldiers or in inventory with UCP totaled about $3.5 billion and turned over every five to 10 years depending on the durability of the items. Deploying soldiers to Iraq and Kuwait had another $170 million worth of UCP uniforms and OCIE. Uniforms and OCIE with the UCP totaled over $3.8 billion in value (see Figure 5). To support soldiers deploying to Afghanistan, the Army maintained uniforms and OCIE with the OEC CP with a value of about $1.4 billion. Based on the average monthly demand, the Army spent approximately $39 million per month sustaining UCP uniforms and OCIE from the Army base operations and maintenance budget for an Army of approximately one million soldiers (active, guard, and reserve components).

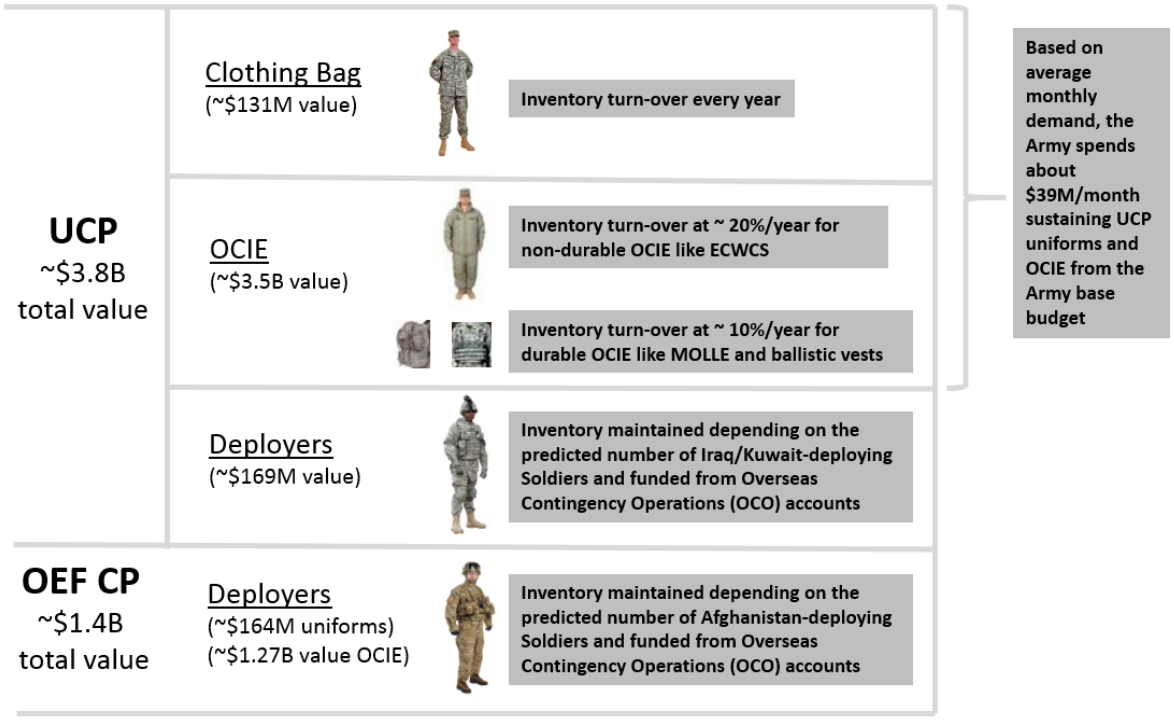


Figure 5: The Value of Camouflaged Army Combat Uniforms and Equipment

Army Combat Uniform Evolution

Figure 6 presents a brief recent history of Army combat uniforms since the adoption of the Army Combat Uniform (ACU) with the Universal Camouflage Pattern (UCP). In 2005, the Army adopted the ACU to replace the Battle Dress Uniform (BDU) with the woodland camouflage pattern and Desert Camouflage Uniform (DCU) with the desert camouflage pattern. The ACU was produced with the UCP—a three-color (urban gray, desert sand, and foliage green) digital pattern. The Army wanted a single combat uniform design with a single camouflage pattern. Field camouflage tests at Fort Lewis, WA; National Training Center at Fort Irwin, CA; and Joint Readiness Training Center at Fort Polk, LA, confirmed the following:

- In woodland environments, the ACU was equally effective as the BDU.
- In a desert environment, the ACU was close to as effective as the DCU.
- In an urban environment, the ACU was equally effective as the BDU or DCU.

Additionally, in camouflage blending tests (day and night) using photo simulation techniques, UCP provided the best average performance across desert, woodland, and urban environments compared to 10 other patterns. These patterns were Marine Pattern (MARPAT) Desert, MARPAT Woodland, Scorpion (a pattern developed by Crye Precision LLC under a contract with the Army), Desert Brush, Desert Track, Desert/Urban Track, Standard Desert (DCU), Woodland Track, Standard Woodland (BDU), and Woodland Brush. The Army's decision to adopt a digital pattern (UCP) was influenced by the success of the U.S. Marine Corps digital patterns—MARPAT Woodland and MARPAT Desert. Ultimately, in testing, UCP provided better or equal concealment than other patterns in urban and desert terrains—obviously very important to the Army embroiled in combat operations in Iraq.

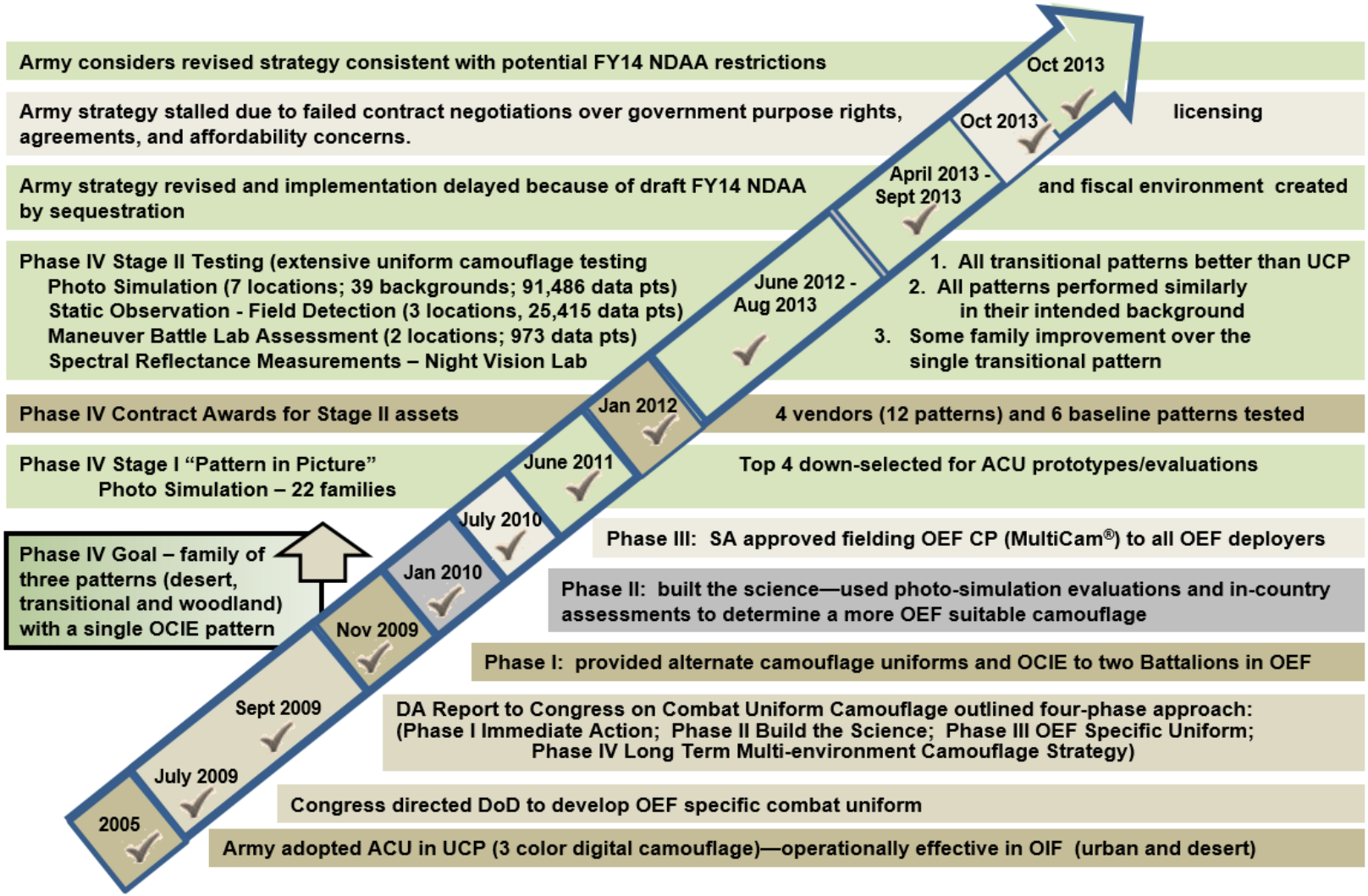


Figure 6: Army Camouflage Uniform Timeline

From after the adoption of the ACU in 2005 until 2009, the Army received overwhelmingly negative feedback from soldiers in combat operations in Afghanistan about the suitability of the FRACUs in UCP for the diverse Afghan backgrounds, terrains, and environments (see Figure 1). As a result, in the FY 2009 Supplemental Appropriations Act, Congress directed the Army to take immediate action to provide effective camouflage for personnel deployed to Afghanistan. In September 2009, the Army submitted a report to Congress on combat uniform camouflage that outlined a four-phased approach: Phase I Immediate Action, Phase II Build the Science, Phase III OEF Specific Camouflage, and Phase IV Army Combat Uniform Decision for a Long Term Multi-Environment Camouflage.

In November 2009, the Army completed Phase I by fielding two Army battalions (approximately 2,000 soldiers) with uniforms and OCIE in two different patterns. One camouflage pattern was Universal Camouflage Pattern-D (UCP-D)—a variant of UCP with coyote brown color added and less sand color—and the other pattern was commercial camouflage called MultiCam© produced by Crye Precision LLC. MultiCam©—a seven-color pattern that was in use at the time with U.S. Special Forces in Afghanistan—was a variation of the original Scorpion pattern considered by the Army earlier in the UCP decision.

From November 2009 to January 2010, the Army conducted Phase II, which involved soldier feedback of the two fielded patterns (MultiCam© and UCP-D) as well as photo simulation (pattern-in-picture) evaluations by soldiers of six camouflage patterns (UCP, MultiCam©, UCP-D, Mirage, Desert Brush, and a Navy pattern referred to as AOR2), inserted into photographs of eight different OEF sites. Soldiers overwhelmingly preferred both MultiCam© and UCP-D with an edge in preference toward MultiCam©. The photo simulation involved assessments of both the detectability (range at which pattern was detected) and blending performance (qualitative measure of how well the pattern blends into background). MultiCam© was harder to detect and blended slightly better than the other five camouflage patterns.

In February 2010, initiating Phase III, the Army selected MultiCam© as the pattern to be used on the Fire Resistant ACU (FRACU) and Organization Clothing and Individual Equipment (OCIE) for deploying soldiers to Afghanistan. The Army named the commercially available MultiCam© pattern as the OEF Camouflage Pattern (OEF CP). Because schedule and speed of delivery was critical, the Army encouraged Crye to enter separate licensing agreements with the companies that printed the OEF CP on FRACUs and OCIE. In July 2010, the Army began fielding uniforms and OCIE in the OEF CP to deploying OEF soldiers. The Army was not privy to the specifics of the licensing agreements. However, the Army ended up paying about a 10% premium on every uniform or piece of camouflaged equipment that was camouflaged with OEF CP compared to uniforms and equipment with UCP. At the time, schedule and getting updated camouflaged uniforms and equipment to field as quickly as possible trumped affordability concerns—especially considering that uniforms for combat operations in Afghanistan were funded by overseas contingencies operations (OCO) accounts without the restrictions placed upon spending that is part of the Army's base budget.

In December 2010, the Maneuver Center of Excellence (MCoE) outlined an 18-month-long competitive effort to lead a camouflage integrated product team (IPT) through the Phase IV effort for the Army's selection of the long-term combat uniform and OCIE camouflage strategy to be effective in desert/arid, transitional, and woodland/jungle environments. The goal was to present the results to Army leadership in the fall of 2012 for a decision.

From January 2011 to June 2011, the Army scoped the Phase IV camouflage effort. Based on work performed by the Natick Soldier Research Development & Engineering Center (NSRDEC) completed in 2009, the Army knew that environmentally specific camouflage patterns outperformed (meaning provided more effective concealment) a single "universal" pattern. The objective of Phase IV was to develop a "family" of three uniform camouflage patterns with a single coordinated pattern for OCIE to provide effective concealment across the globe in woodland/jungle, transitional, and desert/arid environments. A total of 22 family submissions from industry and the government competed in the first stage of Phase

IV—18 family submissions were found to be technically acceptable. These families of patterns participated in “pattern in picture” blending photo simulation evaluation. The patterns were judged based on the best legacy patterns in the Defense Department inventory (desert vs. a Navy pattern called AOR1, transitional vs. OEF CP, and woodland vs. a Navy pattern called AOR2) with family scores equally weighting the woodland, transitional, and desert environments. Five families of patterns (four commercial vendors and one NSRDEC submission) performed as well as or better than the legacy family of patterns. The four down-selected vendors included Crye Precision LLC, Kryptek Inc., Atlantic Diving Supply (ADS) Inc., and Brookwood Companies Inc. It is noteworthy that three patterns were visually similar in appearance: OEF CP (a baseline pattern), the transitional pattern proposed by Crye, and the transitional pattern submitted by NSRDEC named ScorpionW2. Each of these patterns was developed, changed, and optimized independently from the same base pattern called Scorpion—a pattern developed by Crye in the early 2000s under contract with the U.S. Army (see Appendix 2 for a description of the relationships and differences between the Scorpion, MultiCam© [OEF CP], Phase IV Crye transitional, and ScorpionW2 camouflage patterns). All three patterns performed similarly in testing, which served as a built-in, internal verification of the validity of the testing. At the time, even though the NSRDEC family performed well in source selection pattern-in-picture photo simulation testing, the Army decided not to continue to allow the NSRDEC family of patterns to participate in Stage II Phase IV testing because the family of patterns was not of consistent matching geometric shapes—one of the criteria established by the Army and required in the contracts with the four commercial vendors.

In January 2012, Phase IV contracts were awarded to the four down-selected vendors to produce fabric for test articles (both uniforms and OCIE) for the second stage of Phase IV, which would include field testing, extensive photo simulation evaluations, and lab testing. The contracts with each of the four vendors were firm fixed price (FFP) contracts, with periods of performance not to exceed 30 months to supply the Army with 1,000 yards of fabric to be used by the Army to fabricate testing uniforms and OCIE under separate “cut & sew” contracts. The contracts

included FFP options for the government to procure the nonexclusive license rights for each of the proposed camouflage patterns. The competitive range to buy the license rights from the four vendors for a single camouflage pattern ranged from $25,000 to $2.1 million. Crye offered the set of patterns for $600,000 ($200,000 each for three patterns—woodland, desert, and transitional/OCIE), ADS offered the set for $533,000 ($133,000 each for four patterns—woodland, desert, transitional, and OCIE), Brookwood offered the set for $100,000 ($25,000 each for four patterns—woodland, desert, transitional, and OCIE), and Kryptek offered the set for $6.3 million ($2.1 million each for three patterns—woodland, desert, and transitional/OCIE). Each of the four vendors signed a nonexclusive license agreement that provided the Army the option to obtain (for a single lump sum) the rights to use the material for the production of patterns for printing on an unlimited number of uniforms, individual equipment, and unit-level equipment for U.S. government purposes (e.g., Army, Navy, Marine Corps, Air Force, and Coast Guard, including their active and reserve components) excepting foreign military sales with successive renewable 10-year periods.

From July 2012 to March 2013, the Army conducted the most extensive uniform camouflage testing ever undertaken. The 12 commercial vendors' patterns (each of the four vendors had a woodland, transitional, and desert pattern along with a matching transitional OCIE pattern) and six reference patterns (UCP, OEF CP, MARPAT-W, MARPAT-D, AOR1, and AOR2) were printed on fabric, and the fabric was assembled into uniforms and OCIE (see Figure 7).

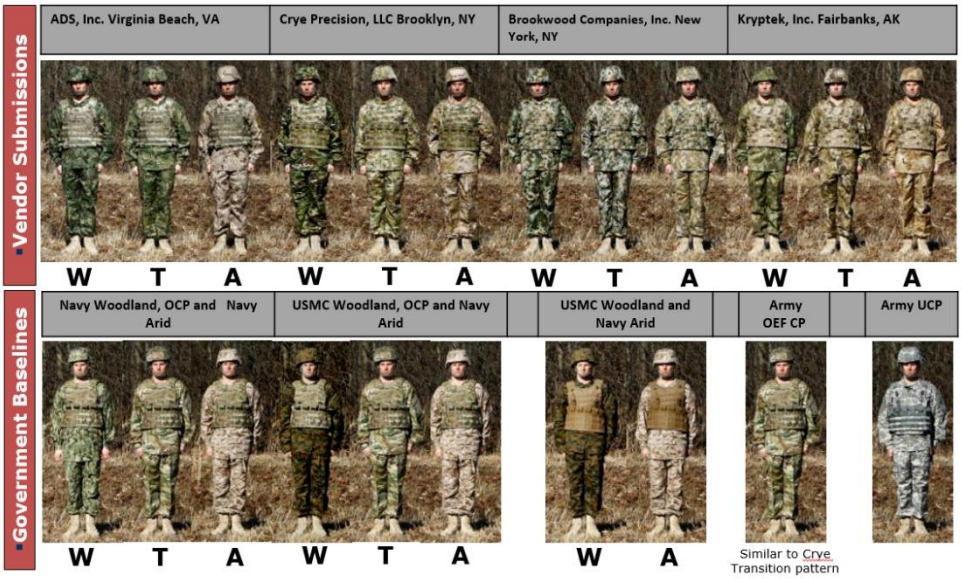


Figure 7: Phase IV Camouflage Patterns Tested (note that W refers to woodland, T refers to transitional, and A refers to arid)

The photo simulation evaluations collected 91,486 data points in detection and blending tests (both day and night) using 39 different backgrounds from seven global locations. Field tests for static observations detections were conducted at three different locations, resulting in the collection of an additional 25,415 data points. Operational field tests with force-on-force soldiers were conducted at two locations, gathering another 973 data points. Finally, the spectral reflectance measurements were conducted by the U.S. Army Night Vision Lab to assess pattern "brightness" in visual, near infrared (NIR), and shortwave infrared (SWIR) bands.

The results of this extensive testing showed that all the vendor patterns in their intended backgrounds performed better than UCP—confirming the Army's intent to replace UCP. All the vendors' patterns performed similarly in their intended backgrounds—this "tight shot" group gave the Army many options and confirmed that overall pattern colors and brightness were much more important than pattern design when assessing concealment effectiveness. There was slight improvement in effectiveness of a family of patterns in their intended backgrounds over the performance of a single transitional pattern across the three background classes; however, the operational relevance of this improved performance could not be quantified.

In May 2013, Army senior leaders approved the expanded use of OEF CP to replace UCP across the Army and the purchase of the nonexclusive government license rights to one of the competing vendors' patterns (the Crye transitional pattern that was very similar and visually indistinguishable from OEF CP) offered as an option in the Phase IV contract. Because all of the vendor patterns performed similarly in testing, the decision was based on other considerations, primarily affordability—the Army could leverage existing inventories of OEF CP OCIE and reduce the overall implementation costs to the Army.

However, the announcement of the decision and implementation was delayed. Army senior leaders were hesitant to announce a uniform change decision during a time of intense budget pressure and with the threat of sequestration looming. More importantly, the draft FY 2014 NDAA was released, and it potentially limited the Army's camouflage flexibility by prohibiting any new camouflage patterns unless all services adopted the new pattern. At the time, it was unclear whether the camouflage patterns tested in the Phase IV effort would potentially violate the NDAA restrictions.

In August 2013, to avoid the threat of protests by Phase IV vendors and subsequent lengthy contractual challenges and to avoid potential violations of the new statutory restrictions in the pending NDAA, the Army changed its contracting strategy to pursue a sole-source contract for the non-exclusive license rights (i.e., government purpose rights) to OEF CP and to delay exercising any remaining Phase IV contract options until the FY14 NDAA language was final. The vendor, Crye Precision LLC, indicated to the Army that the price for OEF CP would be similar to the price offered to the Army for the transitional pattern non-exclusive license rights in the Phase IV contract.

In October 2013, Crye Precision LLC balked at the terms of the contract proposed by the Army for OEF CP. The contract terms for the non-exclusive license rights were identical to the Phase IV contract option terms. Crye Precision LLC now wanted considerably more money for OEF CP than they offered for their transitional pattern.

Part I: Path Forward, Development of a Strategy, Fall 2013

All this information swirled around in Colonel Smith's head as he prepared to meet in the Pentagon with Army senior leaders. Fortunately, for Colonel Smith, the CSA's office wanted the following specifically addressed in the meeting scheduled for December 2013:

- How did this happen? How was a contract reported as signed that was not actually signed? What was the impact of the pending NDAA restrictions, and how would the Army keep Congress informed? What was the impact on the Phase IV contracts?
- What was the schedule and a path toward an Army decision? What were the camouflage options, as well as key program and testing events considering the performance, cost, and schedule implications?
- What were the risks associated with this camouflage decision?

Based on the guidance from leadership, Colonel Smith and his team put together some options for the Army to consider:

- Option 1: Continue to negotiate with Crye for the nonexclusive rights for OEF CP. The initial price quoted started at $65 million but was later reduced to a lump sum of $24 million or 1% royalty on the price of each camouflaged uniform or piece of equipment.
- Option 2: Exercise the Phase IV contract option for nonexclusive rights to the Crye transitional pattern.
- Option 3: Renegotiate all the Phase IV contract options for the nonexclusive rights for the patterns with all four vendors and try to select a pattern after the renegotiations.
- Option 4: Take a strategic pause and consider existing government patterns and patterns for which the government has license rights—for example, the NSRDEC pattern ScorpionW2.

Colonel Smith asked his team if there were any other options and what the decision criteria would be to compare these courses of action. Performance of the patterns remained the Army's most important criteria. However, cost/affordability was important, as well as schedule, congressional considerations (adherence to law), and litigation considerations such as the chance of protests and lawsuits

challenging intellectual property rights to potential patent, copyright, and trademark issues.

Colonel Smith realized this would not be an easy set of meetings at the Pentagon. Despite the importance of combat uniform camouflage, efforts to change camouflage face the challenges that all programs within the DoD face: a complex, bureaucratic defense acquisition institution (refer to Appendix 3 for a description of the defense acquisition institution). Any decision to change Army camouflage crosses multiple chains of command with different decision-makers because it affects both uniforms and equipment. Uniform changes are approved by the CSA—and sometimes the SecArmy, if there is intense congressional, public, or media interest—after an approval recommendation from the Army Uniform Board. But camouflage also goes on organizational clothing and individual equipment (OCIE), and each piece of soldier kit (cold weather clothing, rucksacks, weapons, bags for night vision sights, etc.) may have a different program decision-maker—either a program executive officer or the Army Acquisition Executive (AAE), depending on the acquisition category.

Colonel Smith labored over how to pull together this information into a decision and what recommendation he would make when invariably asked by Army senior leaders. What should the Army decide?

Exhibit 1. Part I Case Study Discussion Questions

- Who are the key stakeholders in combat camouflage uniforms?
- Who is the ultimate decision-maker?
- How relevant was the test paradigm shift in this decision?
- What is a realistic test and evaluation strategy and schedule leading to decision in terms of key program and testing events planned by quarter?
- What options should the Army consider?
- What criteria should the Army use to compare options and then select the best path forward?

Part II: Camouflage Decision, Winter 2013/Spring 2014

Following a series of meetings in the Pentagon with Army senior leaders, the CSA issued the following guidance: delay any immediate decision, ensure all options for the Army moving forward were rigorously tested, ensure the options considered met the intent of the NDAA by pulsing the congressional professional staff members, and provide an update to the SecArmy. The SecArmy subsequently approved the testing of transitional pattern alternatives for March 2014 with an anticipated decision pending successful and positive testing results in April 2014 (see Figure 8).

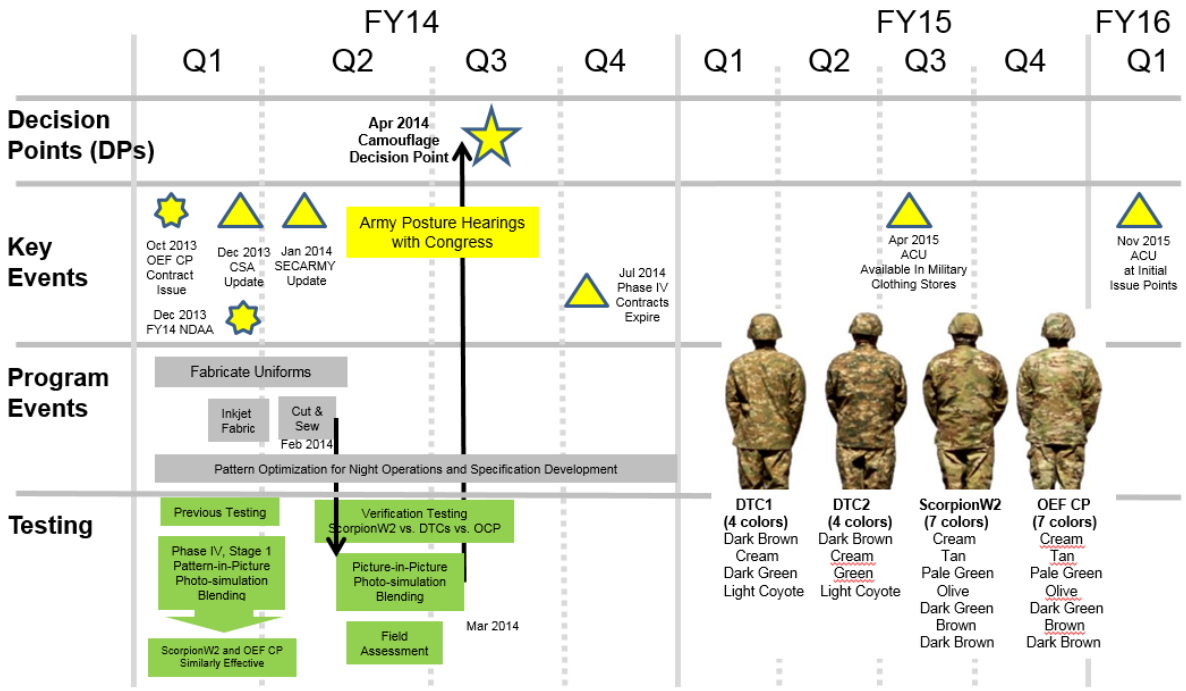


Figure 8: Approved Revised Army Plan

After being reprimanded for lack of proper program oversight and damaging the reputation of Army acquisition leaders in the Pentagon, Colonel Smith led his team to execute yet another revised strategy for combat uniform camouflage testing. In December 2013, the FY14 NDAA became final and officially prohibited the services from adopting new camouflage patterns unless all the services adopted the new pattern. This new law restricted the number of camouflage patterns considered going forward. The intent of the new strategy was to consider alternatives to OEF CP that provided equivalent or better performance, were affordable/fiscally responsible to implement, and were in compliance with the FY14 NDAA. The testing included three baseline reference patterns (UCP, MARPAT Woodland, and MARPAT Desert), OEF CP, and viable OEF CP alternatives. These alternatives were the ScorpionW2 pattern and two digital transitional camouflage patterns (referred to as DTC1 and DTC2—patterns based on MARPAT but with four earth-tone based colors; see Figure 9). The Army had a series of meetings with congressional members who sponsored the NDAA legislation and professional staff members who wrote the actual language to ensure the patterns considered were within the intent of the law. Congressional leaders considered the DTC1 and DTC2 patterns in a "gray area" of the new restrictions and were noncommittal about whether these patterns met the intent of the law. Nevertheless, the Army decided to test these patterns along with the other patterns.

Figure 9: Patterns Tested by the Army at Fort Benning in April 2014

In April 2014, the Army tested alternative transitional patterns at Fort Benning in operational field tests with U.S. Army Sniper School Cadre and in photo simulation assessments using soldiers from the 75th Ranger Regiment (see Figures 10 and 11). The testing to support an Army decision was rigorous and met the intent of the Army CSA. The testing involved used sniper experts to assess the operational relevance of the patterns in operational field tests and 106 soldiers as observers of the patterns in 46 separate backgrounds in photo simulation evaluations—collecting 19,474 data points.

Assessment Summary:

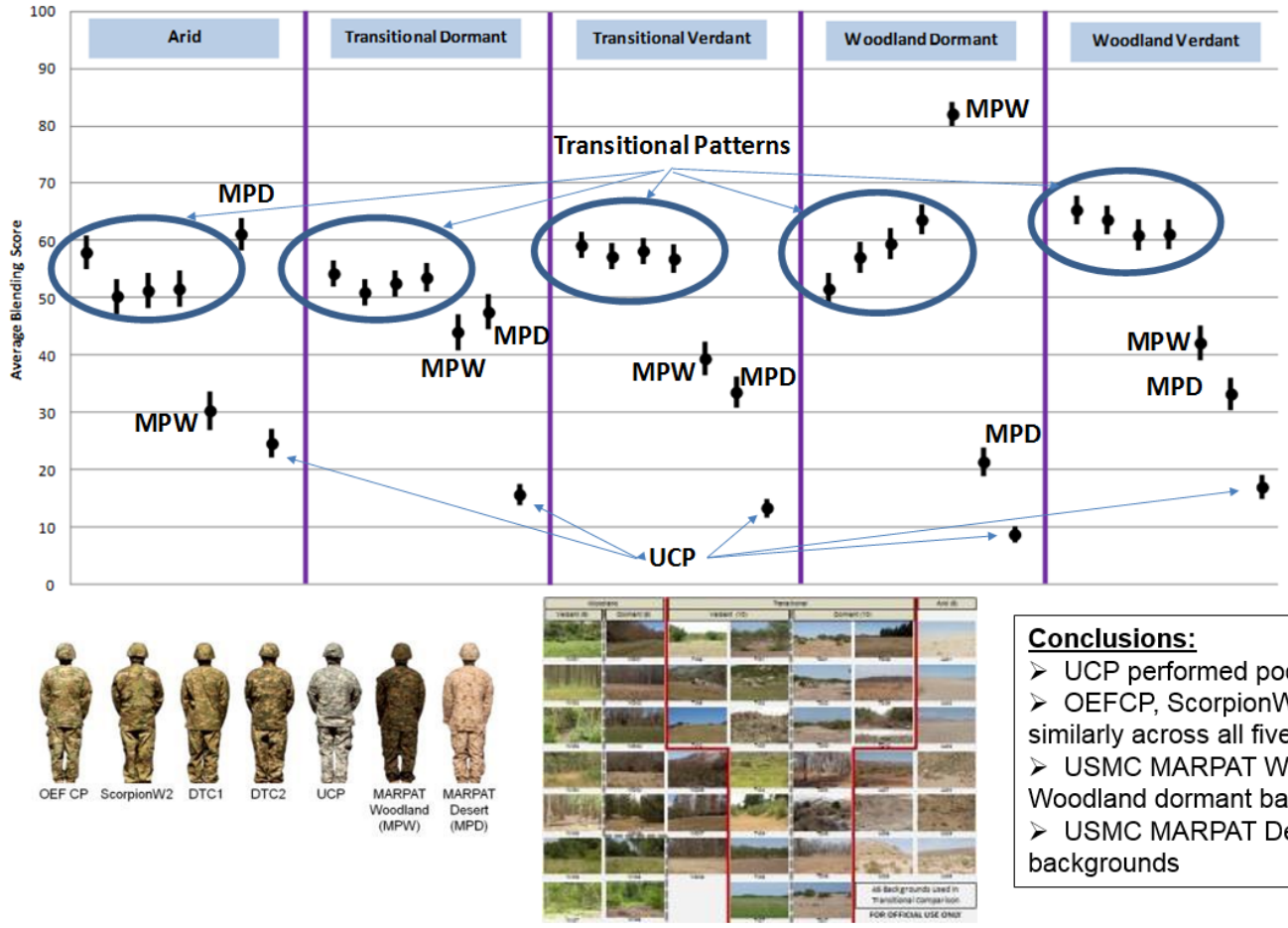
- 7 patterns, US Army Sniper School cadre, 2 locations at Ft. Benning, GA on 18 March 2014
- Mostly dormant wooded and transitional terrains out to 695m
- Sensors included unaided eye and 10x binoculars – daytime visual only

Observer Key Findings:

- After 300m all the transitional patterns appeared the same with the naked eye. With binoculars, they were able to identify DTC2. This is mostly due to the color contrast in the pattern
- DTC1, ScorpionW2 and OEFCP were said to be very similar; differences were difficult to detect
- With binoculars, OEFCP, Scorpion and DTC 1 rated higher than Woodland MARPAT and DTC2 at most stationary locations

MARPAT Woodland (MPW)	MARPAT Desert (MPD)	UCP	DTC2	DTC1	ScorpionW2 (SCORP)	OEFCP
Performance was highly dependent on immediate background	Too bright throughout the assessment	Too bright throughout the assessment	High internal color contrast was evident more than others	Performance was similar to OEF CP and ScorpionW2	Performance was similar to OEF CP and DTC1	Performance was similar to DTC1 and ScorpionW2

Figure 10: Operational Field Test Results



Assessment Summary:

- Purpose: assess from a blending perspective the OEFCP, ScorpionW2 and DTC transitional uniform camouflage pattern candidates
- 7 patterns were assessed by 106 Soldiers from 3/75th Ranger Battalion Headquarters, Fort Benning 30 March -2 April 2014
- Pictures of Uniformed Individuals placed into 46 backgrounds; each photo viewed at least 57 times
- Total data points = 19,474

Conclusions:

- UCP performed poorly in all five backgrounds
- OEFCP, ScorpionW2, DTC1 and DTC2 scored similarly across all five backgrounds
- USMC MARPAT Woodland performed well in the Woodland dormant backgrounds.
- USMC MARPAT Desert performed well in arid backgrounds

Figure 11: Photo Simulation Test Results

From the results shown in Figures 10 and 11, the Army came to the following conclusions: UCP performed poorly in all backgrounds (confirming prior results); OEF CP, ScorpionW2, DTC1, and DTC2 scored similarly across all background types; USMC MARPAT Woodland performed well in woodland dormant backgrounds; and USMC MARPAT Desert performed well in arid environments. The results confirmed that there was a "tight shot" group for the effectiveness and performance of the transitional patterns. The Army decision would probably come down to other considerations like affordability, cost, implementation and execution ease, schedule, contracting challenges, and intellectual property rights concerns (potential patent, trademark, and copyright challenges).

Again, Colonel Smith assembled his team to consider the following options for CSA and SecArmy to consider:

- Option 1: Do nothing. Make no decision at this time and continue the current situation of issuing to soldiers UCP uniforms and equipment for all missions, except in Afghanistan where they would continue to get OEF CP uniforms and equipment.
- Option 2: Select OEF CP, accept the vendor's terms, and expand its use beyond Afghanistan to being the standard pattern of all Army uniforms and equipment.
- Option 3: Select ScorpionW2 and replace UCP uniforms and equipment over time as they wore out.
- Option 4: Select a digital transitional camouflage (DTC1) and replace UCP uniforms and equipment over time when they wore out.

Colonel Smith and his team considered these options the main courses of action for Army senior leaders to consider. The team debated the following decision criteria to apply to these options: performance, schedule, affordability/cost, legal risk, and the perspectives of key stakeholders such as soldiers, Congress, the Marine Corps, and the media.

Colonel Smith prepared for another challenging sets of meetings and did not like the thought of going back into the lion's den again with Army senior leaders in the Pentagon. This would be the third time he attempted to get a decision on camouflage for Army uniforms and equipment. However, he knew that the decision

was of utmost importance for soldiers in combat. Effective camouflage increased soldier combat effectiveness and improved force protection—saving soldiers' lives in battle. Colonel Smith thought about the decision in terms of return of investment (ROI). From 2009 to 2014 (over six years), the Army spent less than $10 million in the research, development, and testing of camouflage patterns, but a camouflage change would affect the purchase of $5.2 billion of uniforms and equipment over the next five to 10 years. Colonel Smith considered the research, development, and testing of camouflage patterns a wise investment for soldiers and for the American taxpayer.

What should the Army do?

Exhibit 2. Part II Case Study Discussion Questions

- Was the $10 million spent over six years in the research, development, and testing of camouflaged uniforms a wise investment for the Army?
- Were the options considered by the Army appropriate? Were other viable options not considered?
- Was the source of funding (contingency funds or base budget funds) an important consideration? Why or why not?
- What were the affordability considerations for the Army in this decision?
- What were the important contractual and legal considerations in this decision?
- How should the Army compare the options and select the best path forward?

Appendix 1. Camouflage Testing Basics

Pattern testing and selection criteria was based on both detection (ability to detect the pattern at ranges out to 450 meters day and 250 meters night) and blending (ability to match the background environment at 50 meters day and 25 meters night). Detection is the ability pick up the camouflage pattern measured at different distances, and blending is how well the camouflage pattern matches the background once detected at a specific close range (see Figure 12).

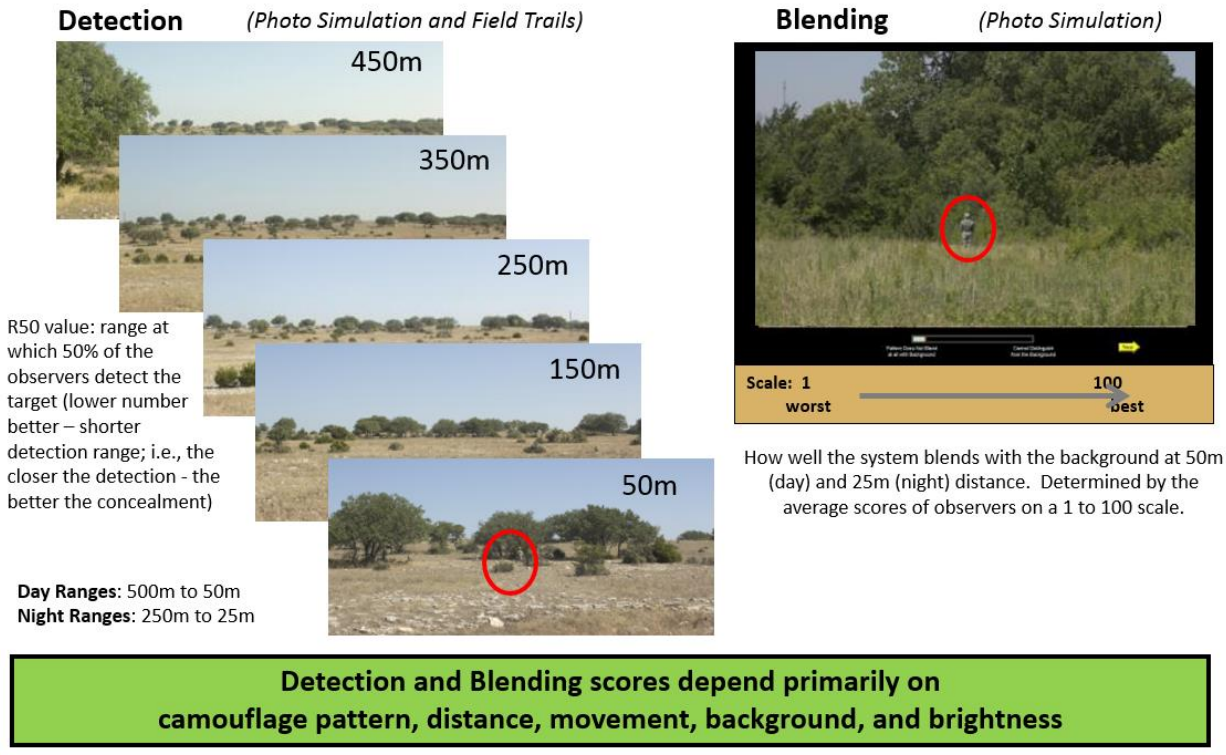


Figure 12: Camouflage Pattern Testing Criteria

Camouflage pattern testing used a combination of field trials and photo simulation evaluations. The field trials included day and night testing, squad-on-squad battle drill lanes, movement to contact drills, and individual soldier detection/acquisition at varying distances and varying soldier positions (prone, kneeling, and standing). The soldier photo simulation evaluations included feedback from soldiers who assessed the camouflage's detection and blending ability using

calibrated images of uniformed individuals in arid, woodland, and transitional backgrounds. Photo simulation evaluations allow for collection of significant data in many backgrounds. These evaluations also control variables (such as distance, movement, background, and brightness) so that change in detection and blending scores are only attributable to different camouflage patterns. The word *simulation* in this case just means that we were simulating soldiers being outside at the various sites by taking images of soldiers and challenging other soldiers to detect them (see Figure 13). Soldiers scored images of real camouflaged personnel in real outdoor scenes (day and night) on a computer monitor. Detection scores came in the form of R50 values, which is the range at which 50% of the observers detect the target (lower numbers are better, meaning shorter detection ranges—in other words, the closer the detection, the better the concealment).

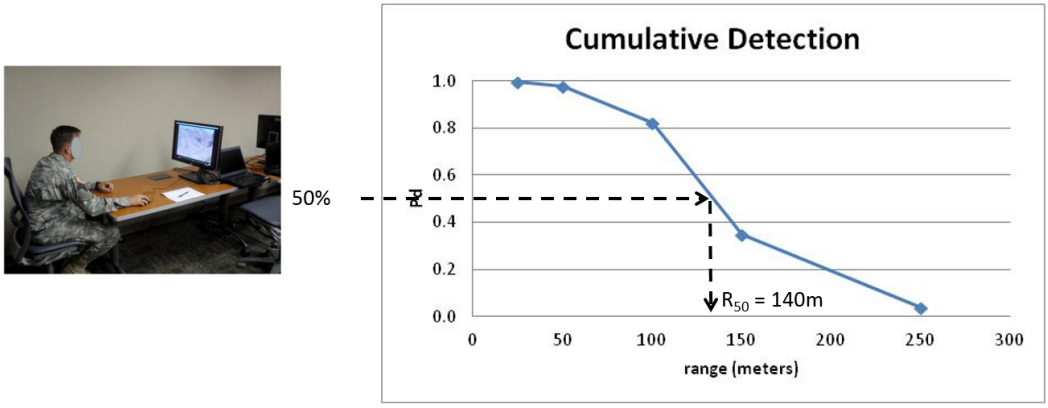


Figure 13: Example Photo Simulation Test and Test Output and the Probability of Detection (Pd) versus Detection Range

An overall summary of the Phase IV photo simulation testing confirmed the following:

- All vendor families of patterns and transitional patterns alone performed significantly better than UCP. On the average, families blended better than UCP (217% better day and 9% better night), and transitional patterns blended better than UCP (190% better day and 4% better night). On average, families of patterns were harder to detect than UCP (16% better day and night), and transitional patterns alone were harder to detect than UCP (10% better day and 21% better night).
- Overall, the vendor families of patterns and their transitional patterns performed similarly with no operational relevance for the differences in scoring among the vendor families or among the transitional patterns. The competing vendor families obtained blending scores within 11% day and within 7% night of each other. On average, there were no significant differences between vendor families or between vendor transitional patterns for detection.
- Families of patterns performed slightly better than their complementary transitional patterns alone, but the operational relevance for the improvement could not be determined. For example, on average, families blended better than transitional patterns (9% better day and 5% better night); however, there were no significant differences between families and transitional patterns for detection scores. The limited detection scoring differences between the families and transitional patterns is explained by the fact that the detection testing was performed at longer ranges where uniform brightness and contrasts between the uniform and OCIE is more critical to soldier concealment than patterns (colors and shapes) alone.
- The USMC and Navy patterns performed similarly to the vendor patterns in their intended environments. No transitional USMC or Navy pattern exists for an equivalent comparison against vendor transitional patterns, UCP, or OEF CP.

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Appendix 2. Scorpion Camouflage Pattern Background

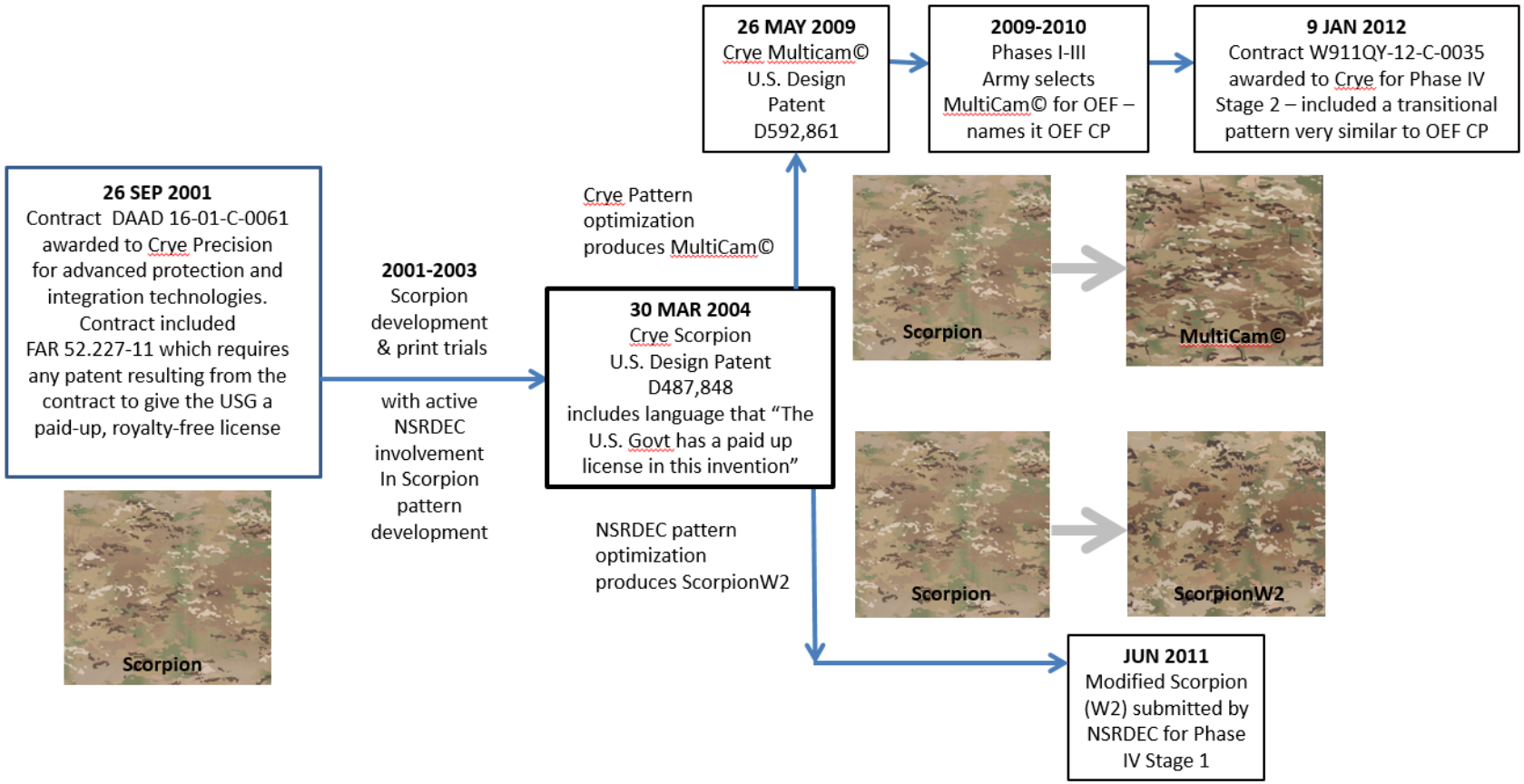

Figure 14: Timeline of Scorpion Pattern Derivatives

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Appendix 3. U.S. Defense Acquisition Institution—Decision Framework

Within the DoD, the development, testing, procurement, and fielding of capability for the warfighter operates within a decision-making framework that is complex. Within the private sector, similar frameworks exist. The U.S. defense acquisition institution has three fundamental support templates that provide requirements, funding, and management constraints. The executive branch, Congress, and industry work together to deliver capability with the program manager (PM) as the central person responsible for cost, schedule, and performance. Figure 15 depicts this framework.

Figure 15: Defense Acquisition Institution

The government PM is at the center of defense acquisition, which aims to deliver warfighter capability. The PM is responsible for cost, schedule, and performance (commonly referred to as the “triple constraint”) of assigned projects—usually combat systems within the DoD. The executive branch of government provides the PM a formal chain of command in the DoD. The PM typically reports directly to a program executive officer, who reports to the service acquisition executive (an assistant secretary for that service—either Army, Navy, or Air Force), who reports to the defense acquisition executive (the under secretary of defense for acquisition, technology, and logistics). Depending on the program’s visibility, importance, and/or funding levels, the program decision authority is assigned to the appropriate level of the chain of command.

Programs within defense acquisition require resources (for funding) and contracts (for execution of work) with industry. Congress provides the resources for the defense programs through the annual enactment of the defense authorization and appropriation acts, which become law and statutory requirements. The PM, through warranted contracting officers governed by the Federal Acquisition Regulation, enters contracts with private companies within the defense industry. Other important stakeholders include actual warfighters, the American public, the media, and functional experts (like engineers, testers, logisticians, cost estimators, etc.), as well as fiscal and regulatory lawyers.

As a backdrop to this complicated organizational structure for defense PMs, there are three decision support templates: one for the generation of requirements, a second for the management of program milestones, and a third for the allocation of resources. Each of these decision support systems is fundamentally driven by different and often contradictory factors. The requirement generation system is driven primarily by a combination of capability needs and an adaptive, evolving threat. The resource allocation system is calendar-driven by Congress writing an appropriation bill—providing control of funding to Congress and transparency to the American public and media for taxpayer money. The defense acquisition management system is event-driven by milestones based on commercial industry best practices of knowledge points and off-ramps supported by the design, development, and testing of the systems as technology matures.

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