Early Synthetic Prototyping: Exploring New Designs and Concepts Within Games

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ABSTRACT

Early Synthetic Prototyping (ESP) is a new concept the Army is exploring that will use game environments to assess novel system designs and concepts early in the acquisition cycle. ESP is a process and tools that enable Soldiers to assess emerging technologies within scenarios to provide feedback that will inform decisions. Acquisition, science and technology, and industry partners develop scenarios and models of interest to serve on the ESP network for Soldiers to play. ESP allows an unbounded increase in potentially disruptive ideas to be explored at minimal cost. The goal is to engage the whole Army in defining the future of the Army and to ensure that the Soldier remains the centerpiece of future development. To this end, we completed a study to explore an unmanned vehicle concept called Wingman. Groups of military officers of all services played red versus blue in three scenarios: chase/recon, attack, and defend. The study asked (1) What feedback could we gather from game players that is useful to the Research Development and Engineering Centers (RDECs) and the Army Capabilities Integration Center (ARCIC), (2) Would the organization value that feedback? Using a game environment to explore design concepts early in the acquisition process is valid and can be applied to early requirement refinement and rudimentary tradeoff analysis. Through the game sessions, players expressed ideas, both creative and surprising, towards a preferred interface and how to best employ Wingman. The encouraging results of this preliminary work clearly demonstrated a strong potential to leverage game environments to explore revolutionary concepts to efficiently and effectively shape the future of the Army.

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INTRODUCTION

We are at a crossroads. Our ability to match the pace of technological change in warfare is in question. Acquisition programs in all services struggle to meet prescribed timelines, remain within budget, and retain the agility needed to meet looming, but unknown, requirement changes. The Department of Defense often looks outside the defense establishment for potential disruptive change with limited success. The private sector is not well tuned to understand modern warfare and all the subtleties that differentiate a revolutionary idea from yet another evolutionary improvement. The creativity and innovative spirit for disruptive change exists in each and every warfighter, but it remains a largely untapped resource. What if it could be harnessed, allowing the free flow of ideas to identify as well as assess capabilities and tactical employment concepts early in the design phase at a time when costs are low and change is relatively easy?

Early Synthetic Prototyping (ESP) is an approach to open a conduit for the flow of ideas using a distributed game network as the medium. Rather than rely exclusively on expert designers within acquisition programs to generate a small number of good ideas which are then prototyped, tested, and revised (at significant cost and time), ESP facilitates the development of an unbounded number of design options in the concept phase. Those options are tested and assessed as virtual prototypes in a game network. Warfighter players "play" the virtual systems while analysts gather data via game analytics to identify what works and what does not.

ESP proposes the use of a crowdsourcing technique to assess the utility and efficiency of virtual prototypes. Crowdsourcing only works if the number of players is very large. It assumes that none of the players is an expert in design or assessment, but that as a group, they are (Surowiecki, 2005). ESP players could be anyone from a Private fresh out of boot camp to a thirty year veteran with extensive combat experience. We assume that all have something interesting to tell us. Therefore, ESP does not concern itself with weeding out bad designs. Players do that. The purpose of ESP is not to find the perfect design, it is to find the best subset of prototypes possible for acquisition professionals to pursue. The pursuit can be conducted with confidence that one of the ideas is a game changer based on evidence displayed through ESP. Additionally, ESP explores force design and force employment in conjunction with capability development at the operator and small unit levels.

The big picture is that ESP will become a cornerstone of Engineering Resilient Systems (ERS) which is intended to address the *entire* acquisition process, not just the early concept phases. ERS seeks to enable better acquisition decisions by providing a rigorous science and engineering process on an open framework for requirements generation, analysis of alternatives, and predicting lifecycle performance and costs (Goerger, 2014). ESP should be considered one facet of what ERS will eventually become.

The Concept

ESP is a persistent game network with instrumented scenarios and metrics for exploring alternative future designs to inform present decision making. The stakeholders include acquisition professionals (government and industry), science and technology programs, and warfighters.

Referring to the ESP schematic in Figure 1, acquisition professionals (1) use scenario editing tools to develop concept ideas for testing. These are playable scenarios (2) that are instrumented with metrics of interest (e.g. system selected, rounds fired, speed attained, distance traveled) specified by the program office. These scenarios are made available for play via a game server (3) that allows distributed warfighter players (4) to play, capturing diagnostic information. Communities of players are coordinated via conventional social media (5). Players can modify scenarios locally. ESP does not assume the best scenarios will come from the program office. More likely, the best ideas will be modifications of those ideas made by players. Gameplay diagnostic data (6) and modified scenarios (7) are returned to the server and then to the program office (8). Program offices can also interact with players via the community (9). Science and technology programs (10) will use ESP to test new ideas at minimal expense before follow-on larger investment. They will also use ESP to demonstrate concepts to potential transition customers (11) to obtain buy-in early which will facilitate an increase in successful transition to programs of record.

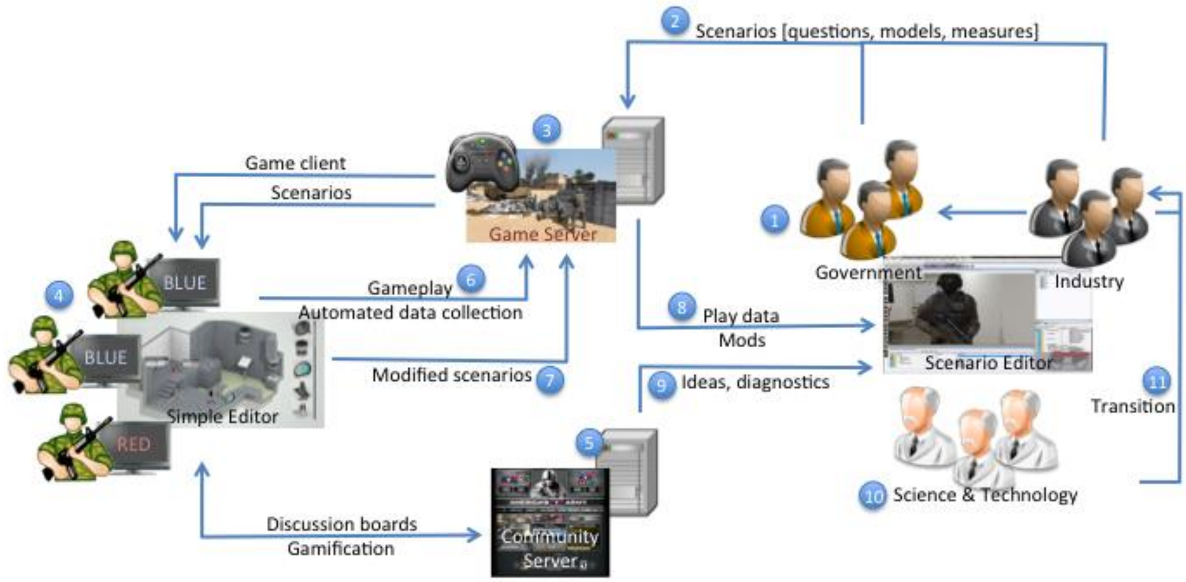

Figure 1. ESP Schematic.

The Barriers

The ESP concept has great face validity as a way to explore new ideas. But presently, it is only a concept. A number of critical steps must be taken before it is realized, specifically:

The network must be distributed worldwide and playable by any authorized player.	America's Army accomplished this over ten years ago (Zyda, Mayberry, Wardynski, Shilling & Davis, 2003). This is a solved problem, but managing specialized player groups will be a challenge.
Scenario editing must be simple yet expressive.	Scenario editing for a program office is similar to level editing in game design. A key issue is setting data collection triggers to capture relevant play data.
Game play must be easy and entertaining or players will simply spend their time doing something else.	America's Army dealt with this as well. Just because a game is free does not mean players will play. We are competing for their time, not their money. Players should also know that the Army is listening to what they have to say.
Players must be able to easily modify scenarios to create new designs and configurations.	While simpler than a full level editor, players must be able to easily modify content similar in complexity to Garry's Mod[1]
Gleaning useful information from game play must be simple, or better yet, transparent to players.	There are two inherent questions here: (1) Can we collect information from gameplay? and (2) Is it useful to decision makers?

In this first phase of ESP, we conducted a study focused on this last issue. We wanted to know if it was possible to glean useful information from game players and we wanted to know if the information collected was useful to those who might need it.

[1] See http://www.garrysmod.com

BACKGROUND

In this section we will explore two key areas of concern to ESP. First is the use of simulation in the acquisition process. There is a deep history in efforts to leverage simulation to reduce costs in system design as well as in test and evaluation. Second, we will explore the literature in measurement within games, or *game analytics*, as a way to glean useful information from gameplay that players may or may not be aware is being collected.

Simulation and Acquisition

ESP appears to be very similar to Simulation-Based Acquisition (SBA), however there are two important distinctions: (1) ESP is focused on early concept development, when costs are relatively low but when it is critical to get major design decisions right, and (2) ESP allows for the consideration of orders of magnitude more design options than SBA or any known acquisition process. ESP operates on the premise that disruptive ideas are more likely to appear when 10,000 design variations are considered rather than just 10.

SBA promised a reduction in time, resources, and risk associated with the acquisition process and an increase in the quality, military utility, and supportability of the systems it fielded (Sanders, 1997; National Research Council, 2002). Despite its merit as a means to reduce expenditures by introducing modeling and simulation into the acquisition cycle, SBA achieved limited success partly because it attempted to address the entire lifecycle from idea inception through production, fielding, and employment (See Figure 2). The use of simulation at each phase of the acquisition process differs. Rather than take a holistic approach to simulation in acquisition, ESP seeks to address the unique needs of the early phases. This also serves to shift the bulk of the change demand (especially from warfighters) from post-Milestone C, when it is expensive to make changes, to pre-Milestone A when it is far cheaper.

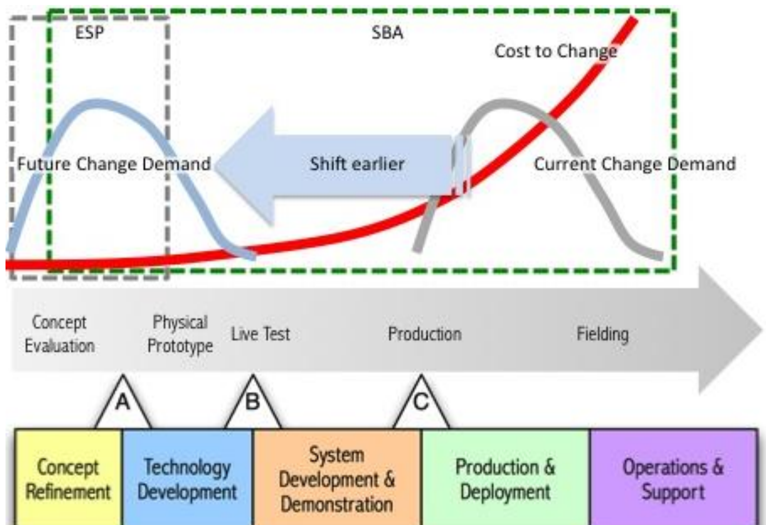

Figure 2. ESP shifts change demands earlier in the cycle when they are less expensive to execute.

Similarly, SMART (Simulation and Modeling for Acquisition, Requirements, and Training) attempted to model physical properties and associated costs in a virtual environment at an early stage and carry those through the fielding and training phases (Davis, 1999). By limiting its focus to the early design phase, ESP has greater latitude regarding the level of precision required to explore an early concept as compared to detailed design decisions later in the acquisition process. During concept exploration, the fidelity of a ballistic model, for example, is of less concern than determining if a weapon system used in a specific way merits further study.

Competitive prototyping is a mandate in the Weapons Systems Acquisition Reform Act (WSARA) of 2009 during the technology development phase prior to Milestone B decisions where the Milestone Decision Authority grants entry into the Engineering and Manufacturing Development phase (WSARA, 2009). Competitive prototyping invites competition from commercial vendors but does not explicitly attempt to bring in novel or leap ahead solutions. Competitive prototyping can result in great motivation for vendors to provide innovative solutions and can help ensure acquisition dollars are spent toward development and evaluation of a near-final production solution. However, costs can quickly escalate if requirements creep during this phase (a common occurrence). Costs associated with competitive prototyping include multiple full-scale mockups for evaluation against alternative options. WSARA affords a program manager the opportunity to request a waiver if the expense of a competitive prototype is not economical given the anticipated system lifecycle cost. ESP can bring the positive features of competitive prototyping, such as requirements refinement, into the low cost, government directed tradespace of a virtual environment before a physical prototype is produced. The ability to refine requirements facilitates pre-Milestone A concept refinement and supports acquisition process improvement.

Defense Acquisition University (DAU) is using a product called Dragonfly as a teaching aid in the program manager course. Dragonfly simulates the tradespace with realistic portrayal of cost and performance factors. The environment is easy to use allowing a player to select preferred components and then weigh associated capability against cost. System performance is evaluated head to head against peers in the Dragonfly virtual environment (*Accelerating our Second Transformation 2010 Annual Report,* 2010, p. 8). The diversity in selected technical solutions presents an opportunity to explore a variety of solutions in a standard trial environment (see SEA below which proposed this as well). The potential for multiple optima emulates the crowdsourcing objective of ESP and provides a space to refine requirements against possible and plausible technical solutions.

A concept similar to ESP was proposed by the Office of Naval Research, called Synthetic Environments for Assessment (SEA). SEA has many of the same objectives as ESP but is focused on human systems (man-in-the-loop) specifically investigating the trade-offs between users (including teams) and equipment (Darken and Cohn, 2012). SEA calls for “calibrated scenarios” that are validated and realistic to be used for testing ideas. It also identifies the need for reusable components (models and software) to ensure repeatability in assessment. These are concepts ESP would do well to embrace.

System Engineering (SE) 2025, as proposed by Rob Smith and Brian Vogt (2014), could incorporate ESP at the front end of a process that aims to provide flexible and adaptable solutions for rapid fielding, even at austere locations, by leveraging techniques such as additive manufacturing. This approach on “mass customization” is based on enabling a platform in which soldiers and engineers can collaborate on technology solutions as well as the tactics to employ the technology. SE 2025 seeks to be an enabling technology in its own right supporting warfighter needs in a more rapid fashion (Smith & Vogt, 2014).

To facilitate the evaluation of trades between capabilities and resources, tools are required to visualize information. The Framework for Assessing Cost and Technology (FACT) is a highly refined and capable design tradeoff analysis environment that meets these goals. FACT offers an open architecture web service to provide rapid exploration of engineering design tradeoffs. Performance, reliability, and cost over the lifecycle of a system can be explored in this comprehensive, near-real time, government owned resource built for the Marine Corps.

The detail, fidelity, and physically-based accuracy presented in the FACT environment far surpasses what we envision for ESP. Rather, ESP is a precursor where design ideas are accumulated, vetted, and accepted or discarded based on estimates of performance. FACT is a tool to hone a good design into a better design. ESP is a tool to help find the good design in the first place. Alternately, refined solutions developed and assembled in the FACT library could be made available for emulation in ESP (in an iterative design process) to assess performance in a specific operational environment or a novel tactical employment scenario. In conjunction with FACT, ESP provides the opportunity to demonstrate virtual employment of a combat system in a combat scenario while garnering contributions from a wide breadth of experienced users.

Game Analytics

The astronomic growth of the video game industry has motivated developers and publishers to seek an edge in determining the makings of a great game as compared to an ordinary game. Game analytics is a burgeoning field of study that addresses this need. “Analytics is the process of discovering and communicating patterns in data, towards solving problems in business or conversely predictions for supporting enterprise decision management, driving action and/or improving performance. … Game analytics is a specific application domain of analytics, describing it as applied in the context of game development and game research.” (El-Nasr, Drachen, and Canossa, 2013, pp. 14-15). The definition of game analytics breaks out two distinct segments: the “game as a product” that should provide a good user experience and the “game as a project” that should perform well on its own and in comparison to other games. ESP is concerned with both product and project: continuous interest from players and a well-developed game environment capable of handling the desired user load and sufficient instrumentation. In ESP, Science and Technology experts within a program office, akin to the game developers, can advise the Program Manager about what data to collect and how to effectively correlate that data to inform decisions for the program.

Game developers intend to craft games that will achieve commercial success. That commercial success is based on a positive user experience. The ability to observe player actions and reactions in the game environment offers the opportunity to dynamically update a game to maximize the monetization of players. Game analytics can be applied to inform decision making by providing a myriad of information to supplement other available business intelligence data. Games are not played on site for developer observation, therefore telemetry (data obtained over distance) provides a view into a player's decisions and resulting success, failure, and game behavior (El-Nasr et al, 2013, p.16). Game metrics are interpretable measures of something related to games -- quantitative measures of attributes of objects within the game environment. Microsoft uses Xbox Live data from 18,000 volunteer players to capture games played, achievements earned, and presence information. The data comes through an XML feed from Xbox. Microsoft also mines online communities for threads relevant to games under development (Zimmermann, Phillips, Nagappan, and Harrison, 2012).

Within the first-person shooter genre, metrics that might apply to ESP include "weapon use, trajectory, item/asset use…loss/win, heat maps, team scores … vehicle use metrics, strategic point captures/losses … avatar movement and posture, … AI-enemy damage inflicted, and projectile traces" (El-Nasr et al, 2013, p. 25). None of these requires special instrumentation or hardware. Players are unaware that data is being collected. Gleaning useful *strategic* information is more difficult. Parameters that might apply to strategies employed might include monitoring the frequency of the previously mentioned attributes, such as event frequency and events initiated.

Crowdsourcing in the context of ESP is the practice of obtaining ideas by soliciting contributions from a large body of players. To gain access to a significant volume of information without negatively impacting the body providing that information is a worthy goal. Consequently, game analytics that are transparent to the players are essential. Crowdsourcing is employed in such venues as Massively Multi-player Online Games (MMOG) where troves of data on character/player activities can be collected, parsed, and evaluated for relevance.

METHOD

We conducted a study that simulated an ESP-like environment where a concept robotic vehicle was placed in a series of realistic combat scenarios and players were asked to use it to meet scenario objectives. Of particular interest was how the players would use the vehicle, what form their feedback might take, and whether or not their feedback would be useful to a program office responsible for making critical decisions on design and employment.

The Army is exploring a semi-autonomous robotic vehicle concept called Wingman. There are many ideas for how Wingman might be used[2] and what configurations may be made available. But how should the Army examine these ideas in order to make critical decisions about how or if the concept will be developed?

We selected three of the candidate scenarios for Wingman – chase (or reconnaissance), attack, and defend. For each, we developed a scenario in VBS2 as an exemplar of the problem set unique to each situation (See Table 1). In our study, the scenarios were not adaptable and we were not able to have participants alter the vehicle configurations, but we asked questions about both of those issues in the debrief interviews.

Table 1. Wingman VBS2 scenarios and descriptions

Scenario	Player Configuration	Location	Details
Chase	All four BLUFOR	Takistan	Night operation
Narrative:	A high ranking OPFOR officer is in the area of Takistan, exact whereabouts unknown. A convoy in Hazar Bagh will meet him. Using APDs, follow the convoy without being detected. When target is seen, eliminate him, all units supporting him, and the convoy.		
Attack	Two BLUFOR, two OPFOR	Geotypical Eastern Europe	OPFOR AI
Narrative:	BLUFOR is in the vicinity of a heavily guarded enemy compound used as a prison for friendly forces. Eliminate OPFOR allowing prisoners to escape.		
Defend	Two BLUFOR, two OPFOR	Porto	Both BLUFOR and OPFOR AI
Narrative:	BLUFOR is defending a position in the vicinity of Porto against an enemy of unknown size. Defend the current position for five minutes.		

The study consisted of a pilot and five groups of four participants each. The 24 participants were experienced military officers at the Naval Postgraduate School but not all were experienced in a ground combat discipline.

[2] See http://www.hood.army.mil/robotics/index.html

Computer game play frequency ranged from none (8 respondents) to over five hours per week (4 respondents). Each session took 2-3 hours to complete. During game play, players were co-located where they could talk to each other directly. For the attack and defend scenarios, we moved the OPFOR team to another room so that they could not hear the other team during planning or scenario execution.

We refer to Wingman as an Autonomous Platform Demonstrator, or APD. The key parameters available to configure each APD are lethality (weapons), vulnerability (armor), and agility (engine and weight). We pre-configured three versions of the APD for this study each with a different balance of lethality, vulnerability, and agility (See Table 2).
We used the standard desktop PC configuration of VBS2 with mouse and keyboard inputs. Each group was first read general instructions pertaining to the study and about the Wingman concept vehicle. Each player was provided a "cheat" card for VBS2 with important keys highlighted. We provided a familiarization scenario that was used to bring all players to a minimum level of competence at using VBS2 both in APD mode and dismounted mode which are always operated separately (players either operate their APD or move their Soldier, but not both simultaneously). Prior to each scenario, specific instructions as to objectives of that scenario were given and player questions were answered. No coaching was provided during scenarios but we did answer questions related to the VBS2 interface. Teams were given five minutes before each scenario run to develop a plan. They were shown the tactical map of the area and their initial positions on that map. Groups were told that they could play any scenario as many times as they collectively wished.

Table 2. APD configurations

Name	Armor Level	Weapon	Engine Power level
APD 25mm/7.62	Moderate	M240	Moderate
APD M134	Moderate	M134 Minigun	Moderate
APD Speedy	Low	M240	High

During game play, all verbal communication was recorded for later analysis. We also used the after-action review capabilities in VBS2. At the conclusion of play, we brought all the participants together for a moderated debrief session. Questions centered on two main topics – those specific to the Wingman concept and those specific to ESP.

RESULTS

Chase Scenario

This scenario was challenging in that it had two distinct phases that had different requirements for the APD. During the chase phase, players wanted a faster APD even if they had to give up armor or lethality. But when they reached the end of the scenario and had to successfully eliminate the target and his supporting units, players needed an APD with armor and lethality. This suggested that players might not want APDs with identical configurations.

Because stealth is a mandatory element of this scenario, players had to master the night vision and lighting features in VBS2. This was also the first scenario after the familiarization that every group executed. Consequently, there was more of a learning curve here than in the following two scenarios.

A successful approach to this scenario utilized bounding overwatch with one APD to the north of the road and one to the south with another trailing the convoy far enough back to not be detected but close enough to be able to support. As shown in Figure 3a, the convoy (5) travelled along the road between villages. It stopped at point 5b which is where the target appears. This group had APD4 to the north of the road and APD3 to the south. APD4 kept to the high ground in order to observe all movement. APD3 also tried to remain in visual contact but was less successful. APD1 trailed the convoy all the way to the end and APD2 remained behind as rear guard. When the target appeared at 5b, players were alerted that they should now attack the convoy. The target and supporting units moved to 5c where they were engaged by all four APDs. The players de-conflicted their fires verbally and through direct observation. This group had positioned its APDs to bind the target on three sides. During the ensuing firefight, APD1 was mostly offensive while APD3 and APD4 prevented the convoy from any chance of egress from the area. APD2 moved into the engagement area from its rear guard position and was able to support APD1. Figure 3b shows the situation immediately prior to the firefight at the end of this run.

While successful, this group "jacked into" their APDs immediately at the start of the scenario while their virtual Soldier remained in their initial location. This group maintained the perspective of robot controller throughout gameplay and never returned to the Soldier perspective. The human operators (their avatars) were not directly employed. Did they need to be on site? One of the player groups provided feedback suggesting that a local controller was essential and three explicitly sought an off-site controller. The other two groups did not offer a direct opinion on the local vs. off-site discussion. Had an APD been disabled in the firefight, an on-site Soldier could move into position to physically support achievement of the objective. An off-site Soldier could not physically assist but may have had a wider vantage point for battlefield situational awareness to provide support from afar.

Figure 3. Map (a) and AAR (b) view of a successful Chase scenario

A problem we saw in 75% of group runs was a failure to remain undetected. This typically occurred when an APD would follow too closely because a player would underestimate the noise signature or acceleration rate of the APD. At the other extreme, after a delay to allow for preparation, the OPFOR convoy moves out. If BLUFOR APDs lagged too far behind, they lost contact with the enemy convoy which ends the scenario.

Every attempt at this scenario was characterized by some level of disorientation at the onset of the run. Ten players reported spatial disorientation in free-form survey comments and all players verbally expressed challenges during play. Even after viewing a map and knowing the location of both the Soldier and APD, the discontinuous switch from a geocentric view of the tactical map to the egocentric view in the APD was difficult to overcome. Allowing the players multiple attempts at this scenario helped. By the second or third attempt, most players reduced their disorientation and were able to execute their plan. In all, only 2 of 24 players were unable to effectively navigate in the game environment to meet the objectives designated in their group plan for the third attempt.

The visual display itself contributed to the disorientation. The direction of movement (shown in an inset view by default) and the direction of the turret and optics (shown in the main view by default) are controlled separately. This was extremely confusing. Players would think they were lined up to move forward on the road but when they pressed the key to move, they would see that the turret was not aligned with their wheels. This took practice to overcome and was the subject of several recommendations made during debrief (see the Discussion section).

Attack Scenario

This scenario presented the first opportunity for players to fight against each other. We immediately saw that having live OPFOR improved the level of engagement of the players on both sides. Because the ESP concept requires players to be highly motivated to play, this was an important observation.

There was a much broader set of strategies used to attempt to defeat the OPFOR. The BLUFOR is badly outnumbered fifteen to one in this scenario, so a direct assault had little chance of success. Also, the AI OPFOR were armed with shoulder-fired rockets capable of disabling an APD with a single shot. Two common strategies involved either stand-off and sniping and/or a flanking maneuver to get behind the compound.

In Figure 4a, we show one group's attempt to flank the OPFOR. APD1 moved a short distance to high ground with cover and, after a delay to allow APD2 to get into position, engaged targets from a distance. APD2 took a circuitous route around APD1 to the north ending on high ground behind the compound. APD1 then proceeded south along the back fence remaining concealed whenever possible. APD2 purposely held his fire until the last possible moment. The two OPFOR players had no idea where the APD1 was navigating until he appeared behind them.

Once shots are fired, the prisoners in the compound attempt to flee. If enough guards have been eliminated, BLUFOR achieves their mission objective. If not, then the guards will shoot the prisoners rather than allow them to escape. In this instance, APD1 and APD2 had cleared enough guards to allow the prisoners to flee. The prisoners exit the compound to the east heading down the road that runs just south of APD1's position.

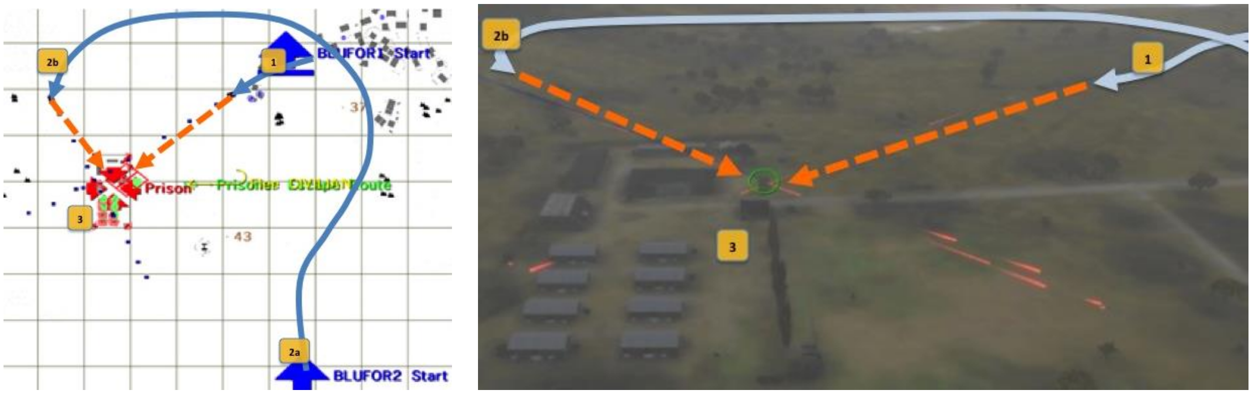

Figure 4. Map (a) and AAR (b) view of a successful Attack scenario

The attack scenario was not as disorienting as chase, probably due to daylight conditions. We observed far less wasted time at the beginning of each run. Groups had a plan and they executed it. This applied to OPFOR as well. One OPFOR group left defense of the compound to the AI OPFOR and went out to hunt the APDs and their operators. This strategy was not very successful because once they fired on an APD and were detected, they were quickly eliminated by the faster, better armed APDs with effective long range sites. Map usage when moving the avatar or APD was particularly important in this scenario.

Another difference in this scenario was that each BLUFOR player was given a truck to quickly move his Soldier to a new location if desired. Unlike the Chase scenario where it was unlikely that BLUFOR would lose an APD until the firefight at the very end, in Attack, a BLUFOR player could lose his APD at any time. Therefore, the positioning of the Soldier became more important to ensure cover and concealment while maintaining situational awareness of the battlefield. Even if the APD was lost, the player still had an armed Soldier to complete the mission.

The APD offered a large visible target for the OPFOR's RPGs[3]. As such, more than half of the players suggested that the APD might be an excellent diversion to cover the actual movement of forces. If they were inexpensive and essentially disposable, they might be capable of masking the movement of a large force. Another suggestion was to protect the APD with armor but not arm it with a weapon at all. Instead, it could be used as a mobile shield and supply transport for foot mobile soldiers during movement to contact.

Defend Scenario

In the Defend scenario APDs were used to protect an unfortified position from an attack of a numerically superior force. BLUFOR typically positioned their APDs in front of the position with their avatars protected behind a solid wall. In this scenario, multiple APDs were made available so that when one was lost, a replacement was immediately available for use.

This scenario offered the least variation in strategy due to the parameters of the scenario design. The large OPFOR with RPGs along with the availability of multiple APDs often resulted in an APD "graveyard" in front of the unfortified position. In all sessions, the default strategy was to rely on the superior armor and firepower of the APDs to both attack the oncoming OPFOR and defend the position. Movement away from the position would have left it far too vulnerable given the number of OPFOR and the speed with which they attacked the position.

[3] Rocket-Propelled Grenade

DISCUSSION

The recommendations received from player teams were focused on (1) the Wingman concept and (2) ESP and the utility of game environments to explore new concepts. The program office defined the critical output as the concept of operations (CONOPs) of how Soldiers most effectively used the APD and the characteristics of Wingman that allowed them to be successful. Of secondary importance was the ability to vary vehicle and scenario parameters to observe and measure the value of different performance metrics.

Wingman Concept

While our scenarios focused on only three pre-conceived methods of employment for Wingman, our players expanded that list significantly during the debriefing:

- *Reconnaissance*: APD has a greater ability to be aggressively applied without fear of casualty or capture. It could be configured with multiple sensors, video communications, or armament. Ground-based reconnaissance may also be a powerful alternative to UAV reconnaissance when weather interferes with the mission.
- *Transport*: Over short distances, APD is useful for transporting people, equipment, ammunition, and supplies.
- *Ambush*: APD is maneuvered to a strategic position and could lie in wait there indefinitely.
- *Breaching*: APD could be configured specifically for breaching walls, fortified doorways, or other strong points that are typically dangerous for personnel to breach.
- *Mobile Mine*: If light and inexpensive, APD could be armed with explosives, quietly maneuvered into the adversary's position, and detonated.
- *Defense*: As an unmanned patrol, APDs could be used to secure or expand the perimeter. Unlike a manned perimeter, players pointed out that one would want the APD to take fire as this identifies the position and possibly strength of the adversary.
- *Attack*: APD must be reconfigurable, possibly even within a mission (e.g. switch from one weapon to another)

ESP appears to be an excellent way to explore human interfaces to systems. As configured in our study, Wingman has limitations, but we were encouraged that the game environment was so effective at identifying what Soldiers would want the interface to be able to do. Among the recommendations, were:

- *Navigation*: Simplify the controller by allowing waypoints to be used so that the APD could auto-drive along a preset path to an objective bypassing obstacles through the use of sensors. The APD could have an autonomous mode that would allow the operator and APD to function simultaneously. A map chip would be useful.
- *Controller*: Wingman needs a specialized controller. The complexity of the mission did not map well to a conventional keyboard and mouse. Most players felt that a typical game controller would be more appropriate.
- *"Pre-sets":* Wingman is a complex vehicle. There are (or could be) multiple configurations for sensors, navigation, or weapons. Players wanted to be able to pre-set several configurations and then switch to each with a single button rather than work through menus to turn lights off, activate NVG, etc.

There was a lively discussion about whether the Wingman APD should be a ground-based unmanned vehicle where the operator remains at a safe distance from danger using a sophisticated interface to control the vehicle as opposed to being controlled by an on-site Soldier who could directly see the APD. A related issue was the complexity of managing the turret and the navigation concurrently. Some players suggested that maybe Wingman should have two operators – one for the turret/weapon and one for the navigation. Players voiced concern about how Wingman alerts the operator of its damage status while employed and then how and at what level maintenance could be accomplished. As the APD takes fire, the interface does not present system "health" status to the player (e.g. status of mobility, sensors, communications, fuel/battery, ammo, and weapons). Lastly, players commented on the potential of creating a moral hazard concerning the use of a lethal robotic weapon system against a human adversary.

ESP Concept

Players almost universally endorsed the concept of using game environments as a testing ground for early ideas with 23 of 24 reporting that they would play this or similar games in the future. However, there were artificialities in our study that ESP will need to address such as co-location of our players. They spoke freely to each other before, during, and after each scenario. ESP could use VOIP[4] communications to enable speaking but capture for analysis would be limited to processing of automated transcriptions without the ability to observe and capture inflection. Also, we gathered our players for a detailed AAR debriefing session. ESP is distributed, therefore if there is an AAR mode, it must be meaningful to players or they will simply skip it. Our VBS2 implementation was instrumented only as far as the built-in AAR was instrumented, limited to shots fired and virtual enemy KIA/WIA. It is imperative that ESP allow the scenario author to specify metrics to be captured.

We asked players if they would have preferred to configure their APDs from components rather than be given a specific APD for each scenario. Most said they would have preferred to build their own, especially if they had attempted scenarios multiple times. After one run, a player starts to understand the limitations of a configuration and is able to express what additional characteristics are desirable. The ESP concept encourages players to explore new equipment and scenarios. Again, we were encouraged by player responses which ranged from recommendations to improve the resilience of the armor to the proposed employment scenario as a resource in support of village stability operations. We asked players if they would author new scenarios or modify existing scenarios provided they were given the tools to do so. There was a mixed response to this. Some players naturally want to design new "levels," others just want to play and master the levels provided. We were encouraged to hear that a large group of players viewed scenario editing as a part of the game, or as a reason why they would want to play ESP games; it is a part of the competition. Lastly, we asked about the fidelity of the game environment. Players commented on artifacts of VBS2 that were somewhat irritating. For example, an APD became hung up on a small bush because VBS2 represented it as a solid obstacle when the real APD would have easily rolled over it. The spatial disorientation and awareness of noise and light emissions in the game environment represent some of the weaknesses of system evaluation in the game medium due to fidelity. Even so, players readily adapted to the lack of fidelity after only a few attempts and were able to draw reasonable conclusions based on what they saw and experienced in the scenarios. Given that the ESP concept is founded on an assumption that low fidelity game environments can be useful for early assessment, we found this to be very encouraging. Furthermore, the experience generated warfighter feedback that, otherwise, would not have been collected. This study demonstrated that useful data can be gleaned from these types of environments.

CONCLUSIONS

Our ESP trial was able to produce valuable contributions to an actual acquisition program in the form of proposed methods for system employment, recommendations for the system interface, and hours of accumulated virtual usage data that offers a variety of proposed tactics and techniques in the context of realistic scenarios. ESP appears to excel in the areas of concern to the program office – concept of operations evaluation and linking capabilities to outcomes. We were able to create enough realism to elicit novel ideas that were testable and would readily scale up to a distributed game environment. Players clearly wanted to play, they wanted to win, and they were more than willing to talk about the experience. We found that individual motivation and friendly rivalry sparked incentive to meet the mission objectives and pursue successful employment strategies. Upon this baseline, it is reasonable to pursue ESP on a broader scale in a persistent, networked, game environment widely available for play by warfighters to contribute to a larger goal of obtaining insights and data on one or more proposed systems. Accepting the limitations of a game environment is critical. ESP scenarios are admittedly crude, yet we were able to gain important operator feedback at an early phase of development at extremely low cost. Collecting data useful for analysis will be nontrivial as we move from our laboratory to a distributed setting. Leveraging game analytic techniques will be imperative to the capture of relevant, digestible data for application to system attributes, specifications, or employment tactics. The next steps for ESP will be to increase the players' ability to customize a limited number of elements of the proposed systems being evaluated and to move to a distributed framework with instrumented scenarios to gather and analyze game data. The ESP concept appears to have a bright future to enable the Army to put Soldiers at the center of capability and concept development, where they belong.

[4] Voice over IP

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