



**Research Report 2014**

**Unmanned Aerial System Four-Dimensional Gunnery  
Training Device: Training Effectiveness Assessment**

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**October 2017**

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**United States Army Research Institute  
for the Behavioral and Social Sciences**

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**October 2017**

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# UNMANNED AERIAL SYSTEM (UAS) FOUR-DIMENSIONAL GUNNERY TRAINING DEVICE: TRAINING EFFECTIVENESS ASSESSMENT

## EXECUTIVE SUMMARY

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### Research Requirement:

This research effort examined the effectiveness of the GUAVA (Gunnery Unmanned Aerial Vehicle Application) four dimensional (4D) digital training device as described in James, Gallogly, and Miller (2017). GUAVA was designed and built as a tool to increase UAS Operators' mental model of the three dimensional (3D) space in which they operate and to supplement Gray Eagle UAS gunnery training. Training challenges, as identified by the Gray Eagle Master Gunner, in the current UAS Gunnery program of instruction (POI) included developing a visual representation that depicted all aspects of an autonomous or remote engagement. Dynamics of missile flight path, UAS position, exclusion zones, offset geometry, and friendly/enemy positions were some of the factors considered and represented in GUAVA to establish UAS operators' mental models. Accordingly, we specifically sought to determine whether the use of GUAVA in the Gray Eagle UAS gunnery training program of instruction would increase Soldiers' situational awareness of the airspace in which they operated and impact their understanding of gunnery concepts.

### Procedure:

Two GUAVA systems were provided to 2-13<sup>th</sup> Aviation Regiment Gray Eagle Instructors for use within the classroom portion of the GE Gunnery POI. Early collaboration between research team members and GE instructors identified when and how to insert GUAVA into the classroom gunnery training. Instructional examples for each scenario along with instructor training were provided prior to the implementation of GUAVA within the GE POI.

A matched group pretest-posttest quasi-experimental design procedure was applied to three classes of Gray Eagle students was conducted from December 2016 through April 2017. The control group conducted scheduled training with no intervention (without GUAVA), while the experimental group conducted scheduled training with an experimental intervention (with GUAVA). Pretest and posttest results were collected and analyzed to determine the impact of GUAVA on student learning.

### Findings:

We failed to find any statistically significant increase in gunnery knowledge for the group using GUAVA as compared to a control group receiving standard gunnery instruction. However, there was considerable interest in the technology from the Gray Eagle Gunnery trainers for the technology, and they see potential in expanding the applications.

## Utilization and Dissemination of Findings:

Results of this effort were presented to the 2-13<sup>th</sup> Aviation Regiment UAS Training Committee members and MQ-1C Gray Eagle Course Supervisors, Course Managers, and Instructors on 10 May 2017.

UNMANNED AERIAL SYSTEM (UAS) FOUR-DIMENSIONAL GUNNERY TRAINING  
DEVICE: TRAINING EFFECTIVENESS ASSESSMENT

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# **Unmanned Aerial System (UAS) Four-Dimensional Gunnery Training Device: Training Effectiveness Assessment**

## **Background**

U.S. Army training and education policies, directives, and execution is constantly evolving to better prepare Soldiers for an ever-evolving operational environment (OE). A common thread is the use of technology in the classroom. The recent update and release of U.S. Army Training and Doctrine Command (TRADOC) Pamphlet 525-8-2 *The U.S. Army Learning Concept for Training and Education 2020-2040* (ALC-TE) in April 2017 stresses the importance of enhancing learning in the classroom, field, and through self-development. It provides a vision of the future learning environment where technology will supplement or replace many of the traditional means of individual and collective learning (TRADOC, 2017, p. 11). This research effort was one instance of technology supplementing a traditional means of providing instruction.

In 2009 and 2010 the U.S. Army successfully integrated and fired Hellfire missiles from the MQ-1C ERMP (Extended Range Multi-Purpose) unmanned aerial system (UAS) and subsequently announced the deployment of four armed newly renamed MQ-1C Gray Eagle UAS systems to Afghanistan piloted by Soldiers (Leipold, 2010). Since the initial deployment Soldiers have and are currently flying the MQ-1C Gray Eagle UAS in support of operations throughout the world.

The acquisition of armed UASs for Army Aviation with the resulting transition from reconnaissance, surveillance, and target acquisition (RSTA) to RSTA and *direct fire engagement* missions has necessitated modifications to Gray Eagle UAS Operator individual training to include gunnery within the program of instruction (POI) (Capri, 2014). Updated U.S. Army doctrine outlines Gray Eagle UAS operator proficiency requirements for Combat Aviation Gunnery (Department of the Army [DA], 2014a) to include knowledge through Gunnery Table V. Specifically, the Gray Eagle operator must proficiently exercise the ability to “engage and achieve required target effect standards on stationary and moving targets” (DA, 2014a, p. 7-6).

## **U.S. Army UAS Operator Training**

Current Army UAS training for operators of the Shadow and Gray Eagle (referred to as GE from this point forward) systems occurs at Fort Huachuca, Arizona in the 2-13<sup>th</sup> Aviation Regiment. The Shadow UAS is considered a weaponized platform as the payload consists of a laser designator and range finder only, whereas the Gray Eagle UAS is considered an armed platform as it carries munitions as part of the primary operational configuration (DA, 2014a). Soldiers attend an eight-week common core curriculum followed by platform-specific training – 18 weeks for Shadow and 25 weeks for GE. The curriculum consists of classroom instruction, simulation training, and live-flight exercises that stress the employment of the UAS and the associated payloads. Simulation and live-flight training are conducted using simulated and live ground control stations (GCS) which provide key information on flat panel screens that is text based or two-dimensional (2D) graphics. Where the curriculum differs between the Shadow and

GE airframes is that GE has the capability of carrying and launching four Hellfire missiles and, as such, operator training must include how to fire these missiles.

### **Problem Definition**

At present, U.S. Army GE individual level training introduces tenets of gunnery in Common Core training, followed by payload-specific gunnery instruction in UAS platform-specific training. Laser designation and missile engagements are introduced in classroom curricula and subsequently exercised in a simulation environment. Upon demonstrating proficient use of laser and/or weapons deployment in simulation, UAS operators' gunnery knowledge and skills are reinforced in a live culminating training exercise.

Training challenges in the current UAS Gunnery curriculum include developing a visual representation that depicts all aspects of an autonomous or remote engagement as well as building Soldiers' mental models of the three-dimensional space in which they operate. Dynamics of missile flight path, UAS position, exclusion zones, offset geometry, and friendly/enemy positions are some of the factors to consider in establishing UAS operators' mental models. Successful individual gunnery training should enable UAS operators to understand the impact of three-dimensional parameters plus time (fourth dimension [4D]) to employ maximum weapons effectiveness and/or accept tolerable levels of diminished capabilities.

### **4D UAS Gunnery Training Device**

The initial phases of this research effort resulted in the development of a 4D UAS gunnery training device (James, Gallogly, & Miller, 2017). GUAVA (gunnery unmanned aerial vehicle application) is a 4D training device developed using Unity software and zSpace hardware. 3D scenarios are displayed on a high-definition monitor and viewed through the use of polarized passive eyewear. Users interact with the scenarios via a 3-button stylus and are able to manipulate the models and graphics along three axis. Figure 1 depicts the GUAVA training device.

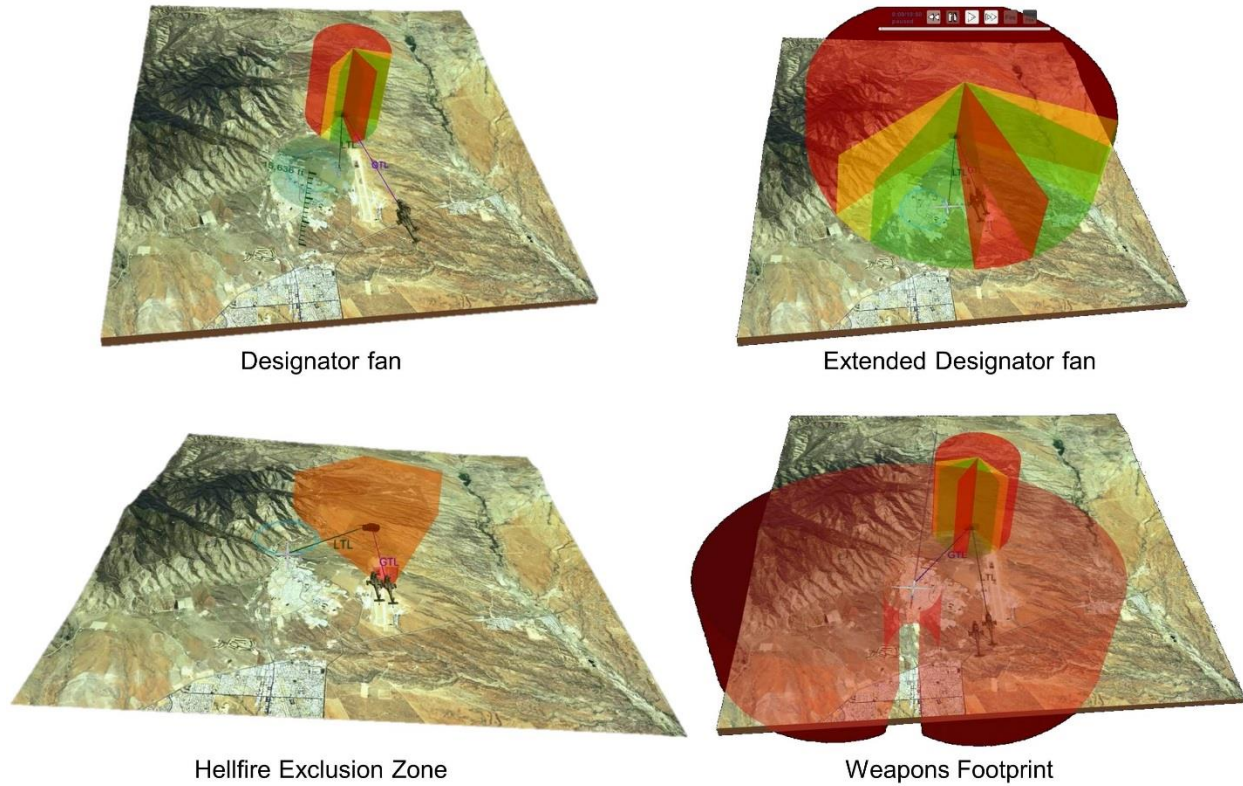


*Figure 1.* GUAVA desktop training device. The training device was developed to enhance the Soldier’s mental model of the 3D airspace in which they operate.

GUAVA contains three scenarios that were developed based on TC 3-04.45 *Combat Aviation Gunnery* UAS minimum proficiency levels.<sup>1</sup> Two scenarios depict remote engagement conditions whereby the UAS would designate a target for an Armed Weapons Team (AWT) to engage, or the AWT would designate for the UAS to engage. The third scenario depicted an autonomous engagement where the UAS would self-designate and engage. Three-dimensional graphics were developed to depict exclusion zones, offset geometry, and friendly/enemy positions. Figure 2 depicts examples of the 3D graphics incorporated into GUAVA.

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<sup>1</sup> Minimum proficiency levels are “critical skills that must be trained and evaluated” (DA, 2014a, p. 7-2).



*Figure 2.* UAS Gunnery 3D graphics. 3D graphics were developed to depict safety and engagement zones that Soldiers must consider when operating the UAS.

GUAVA scenarios are not static or “canned” scenarios that are played and repeated, rather, GUAVA provides the user with the flexibility to manipulate models to demonstrate and reinforce multiple concepts of UAS gunnery. A heads-up display (HUD) was added to the training device as a means for the Soldiers to mentally connect the 3D image seen in GUAVA to the information provided by the 2D panels in the actual UAS ground control stations. Figure 3 depicts the HUD.

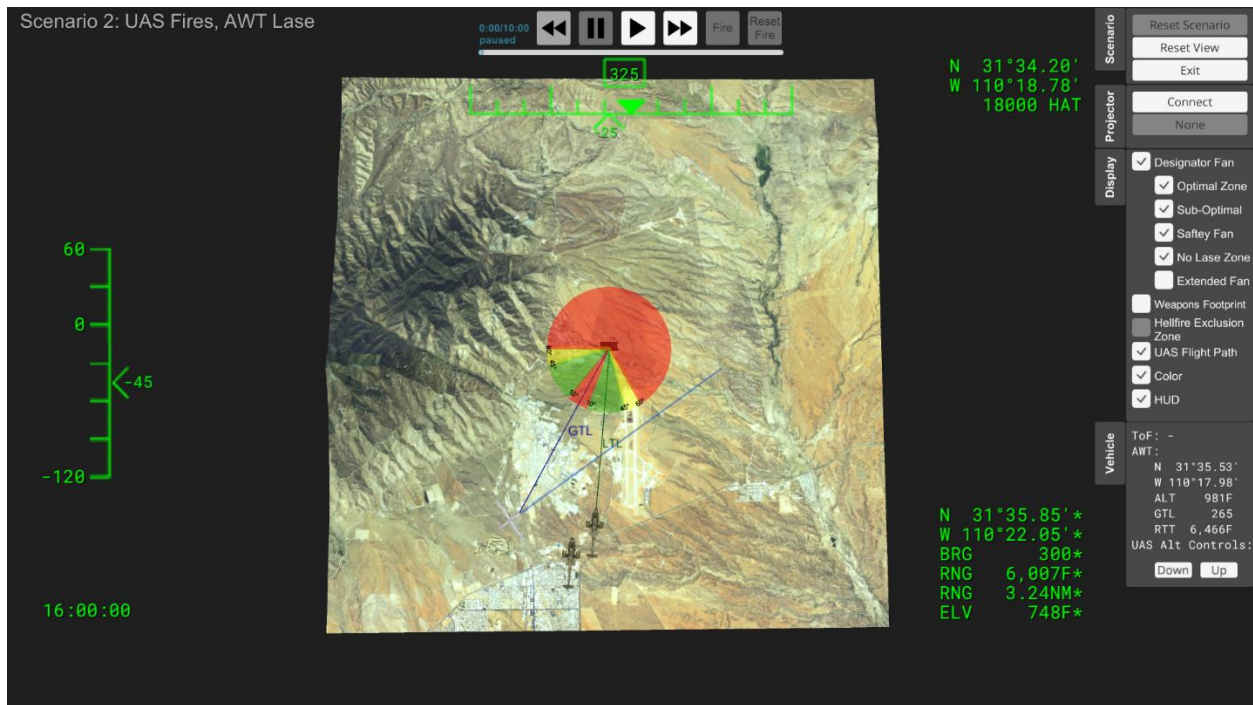


Figure 3. GUAVA heads-up display. The HUD information (green text) is displayed in a format similar to what the Soldiers would see in an actual UAS ground control station.

The HUD information dynamically changes as the user moves one, or all, of the three models – the UAS, the AWT, or the target. HUD information includes: UAS location and heading, payload offset, payload elevation, UAS height above target (HAT), UAS altitude, bearing and range to target, and AWT location and heading.

## Instructor Training

This research effort required the GE Instructors to use GUAVA during GE gunnery classroom training. The intent was to connect GUAVA to the classroom audiovisual equipment and display the application via an overhead projector onto the screens at the front of the classroom. Instructors would display the current POI 2D training materials on one screen while simultaneously displaying GUAVA on the second screen. Soldiers would be able to view both sets of material at the same time. Instructors would manipulate GUAVA to reinforce key points during training.

To this end, the research team met with four GE instructors to determine when, during training, GUAVA would be displayed. Previous training observations of the classroom training guided the discussion between participants. The GE Master Gunner and three instructors, one per shift, together with two research team members discussed how to integrate GUAVA into the classroom training. The discussion focused on sequencing of lesson plans and content to aid in scaffolding learning first, followed by including GUAVA as a tool to bring it all together. The research team provided an instructional guide to the instructors for their consideration when standardizing training. The instructor's guide can be found in Appendix A.

## Research Objective

The objective of this research was to assess the training effectiveness of 4D visualization training device for GE UAS gunnery in support of individual training and refresher training. Use of the 4D training aid within the GE gunnery classroom POI could show an increase in student understanding of the concepts of direct fire engagements.

## GUAVA Training Effectiveness Research Effort

### Method

**Research design.** The research design was contingent on the availability of Soldiers in the GE operator course. GE Operator training is conducted five times in a calendar year. The optimum class size is 12 Soldiers per shift for a total of 36 Soldiers per class. In some instances, class size is increased due to unit manning requirements. We had access to three classes of Soldiers based on the timeframe of this research effort.

This was a quasi-experimental design as we had no influence over how Soldiers were assigned to each class and Soldiers are not randomly assigned to each GE Operator class. Class fills are based on when the Soldier is accessed into the Army, completes Basic Combat Training (BCT), and completes 15W common core training. Additionally, some Soldiers, who are re-classifying into the military occupational specialty (MOS) as GE Operators, are added to each class. Each of the five classes in the calendar year is filled in a similar manner.

We elected to use a pretest-posttest design with a control group and an experimental group. The control group would conduct GE gunnery training as scheduled within the POI with no manipulation (without GUAVA). The experimental group would conduct the same scheduled GE gunnery training with the inclusion of the experimental intervention (with GUAVA).

**Participants.** There were  $N = 81$  Soldiers attending GE Operator training who participated in this research effort. Classes – 027, 001, and 003 – became the control and experimental groups. Soldiers attending the GE Operator training were from the enlisted ranks in the grades of E1-E7 (Private through Sergeant First Class). Soldiers were either new to the Army and the MOS or were considered re-classes—e.g., Soldiers with prior UAS MOSs. Soldiers had completed the common core training and were in the second week of GE specific training.

**Control group.** The control group consisted of 50 Soldiers: 40 Soldiers attending GE Operator training class 027 and 10 Soldiers attending class 001. Soldiers were divided into three shifts for training based on resource constraints, i.e., number of instructors, simulators, and aircraft available. The midnight shift conducted training from 0001-0800 hours, the day shift from 0800-1600 hours, and the late shift from 1600-2400 hours. Soldiers ranged in rank from Private (PVT) to Staff Sergeant (SSG) with UAS experience levels ranging from none to multiple system certified. Table 1 lists the Soldiers experience level by group.

Table 1

*Control Group participant UAS experience level by group*

Group	None	Hunter	Shadow	Other* (Raven, Puma, Wasp, Warrior A)
Midnight Shift ( <i>n</i> = 13)	8	2	3	2
Day Shift ( <i>n</i> = 13)	11	1	1	1
Late Shift ( <i>n</i> = 14)	6	3	5	3
Day Shift** ( <i>n</i> = 10)	9		1	

*Note.* \* Seven Soldiers were certified on multiple UAS systems, for example, one Soldier was certified on the Shadow and Warrior-A: \*\* The day shift from class 001. This shift was combined with the control group as GUAVA was not used during the POI.

**Experimental group.** The experimental group consisted of 20 Soldiers attending GE Operator training class 001 and 10 Soldiers attending class 003. As with the control group, this group was broken down into three shifts attending training on the same schedule as the control group. Soldiers ranged in rank from PVT through SSG with UAS experience levels ranging from none to one system certified. Table 2 lists the Soldiers experience level by groups.

Table 2

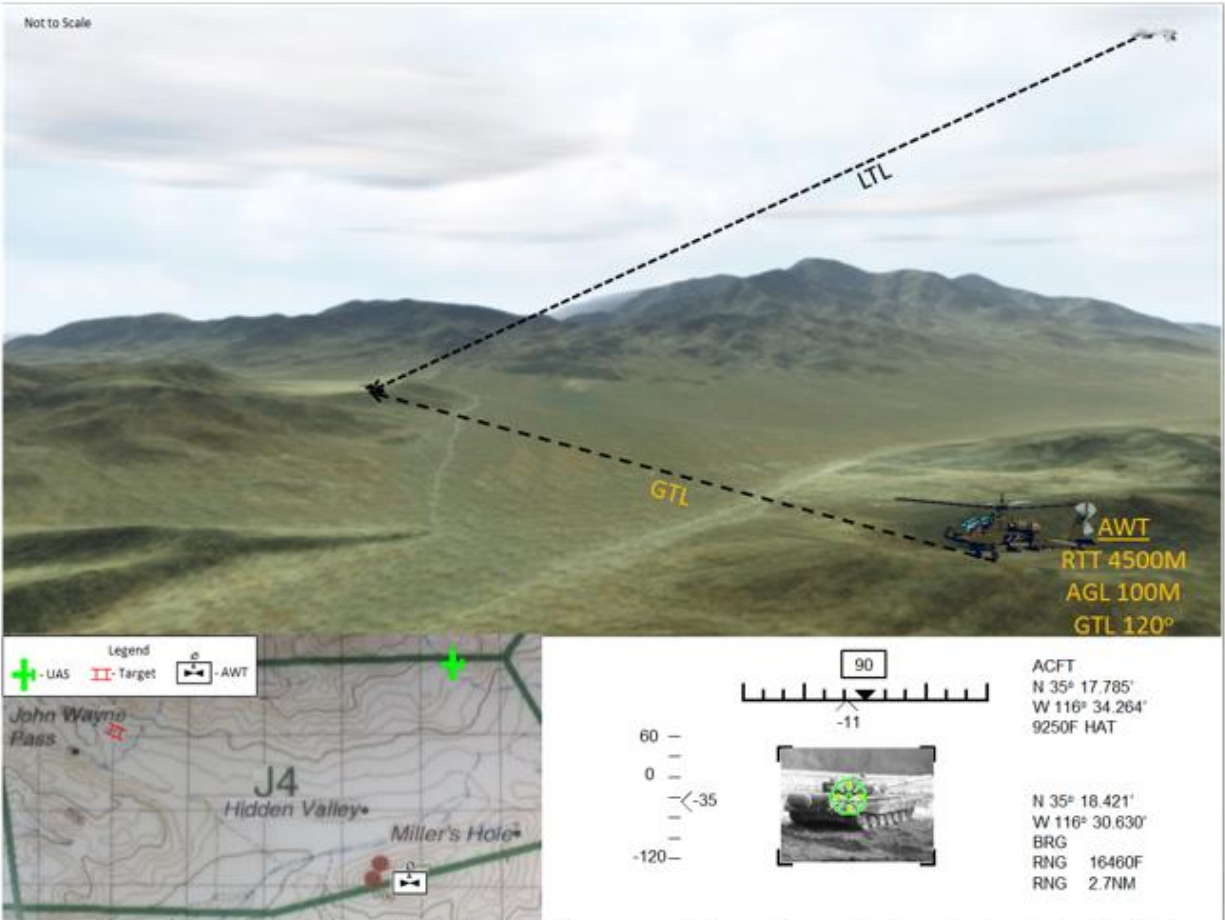
*Experimental Group participant UAS experience level by group*

Group	None	Hunter	Shadow	Other (Raven, Puma, Wasp, Warrior A)
Midnight Shift ( <i>n</i> = 8)	7		1	
Late Shift ( <i>n</i> = 12)	11		1	
Late Shift* ( <i>n</i> = 10)	10			

*Note.* \* The late shift from class 003.

**Data collection instrument.** The research team developed, reviewed, and revised a GE Student Gunnery Test with input from the GE Master Gunner and GE instructors. The test was developed to measure the construct of UAS gunnery concepts, that is, students’ levels of knowledge of safety and exclusion zones, offset geometry, and laser operations.

The test was designed to require students to interpret panels of information as depicted in Figure 4. The two lower panels provided information that was similar to the information provided in the UAS ground control station – a 2D map image overlaid with UAS and AWT locations, and a payload image with corresponding HUD output. The upper panel provided information presented as graphical representations of the airspace: this view is not found within the UAS ground control station. Interpretation of all three panels of information was required to answer the scenario questions. Additionally, a glossary of terms and acronyms was provided as some of the information had yet to be covered in the POI. A situational statement was followed by six questions. We provided the students the option of selecting “I don’t know” as the pretest would be administered prior to the UAS gunnery lessons.



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the "Missile Away" step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don't know, check the box.

- |   |   |                                       |
|---|---|---------------------------------------|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT   | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT  | <input type="checkbox"/> I don't know |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan | <input type="checkbox"/> I don't know |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range  | <input type="checkbox"/> The payload elevation is out of the acceptable range   | <input type="checkbox"/> I don't know |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> I don't know |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude   | <input type="checkbox"/> I don't know |
| <input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location   | <input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS  | <input type="checkbox"/> I don't know   |                                       |

Figure 4. UAS gunnery concepts test example. Soldiers were required to interpret the information provided in each panel to answer the scenario questions.

The test was devised using a review-revise iterative process. Initial test content – graphics and open-ended questions – were developed based on training observations then submitted to the GE Master Gunner for feedback. Graphics and questions were refined, a second version of the test was developed, and further feedback was obtained from the GE Instructors. Review of the second version of the test was conducted in concert with the demonstration of GUAVA to the GE Instructors. A research team member had the opportunity to present the test to each instructor and document the feedback. Further refinement to the information panels resulted from the review. Type of information and how it was displayed was adjusted to closely match the information provided in the ground control stations. The test was submitted to the GE course supervisor, manager, and instructors for one final review in preparation for use with the control and experimental groups.

The test consisted of eight GE gunnery scenarios sub-divided into three test versions, one for each shift (see Appendices B, C, and D). Each version consisted of one demographic question – to determine participants’ prior UAS experiences – and four scenarios with six questions per scenario:

- Version A – Scenarios 1-4,
- Version B – Scenarios 3-6, and
- Version C – Scenarios 5-8.

The questions for each scenario remained the same while the panel information differed. That is, the location of the UAS and AWT changed, along with the corresponding information in the 2D map and HUD.

**Data collection procedures.** Data collection occurred twice for each shift within each class – pretest and posttest. Through coordination with the GE Course Manager, we integrated our collection sessions into the gunnery training. Pretests were administered at the beginning of training and posttests were administered after completion of the first day of simulation training. Time between pretest and posttest were similar for each shift to mitigate any differences in knowledge acquisition.

Each collection effort began with the administrative requirements for data collection (introduction of the research purpose, informed consent, privacy act, and assignment of a unique identifier), followed by the administration of the tests. Time data was collected for each session, that is, the total time for each shift to complete the test. Scores were tabulated for each test for comparison between tests and between groups.

## Results

GE Student Gunnery Tests were scored for the number of correct responses for both pretest and posttest. When prior experience with UAVs was examined, there was a much larger number of MOS transfers in the control group. However, there was no difference in the pretest scores between the students with previous UAV experience and the students who had no previous UAV experience, so no action was taken to remove these students from the analysis.

A two-way repeated measured analysis of variance was conducted on the data to examine the effects of Pre- vs Posttest, the effects of using GUAVA and the interaction of these variables.

There was a significant difference,  $F(1, 79) = 67.19, p < 0.001$ , for score on the pretest as compared with score on the posttest. As can be seen in Figure 5, score on the posttest were much higher as compared to the pretest. This indicates that learning did take place during the Gunnery course.

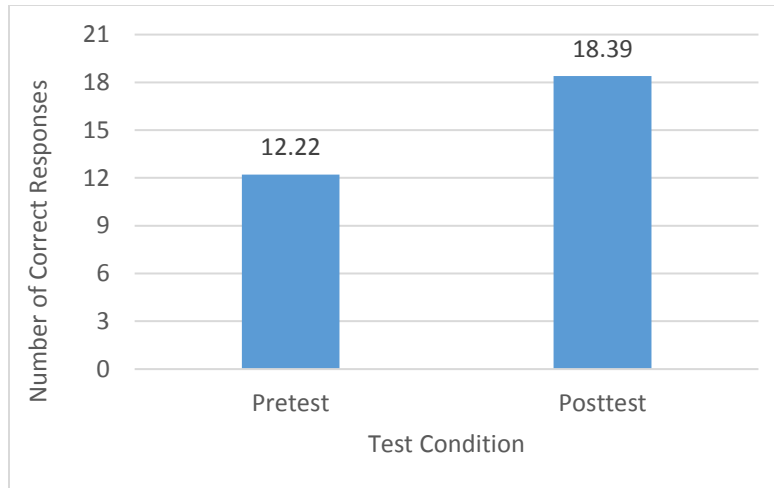


Figure 5. The Number of Correct Responses on the GE Student Gunnery Test for Pretest and Posttest Conditions.

Comparing the experimental and control groups' performance on the GE Student Gunnery test no overall difference was found,  $F(1, 79) = 0.254, p = 0.615$ . As can be seen in Figure 6, performance was virtually identical for the two groups combining pretest and posttest performance.

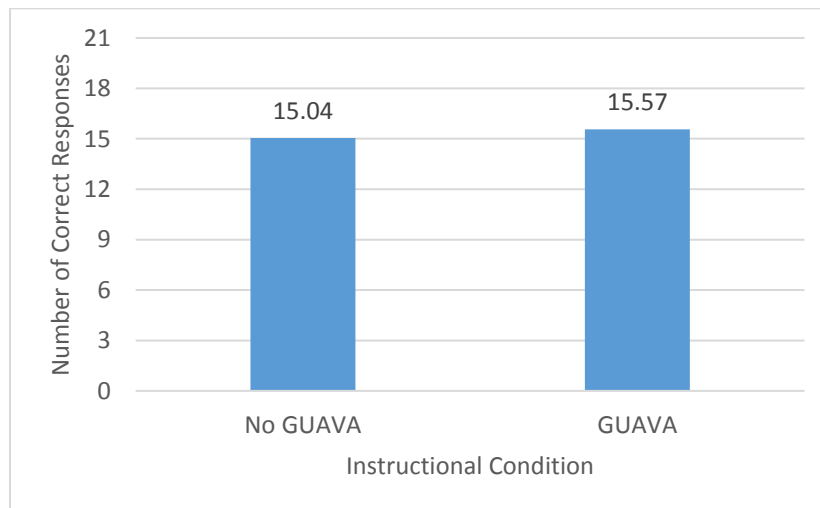


Figure 6. The Number of Correct Responses on the GE Student Gunnery Test for No GUAVA and GUAVA conditions.

Finally, the interaction of the two variables was non-significant as well,  $F(1, 79), = 3.51, p = 0.065$ . Examining Figure 7, the students receiving GUAVA as part of their gunnery instruction

had a steeper increase in the number of questions correctly answered from the pretest to the posttest when compared to the students who had the traditional gunnery instruction.

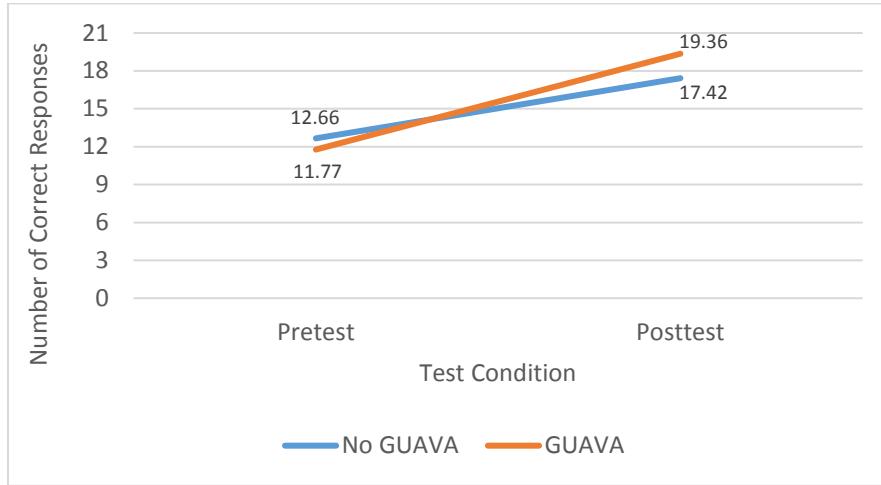


Figure 7. The Number of Correct Responses on the GE Student Gunnery Test for No GUAVA and GUAVA conditions as a function of Pretest and Posttest.

## Discussion

This research was conducted to assess the effectiveness of GUAVA, a 4D visualization training device for GE UAS gunnery, in increasing the UAS operators understanding of UAS gunnery concepts and building their mental models of the 3D airspace in which they operate.

We failed to find any statistically significant increase in performance on the GE Student Gunnery Test for the group using GUAVA. There was no overall performance gain from using GUAVA nor were there gains specifically in the posttest for students in the GUAVA training group. There are several possible complications that occurred during the course of the study that may have contributed to this result. These are discussed below in more detail. It does appear from the analysis of the pretest and posttest data that the GE Student Gunnery Test was sensitive to learning of gunnery concepts.

## Acceptance and Perceived Applicability

While the results of the effectiveness assessment did not indicate a significant difference in learning between the control and experimental groups, the acceptance and perceived applicability of the technology was recognized by GE leaders, training developers, and instructors.

Feedback indicated that overall there was a general consensus that the technology used [4D] and the content developed could enhance the training of UAS operators as currently no other training device or simulator exists that provides the operators with a dynamic view of the airspace and weapons engagement and safety zones in three dimensions. However, they did indicate that scenario content relevance could be improved as operational conditions are

constantly changing (i.e., different munitions being released from fixed-wing aircraft overhead) and should be easily replicated and reflected in a training device.

Participants in the project out-brief indicated that they thought the technology, albeit with modifications, would be applicable to additional courses conducted within the 2-13<sup>th</sup> Aviation Regiment, such as the Shadow UAS operators course, the Instructor/Operator (I/O) trainers course, and the UAS Master Gunner course. Of note, recently re-deployed NCOs now in the roles of course managers and curriculum developers indicated that they thought the technology had application with Forces Command (FORSCOM) units for use as a pre-mission planning tool and a post-mission after action tool (recreating the engagement conditions for discussion).

### **Recommendations**

Although this effort represents a limited examination of the use of technology to supplement traditional learning, lessons learned from this effort could be applied to future efforts. This effort went beyond a “book-in-a-box” solution in that an emerging technology was selected specifically to address previously identified learning deficiencies. As with any introduction of new technologies steep learning curves were encountered by both groups involved – the research team, but more importantly, instructors of the GE UAS Operators course.

As stated upfront, ALC-TE 2020-2040 envisions technology supplementing, if not replacing, traditional means of providing learning (2017); the consequences of this statement will result in more attempts to introduce technology into the classroom. Based on our efforts, we offer the following recommendations when implementing and assessing the use of technology.

### **Needs Analysis**

In our case, the problem had already been defined, “improve the UAS operator’s understanding of, and assist in building a mental model of, the three-dimensional space in which they operate.” Armed with the problem and a cursory understanding of the subject matter, it would have been simple to begin devising a solution. However, we recognized the need for further exploration. We blocked out time upfront in the research effort to gather as much information from as many sources as possible to help define the solution. We sat through multiple UAS gunnery classes, observed simulator training, reviewed doctrinal publications and instructional material, and exploited the experiences of the senior Gray Eagle Master gunner (a UAS gunnery expert). From our initial efforts we gained a better understanding of how to craft the solution and formulated ideas of how to implement the solution. We recommend conducting an exhaustive analysis up front for two reasons: (a) to gather a detailed list of requirements, and more importantly (b) to interact with the end users. Interacting with end users, in this case, the instructors and managers of the GE course, established relationships and initiated instructor buy-in which became essential as the research effort progressed.

### **Managing Expectations**

Soldiers are taught to identify a problem, determine a solution, and implement said solution in a short time frame. This mentality is appropriate for the fast moving situations the

Soldiers are exposed to. However, this mentality can be detrimental to a research effort that involves building a technological solution which spans 12 – 18 months. Managing the end users expectations early and often will provide a smooth transition from requirements gathering through development and into deployment and assessment. One additional point, managing expectations can start again when a changing of the guard happens. Soldiers and DA civilians can move on during the course of the research effort, be prepared to establish new relationships and manage new expectations.

### **Technological Solution Development**

The relationships established upfront impact the solution development. The subject matter expert (SME) becomes an iterative reviewer as the stages of content development occur. We presented to and received feedback from our SMEs throughout the development process. They clarified our initial interpretations of the requirements to ensure that the content met doctrinal and instructional needs, and addressed the identified learning deficiencies. Further review of a beta version of the solution by 17 instructors increased its utility and tangentially increased instructor buy-in. We recommend using the experts and end users to validate development, rather than developing in a vacuum.

### **Experimental Conditions**

Field research is messy; the researcher must work within the confines of the environment. In this case, we were limited based on the number of classes conducted within the research period of performance and the requirement for qualified instructors to use the technology. Our initial research design entailed using an early class as the control group with assigned instructors and a later class as the experimental group with the GE Master Gunner (the SME) as the primary instructor. We planned on delivering the technology early and providing training and examples of how to integrate the technology into the course POI. This early delivery would allow the SME to rehearse his presentation using the new technology.

However, just before data collection began, we were told that the SME would retire from the Army and not be available for the remainder of the research effort. The departure of the SME precipitated a crash course of action to prepare other instructors to use the technology. We delivered on time and provided training to a new group of instructors, but ultimately, even with instructor buy-in, these instructors did not become as familiar with the technology as we envisioned and had an impact on the training effectiveness assessment results. In hindsight, given the conditions that the course instructors had to use the technology, we should have planned for more time to train the instructors and show them how to integrate the technology into the POI. We recommend that during the initial stages of the research that implementation discussions are conducted to identify who will use the technology, when will the train-up occur and for how long, and what is the back-up plan should the primary instructor(s) become unavailable.

## **Future Research**

Our research effort was limited in scope as a result of time constraints and unforeseen circumstances. While our measures indicated a difference in learning at the initial stages of UAS operator training, a truer assessment of the effectiveness of the technology could occur in determining the far transfer of skills to the operational environment.

Additionally, as identified by the UAS cadre, 4D technology could be applicable to other domains within the U.S. Army and U.S. Air Force. As the UAS becomes more prevalent in the operational environment more Soldiers and Airmen on the ground and in the air will interact with them in Manned and Unmanned Teaming (MUM-T) roles. This technology could help increase situational awareness for these types of operations.

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## Acronyms and Abbreviations

AO	Aircraft Operator
ALC-TE	Army Learning Concept for Training and Education
ARI	U.S. Army Research Institute
AWT	Armed Weapons Team
BCT	Basic Combat Training
ERMP	Extended Range Multi-Purpose
GCS	Ground Control Station
GE	Gray Eagle
GT	Gunnery Table
GTL	Gun Target Line
GUAVA	Gunnery Unmanned Aerial Vehicle Application
HAT	Height Above Target
HUD	Heads-up Display
LTL	Laser Target Line
MOS	Military Occupational Specialty
MUM-T	Manned and Unmanned Teaming
PO	Payload Operator
POI	Program of Instruction
PVT	Private
RSTA	Reconnaissance Surveillance and Target Acquisition
SME	Subject Matter Expert
SSG	Staff Sergeant
UAS	Unmanned Aerial System

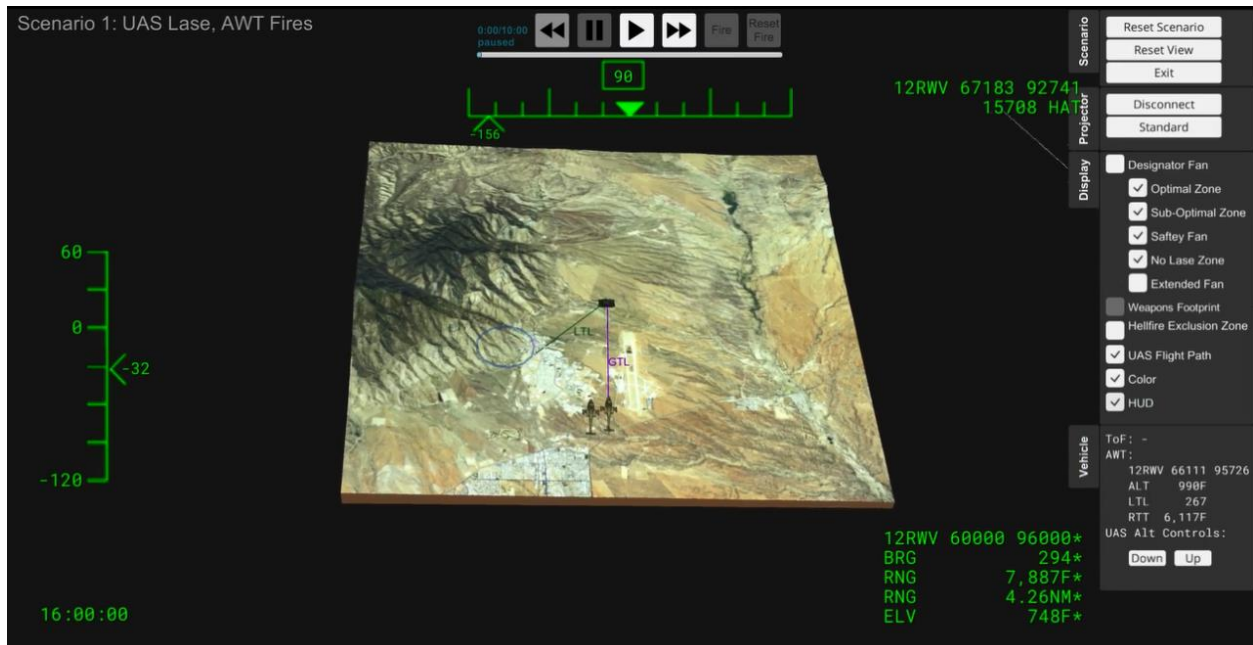
## Appendix A

### GUAVA Instructional Guide

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## Scenario 1 (Remote Engagement) – UAS (Designator) AWT (Shooter)

This Scenario has the UAS designating with a laser while an AWT fires a missile.



### List of relevant elements

- UAS
- UAS LTL
- UAS Flight Path
- Designator Fan
- AWT Team (two Apaches)
- AWT GTL
- AWT Hellfire Exclusion zone
- HUD
- Target

### Instructor high level use case example

This is high level to show an example of how the tool will be used to teach the concepts.

#### Pre-instruction GUAVA set-up

- Assistant Instructor (AI) loads Scenario 1
- AI toggles on UAS HUD by selecting the “HUD” button
- AI turns off UAS LTL color by de-selecting “Color” button
- AI toggles off Optimal Zone, Sub-optimal Zone, and Safety Fan by de-selecting buttons
- AI moves terrain on 3 axis to best display initial content

Instructional Lead-in

“We are now going to discuss the remote engagement gunnery concepts” “This scenario depicts the remote scenario with the UAS designating and the AWT launching” “This is one of the minimum proficiency level scenarios you will be required to perform as a UAS crew during gunnery qualification at your homestation”

- Primary Instructor (PI) toggles classroom display controls to show GUAVA on the big screen
- PI orients the class to the display
  - Libby Army Airfield
  - UAS
  - AWT
  - Target
- PI explains that the images shown within the tool are not what the student will see in the GCS.
- PI asks question
  - Q: What are the employment factors of a remote engagement which ensure proper and safe delivery of the Hellfire?
  - A: Offset geometry, Gun to Target Line (GTL), Laser to Target Line (LTL), target location, laser codes, and launch and delivery modes (TC 3-4.45, p. 14-70, para. 14-281)
- PI states “First we are going to discuss offset geometry and the LTL and GTL”
- PI asks question
  - Q: What is the maximum laser designation offset angle between the LTL and the GTL?
  - A: 60 degrees on each side of the GTL or a total of 120 degrees (TC 3-4.45, p. 14-56, para. 14-237 and p.14-72, figure 14-43)

PI Actions	AI Actions
	<ul style="list-style-type: none"> <li>• AI toggles on Designator Fan by selecting “Designator Fan” button</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses the offset angle between the GTL and LTL</li> </ul>	<ul style="list-style-type: none"> <li>• AI moves AWT to show how the designator fan moves with the GTL</li> </ul>
<ul style="list-style-type: none"> <li>• PI orients class to different zones within the designator fan</li> </ul>	<ul style="list-style-type: none"> <li>• AI rotates terrain to depict top-down view of designator fan</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses why lasing outside of the 120 degree offset angle impacts the delivery of the Hellfire</li> </ul>	<ul style="list-style-type: none"> <li>• AI moves UAS to depict lasing through the No-Lase Zone</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how and why this zone can be used to illuminate the target but is not the preferred zone.</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the 15° sub-optimal (Yellow) portions of the designator fan</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses why this is the best angle for lasing targets.</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the 35° Optimal (Green) portions of the designator fan</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses this area as it should be avoided for weapons release unless the situation necessitates</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the 20° Safety Zone (Red) portion of the designator fan</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how the angles expand at distance and that with the GE laser</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the extended view of the designator</li> <li>• AI moves UAS loiter in line with optimal zone</li> </ul>

PI Actions	AI Actions
capabilities lasing from a distance provides greater airspace in which to loiter.	<ul style="list-style-type: none"> <li>AI rotates the terrain to show the UAS orbit within the designator fan Optimal zone.</li> <li>AI toggles-off the designator fan</li> </ul>
<ul style="list-style-type: none"> <li>PI asks question</li> <li>Q: If the GTL is 360 or 0 degrees, what should the LTL be to lase through the optimal zone?</li> <li>A: Between 11 and 45 degrees or between 315 and 349 degrees</li> </ul>	
<ul style="list-style-type: none"> <li>PI highlights BRG reading in HUD</li> <li>Discusses difference between UAS heading and payload offset in HUD</li> </ul>	<ul style="list-style-type: none"> <li>AI moves AWT until GTL = 360 or 0 degrees</li> <li>AI moves UAS loiter to both optimal zones</li> </ul>
	<ul style="list-style-type: none"> <li>AI toggles-off Designator Fan</li> <li>AI moves AWT and UAS to different positions</li> </ul>
<ul style="list-style-type: none"> <li>PI asks question</li> <li>Q: Is this an acceptable position for the UAS to lase from?</li> <li>Students must use information provided in UAS HUD and AWT GTL reading to determine answer</li> </ul>	
	<ul style="list-style-type: none"> <li>AI toggles-on "Color" button</li> <li>AI toggles-on "Designator Fan" button</li> </ul>
<ul style="list-style-type: none"> <li>PI states "We are now going to discuss Hellfire launch and delivery modes in relation to this scenario"</li> </ul>	<ul style="list-style-type: none"> <li>AI toggles "Reset Scenario" button</li> </ul>
<ul style="list-style-type: none"> <li>PI asks question</li> <li>Q: As the designating platform in this scenario, what must you conform to in order to remain protected from inadvertently becoming the target for missile launched by the AWT?</li> <li>A: The Hellfire Exclusion Zone (TC 3-4.45, p. 14-70, para. 14-284)</li> </ul>	
	<ul style="list-style-type: none"> <li>AI toggles-on the hellfire exclusion zone to show students the zone</li> <li>AI rotates the terrain to show the zone from top-down view, side-view, and pseudo 3D-view.</li> </ul>
<ul style="list-style-type: none"> <li>PI discusses that the missile will fly within the hellfire exclusion zone based on the flight mode selected by the AWT – High, Direct, or Low</li> </ul>	
<ul style="list-style-type: none"> <li>PI discusses the dimension of the hellfire exclusion zone and how it relates to positioning of the UAS to ensure the UAS is not within the hellfire exclusion zone.</li> </ul>	<ul style="list-style-type: none"> <li>AI moves the AWT to depict how the exclusion zone moves with the launching platform along the GTL.</li> </ul>

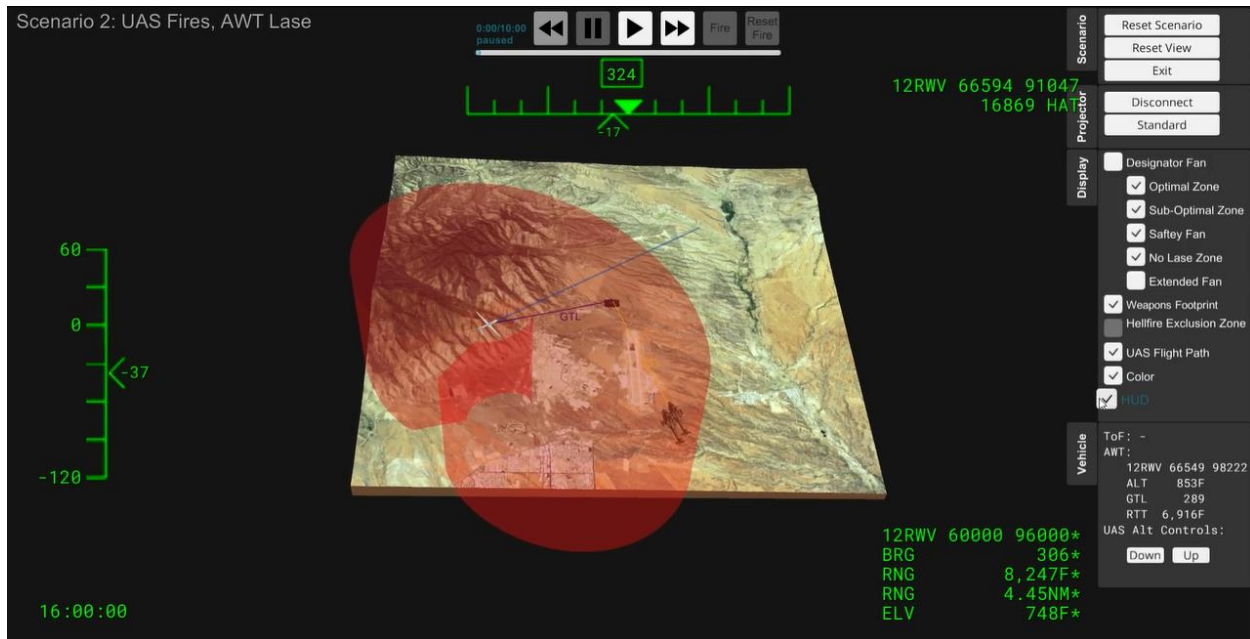
PI Actions	AI Actions
<ul style="list-style-type: none"> <li>PI discusses how the missile seeker head could acquire the source of the laser rather than the return on target is the UAS is within the hellfire exclusion zone.</li> </ul>	
	<ul style="list-style-type: none"> <li>AI clicks the Rest Scenario to return the scenario to the default position.</li> <li>AI toggles-off the hellfire exclusion zone.</li> </ul>
<ul style="list-style-type: none"> <li>PI direct the AI to click the Fire button</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks the play button the UAS moves along its orbit with the attached LTL.</li> </ul>
<ul style="list-style-type: none"> <li>PI explains that the change in color of the hellfire exclusion zone depicts the missile in flight</li> </ul>	
<ul style="list-style-type: none"> <li>PI directs the AI to pause the scenario when the hellfire exclusion zone changes color indicating the last 10 seconds of ToF</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks Pause button</li> </ul>
<ul style="list-style-type: none"> <li>PI discusses the importance of the last 10 seconds of ToF and laser movement on the target</li> </ul>	
<ul style="list-style-type: none"> <li>PI directs AI to click play, the scenario continues until the missile flight path depiction reaches the target and the target is destroyed.</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks Play button</li> </ul>
	<ul style="list-style-type: none"> <li>AI clicks Rest Scenario button</li> </ul>

Check on Learning

- Q: What is the maximum laser designation offset angle between the LTL and the GTL?
- A: 60 degrees on each side of the GTL or a total of 120 degrees (TC 3-4.45, p. 14-56, para. 14-237 and p.14-72, figure 14-43).
- Q: What is the terminal guidance time for a UAS as the designator, why?
- A: The last 10 seconds of missile ToF, to ensure the missile will guide to the intended target (TC 3-4.45, p. 14-45, para. 14-230 and table 14-13).

## Scenario 2 (Remote Engagement) – UAS (Shooter) AWT (Designator)

This Scenario has the UAS Shooting while an AWT lases



### List of relevant elements

- UAS
- HUD
- UAS GTL
- UAS Flight Path
- UAS Weapons footprint
- Designator Fan
- AWT Team (two Apaches)
- AWT LTL
- Target

### Instructor high level use case example

This is high level to show an example of how the tool will be used to teach the concepts.

#### Pre-instruction GUAVA set-up

- Assistant Instructor (AI) loads Scenario 2
- AI toggles-on the weapons footprint color by selecting Color button
- AI positions UAS to ensure that weapons footprint is red
- AI toggles-off the weapons footprint color by deselecting the Color button
- AI turns off the UAS flight path by deselecting the UAS Flight Path button
- AI moves terrain on 3 axis to best display initial content

#### Instructional Lead-in

“We are now going to discuss the second type of remote engagement” “This scenario depicts the remote scenario with the AWT designating and the UAS launching” “This is another of the minimum proficiency level scenarios you will be required to perform as a UAS crew during gunnery qualification at your homestation”

- PI toggles classroom display controls to show GUAVA on the big screen
- PI orients the class to the display
  - Libby Army Airfield
  - UAS
  - AWT
  - Target
- PI explains that the images shown within the tool are not what the student will see in the GCS.
- PI asks question
  - Q: What are the differences between this remote engagement and the one we just discussed?
  - A: UAS launching, AWT designating, no hellfire exclusion zone, weapons footprint, designator fan now aligned with UAS not AWT.

PI Actions	AI Actions
<ul style="list-style-type: none"> <li>• PI states that the GTL and LTL offset requirements are the same as previously discussed</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the designator fan</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how the designator fan moves with the GTL from the launching platform</li> </ul>	<ul style="list-style-type: none"> <li>• AI grabs UAS and moves it on the terrain</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how designating and firing platforms have to move to align themselves into the optimum positions</li> </ul>	<ul style="list-style-type: none"> <li>• AI grabs the AWT and moves it to depict how the LTL moves with the AWT</li> </ul>
	<ul style="list-style-type: none"> <li>• AI clicks the Reset Scenario button to return the scenario to the default position.</li> </ul>
<ul style="list-style-type: none"> <li>• PL asks question</li> <li>• Q: As the launching platform, what does the GCS display provide that enables you to determine if the target is within range of the missile based on your altitude and location?</li> <li>• A: The horizontal weapons engagement zone or commonly referred to as the weapons footprint.</li> </ul>	
	<ul style="list-style-type: none"> <li>• AI toggles-on the weapons footprint</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how the weapons footprint shape also changes based on the missile flight mode – High, Direct, and Low</li> </ul>	<ul style="list-style-type: none"> <li>• AI rotates the terrain to show the footprint from top-down view, side-view, and pseudo 3D-view.</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses what impacts the weapons footprint, i.e. slant range</li> </ul>	<ul style="list-style-type: none"> <li>• AI moves the UAS to depict how the footprint moves with the UAS.</li> </ul>

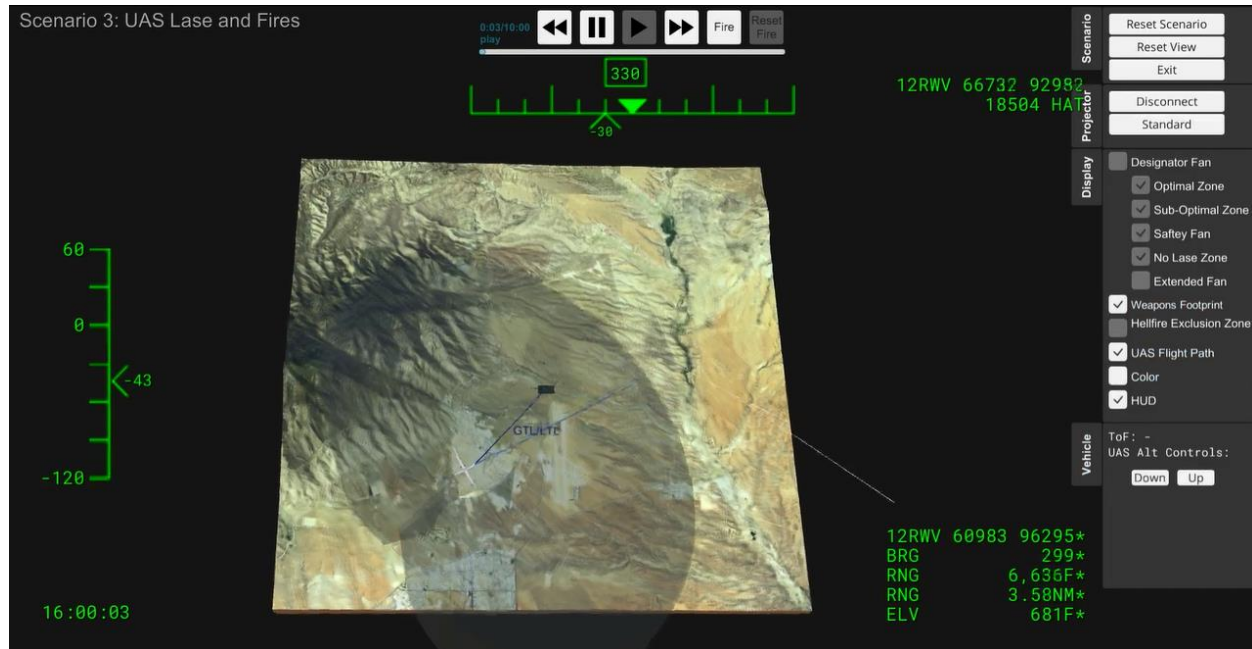
PI Actions	AI Actions
	<ul style="list-style-type: none"> <li>AI changes UAS altitude to display how the weapons footprint changes shape</li> </ul>
	<ul style="list-style-type: none"> <li>AI clicks the Reset Scenario button to return the scenario to the default position.</li> </ul>
	<ul style="list-style-type: none"> <li>AI toggles-on the weapons footprint</li> </ul>
<ul style="list-style-type: none"> <li>PI directs AI to click the play scenario button</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks Play button</li> </ul>
<ul style="list-style-type: none"> <li>The UAS moves along its orbit with the attached GTL and weapons footprint.</li> </ul>	
<ul style="list-style-type: none"> <li>The UAS weapons footprint moves over the target the footprint changes from red to green indicating the target is within range and location for the UAS to engage.</li> </ul>	
<ul style="list-style-type: none"> <li>PI directs the AI to click the fire button</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks Fire button</li> </ul>
<ul style="list-style-type: none"> <li>PI discusses R9 message sent to missile</li> </ul>	
<ul style="list-style-type: none"> <li>The target is destroyed.</li> </ul>	
	<ul style="list-style-type: none"> <li>AI clicks Reset Scenario button <a href="#">Error! Reference source not found.</a></li> </ul>

Check on Learning

- Question: What is the purpose of the weapons footprint?
- Answer: To inform the UAS crew when the target is within range of the missile
- Question: What color is the weapons footprint when the target is out of range of the missile
- Answer: Red

## Scenario 3 (Autonomous Engagement [Inline and Offset]) – UAS (Designator/Shooter)

This scenario depicts the UAS designating and shooting the target in either an inline or offset engagement.



### List of relevant elements

- UAS
- UAS LTL/GTL
- UAS Weapons footprint
- UAS Flight Path
- UAS HUD information
- Target

### Instructor high level use case example

This is high level to show an example of how the tool will be used to teach the concepts.

#### Pre-instruction GUAVA set-up

- Assistant Instructor (AI) loads Scenario 3
- AI positions target from aircraft to ensure payload offset is greater than plus or minus 10 degrees
- AI positions UAS to ensure that weapons footprint is red
- AI turns off the UAS flight path by deselecting the UAS Flight Path button
- AI turns off the weapons footprint color by deselecting the Color button
- AI moves terrain on 3 axis to best display initial content

Instructional Lead-in

“The last scenario we will discuss is the autonomous engagement.”

- PI toggles classroom display controls to show GUAVA on the big screen
- PI orients the class to the display
  - Libby Army Airfield
  - UAS
  - Target
- PI explains that the images shown within the tool are not what the student will see in the GCS.
- PI asks question
  - Question: “What is an autonomous engagement or autonomous laser designation?”
  - Answer: “An autonomous engagement or laser designation is when the aircraft launching the missile also provides the laser designation to guide the missile”. TC 3-04.45 p. 14-53, para. 14-229.
- PI asks question
  - Question: As a GE AO and PO what are the two types of autonomous engagements you will be required to shoot?”
  - Answer: Inline and Offset. TC 3-04.45, p.7-2, Table 7-2.
- PI asks question
  - Question: What is the difference between an inline engagement and an offset engagement?”
  - Answer: In an inline engagement the seeker head is pointing within plus or minus 10 degrees off the nose of the aircraft, in an offset engagement the seeker header is pointing plus or minus 11 degrees or greater off the nose of the aircraft”

PI Actions	AI Actions
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Question:” What information provided on your GCS display would you use to position your aircraft and payload for an inline engagement?”</li> <li>• Answer: Aircraft heading and payload offset</li> </ul>	
	<ul style="list-style-type: none"> <li>• AI toggles on HUD by selecting HUD button</li> </ul>
<ul style="list-style-type: none"> <li>• PI orients the class to the HUD information</li> </ul>	
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: What is the current payload azimuth in relation to the aircraft?</li> <li>• A: Read from HUD</li> </ul>	
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: If the payload offset is greater than plus or minus 10 degrees, as a crew how and what do you adjust to ensure you are in line with the target?</li> </ul>	

PI Actions	AI Actions
<ul style="list-style-type: none"> <li>• A: UAS flight path heading</li> </ul>	
	<ul style="list-style-type: none"> <li>• AI toggles on UAS flight path by selecting UAS Flight Path button</li> </ul>
<ul style="list-style-type: none"> <li>• PI discusses how adjusting the flight path impacts the payload azimuth offset with a stationary/fixd target</li> </ul>	<ul style="list-style-type: none"> <li>• AI moves flight path to until payload offset is less than <math>\pm 10</math> degrees from aircraft heading</li> </ul>
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: Once you have adjusted your flight path to ensure your aircraft heading and the payload offset does not exceed <math>\pm 10</math> degrees, how do you know whether or not you can launch the missile with a high probability of hitting the target?</li> <li>• A: Weapons Footprint</li> </ul>	
<ul style="list-style-type: none"> <li>• PI discusses Weapons Footprint characteristics</li> <li>• Color change</li> <li>• Size based on elevation changes</li> <li>• Slant range</li> </ul>	<ul style="list-style-type: none"> <li>• AI toggles-on the UAS weapons footprint and rotates the terrain to show the footprint from top-down view, side-view, and pseudo 3D-view</li> <li>• AI clicks on Color button</li> <li>• AI moves the UAS to depict how the footprint moves with the UAS.</li> <li>• AI grabs the UAS and changes the altitude to depict how the weapons footprint resizes.</li> </ul>
	<ul style="list-style-type: none"> <li>• AI clicks Reset Scenario button</li> </ul>
<ul style="list-style-type: none"> <li>• PI directs AI to play scenario</li> </ul>	<ul style="list-style-type: none"> <li>• AI clicks the play button and the UAS moves along the designated flight path with the weapons footprint adjusting to the direction of travel.</li> </ul>
<ul style="list-style-type: none"> <li>• PI directs the AI to pause the scenario</li> </ul>	<ul style="list-style-type: none"> <li>• AI clicks the pause button</li> </ul>
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: Is this an inline or offset engagement?</li> <li>• A: Read from HUD</li> </ul>	
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: When should you launch the missile</li> <li>• A:</li> </ul>	
<ul style="list-style-type: none"> <li>• PI discusses launch parameters</li> </ul>	
<ul style="list-style-type: none"> <li>• PI directs AI to play scenario</li> </ul>	<ul style="list-style-type: none"> <li>• AI clicks Play button</li> </ul>
<ul style="list-style-type: none"> <li>• PI directs AI to fire the missile</li> </ul>	<ul style="list-style-type: none"> <li>• AI clicks Fire button</li> </ul>
	<ul style="list-style-type: none"> <li>• AI clicks on Rest Scenario button</li> <li>• AI toggles-off HUD</li> </ul>
	<ul style="list-style-type: none"> <li>• AI moves the target to a position on a line greater than <math>10^\circ</math> from the flight path.</li> </ul>
<ul style="list-style-type: none"> <li>• PI asks question</li> <li>• Q: Is this an inline or offset engagement?</li> <li>• A: Read from HUD</li> </ul>	

PI Actions	AI Actions
	<ul style="list-style-type: none"> <li>AI toggles-on HUD</li> </ul>
<ul style="list-style-type: none"> <li>PI directs AI to play the scenario</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks the Play button</li> </ul>
<ul style="list-style-type: none"> <li>PI directs AI to fire the missile</li> </ul>	<ul style="list-style-type: none"> <li>AI clicks Fire button</li> </ul>
	<ul style="list-style-type: none"> <li>AI clicks Reset Scenario button <b>Error!</b> <b>Reference source not found.</b></li> </ul>

Check on Learning

- Question: As a GE AO and PO what are the two types of autonomous engagements you will be required to shoot?"
- Answer: Inline and Offset. TC 3-04.45, p.7-2, Table 7-2.
- Question: What is the difference between an inline engagement and an offset engagement?"
- Answer: In an inline engagement the seeker head is pointing within plus or minus 10 degrees off the nose of the aircraft, in an offset engagement the seeker header is pointing plus or minus 11 degrees or greater off the nose of the aircraft"
- Question: If the aircraft heading is 180 degrees and the payload offset is -30, to what heading should you correct to conduct an inline engagement
- Answer: Between 140 and 160 degrees

## **Appendix B**

Gray Eagle Student Gunnery Test Version A

Participant Code: \_\_\_\_\_

Date: \_\_\_\_\_

**MQ-1C**  
**UAS GUNNERY CONCEPTS TEST**  
**Version A**

Student Demographics

Are you certified as an aircraft operator (AO) and/or payload operator (PO) on any other UAS airframes? Circle either Yes or No.

Yes                      No

If Yes, write a checkmark next to each airframe in either or both the AO and PO columns.

<u>UAS</u>	AO	PO
Hunter		
Shadow		
Raven		
Puma		
Wasp		
Micro Air Vehicle (gMAV)		
Other: _____		
Other: _____		

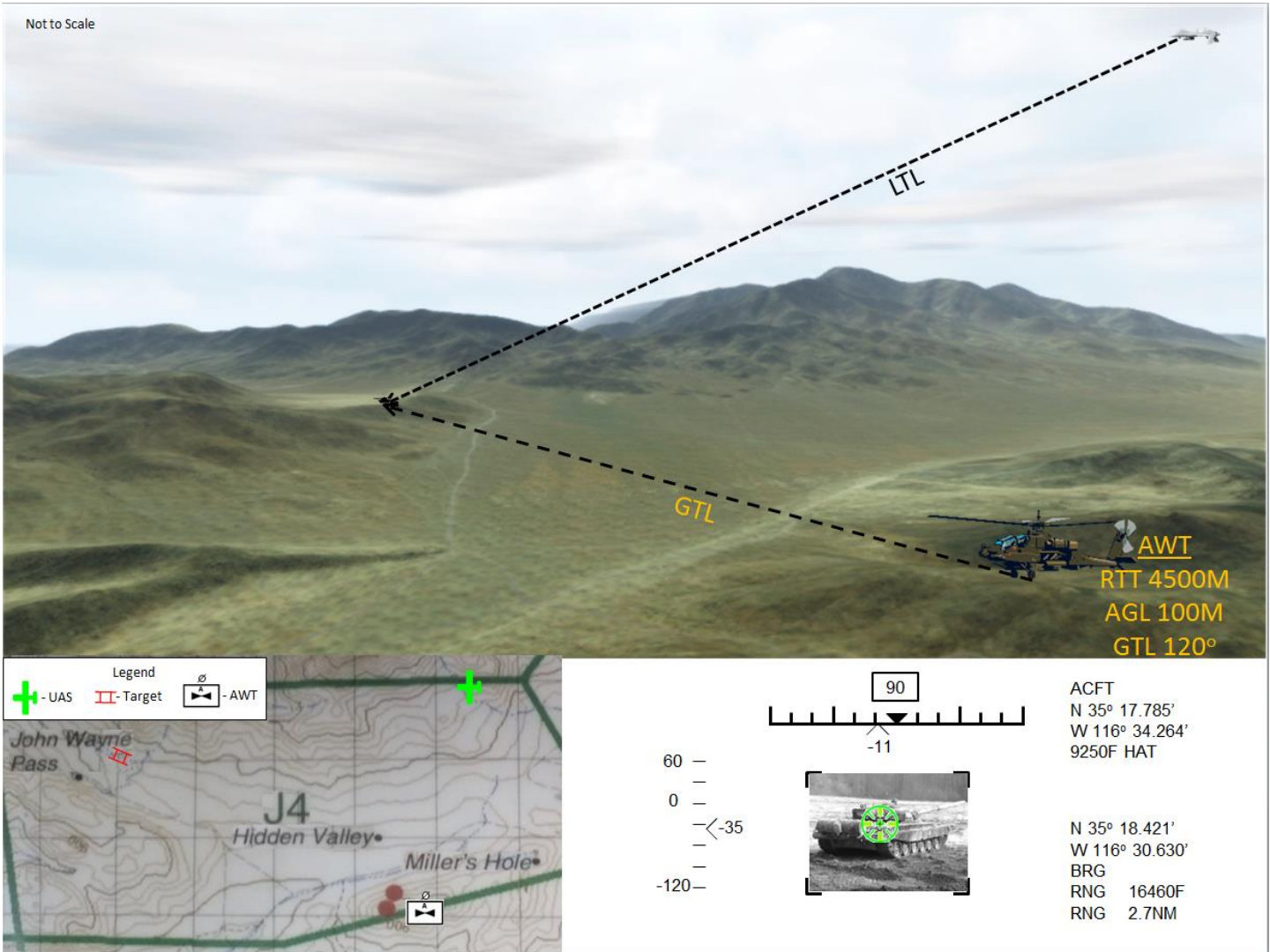
Instructions

There are four separate situations that will require you to determine if the depicted UAS is in an acceptable position in relation to the AWT. Use the information provided in the graphics for each situation to answer the questions.

Glossary

ACFT	Aircraft
AGL	Above ground level
AWT	Attack Weapons Team
Designator Fan	60-degree fan on both sides of the GTL
GTL	Gun Target Line
HAT	Height above target
Hellfire II Exclusion Zone	A 30-degree cone which originates at the firing aircraft, extending outward to the maximum range of the missile
LTL	Laser Target Line
RNG	Range
RTT	Range to target

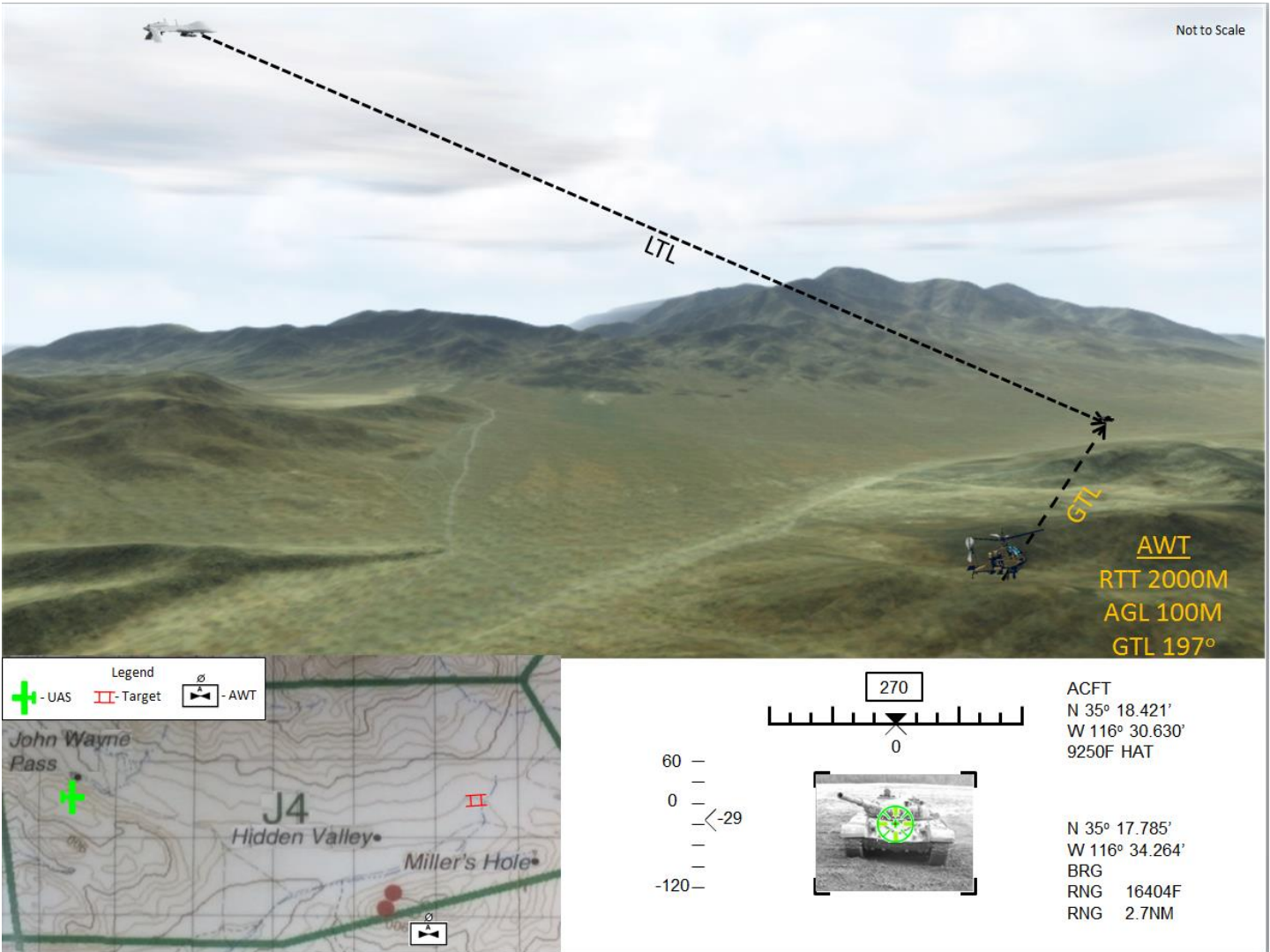
Scenario 1



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

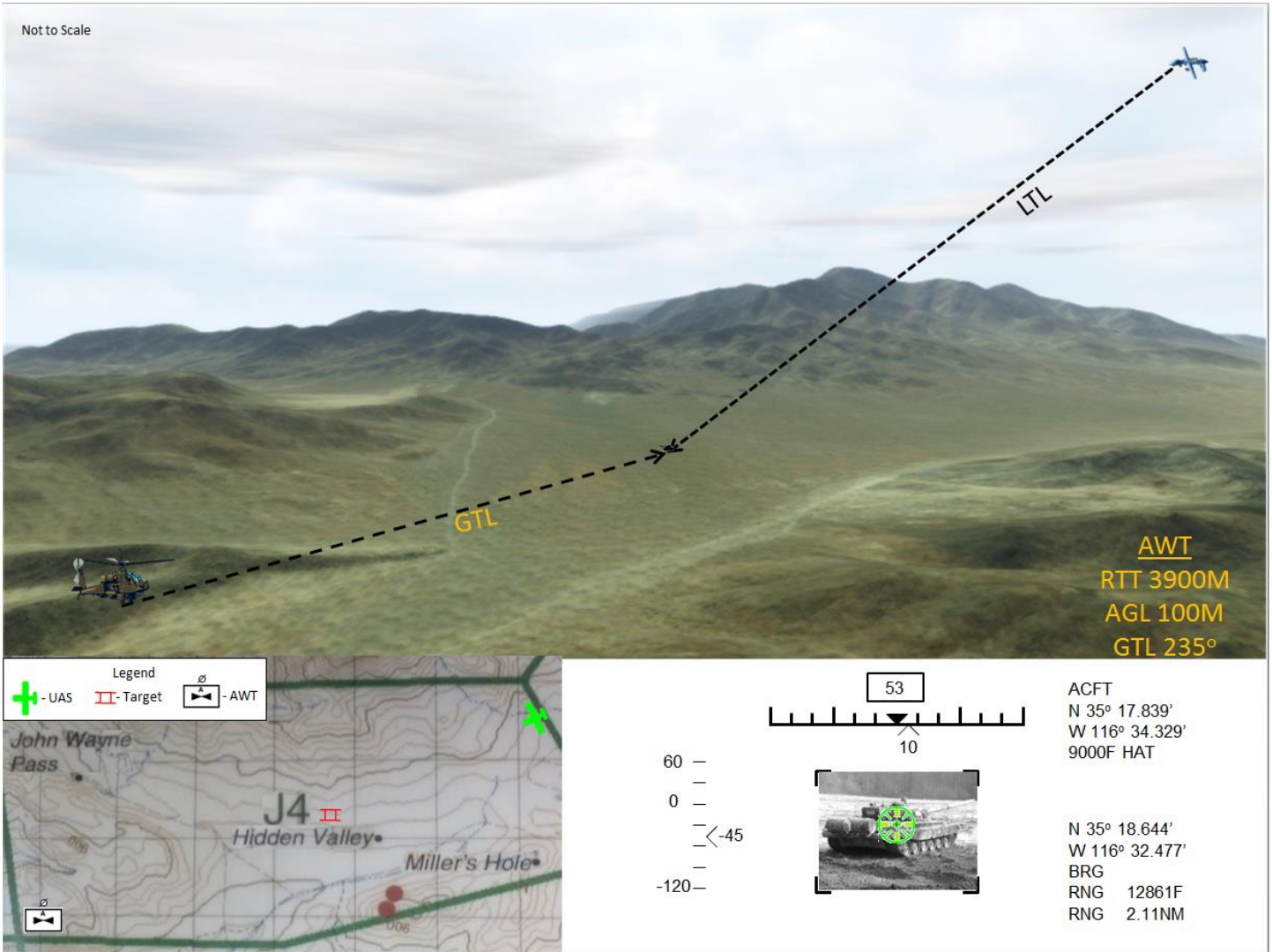
Scenario 2



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   | <input type="checkbox"/> I don't know  |  |

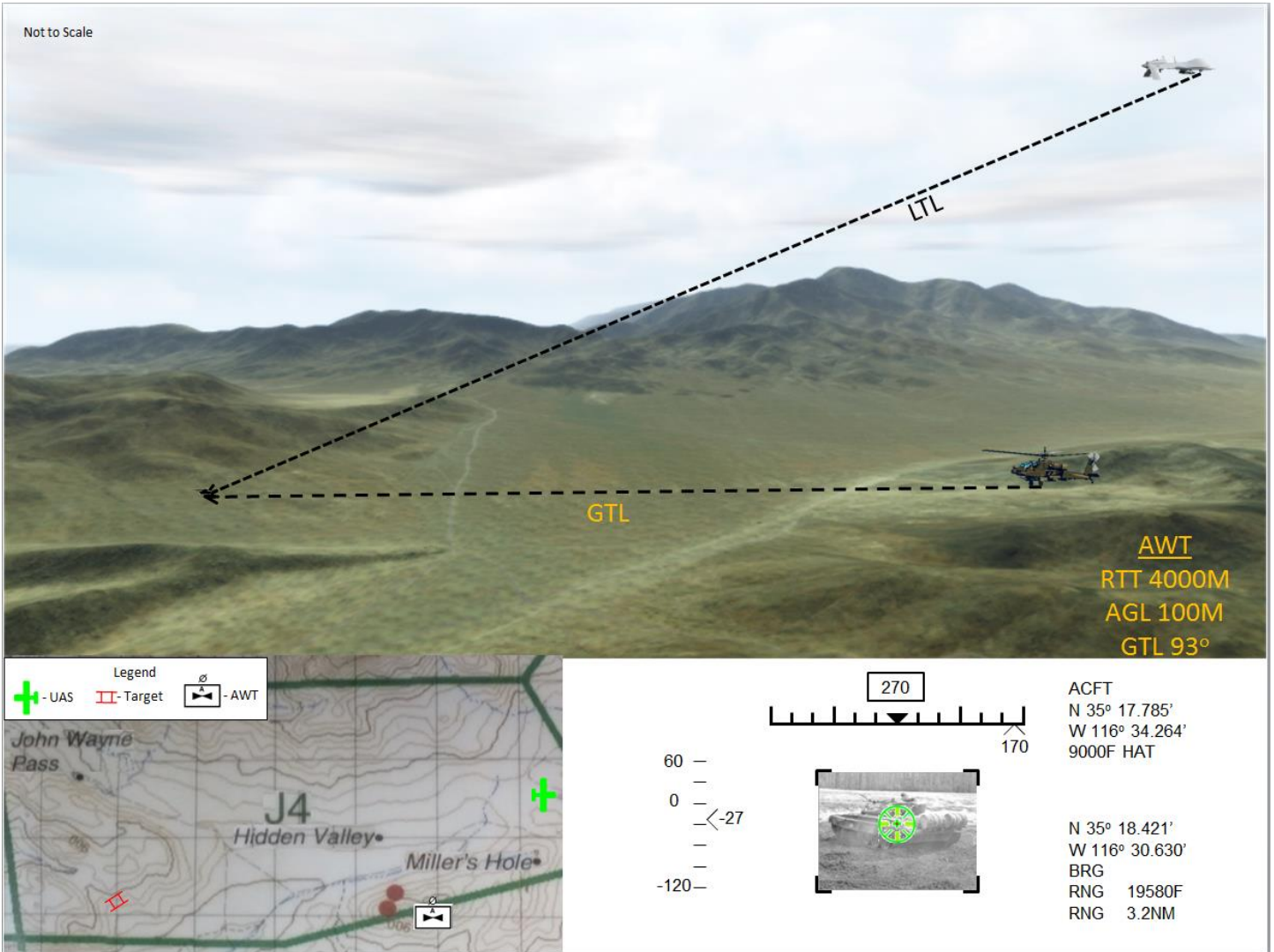
Scenario 3



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

Scenario 4



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   | <input type="checkbox"/> I don't know  |  |

## **Appendix C**

Gray Eagle Student Gunners Test Version B

Participant Code: \_\_\_\_\_

Date: \_\_\_\_\_

**MQ-1C**  
**UAS GUNNERY CONCEPTS TEST**  
**Version B**

Student Demographics

Are you certified as an aircraft operator (AO) and/or payload operator (PO) on any other UAS airframes? Circle either Yes or No.

Yes                      No

If Yes, write a checkmark next to each airframe in either or both the AO and PO columns.

<u>UAS</u>	AO	PO
Hunter	<input type="checkbox"/>	<input type="checkbox"/>
Shadow	<input type="checkbox"/>	<input type="checkbox"/>
Raven	<input type="checkbox"/>	<input type="checkbox"/>
Puma	<input type="checkbox"/>	<input type="checkbox"/>
Wasp	<input type="checkbox"/>	<input type="checkbox"/>
Micro Air Vehicle (gMAV)	<input type="checkbox"/>	<input type="checkbox"/>
Other: _____	<input type="checkbox"/>	<input type="checkbox"/>
Other: _____	<input type="checkbox"/>	<input type="checkbox"/>

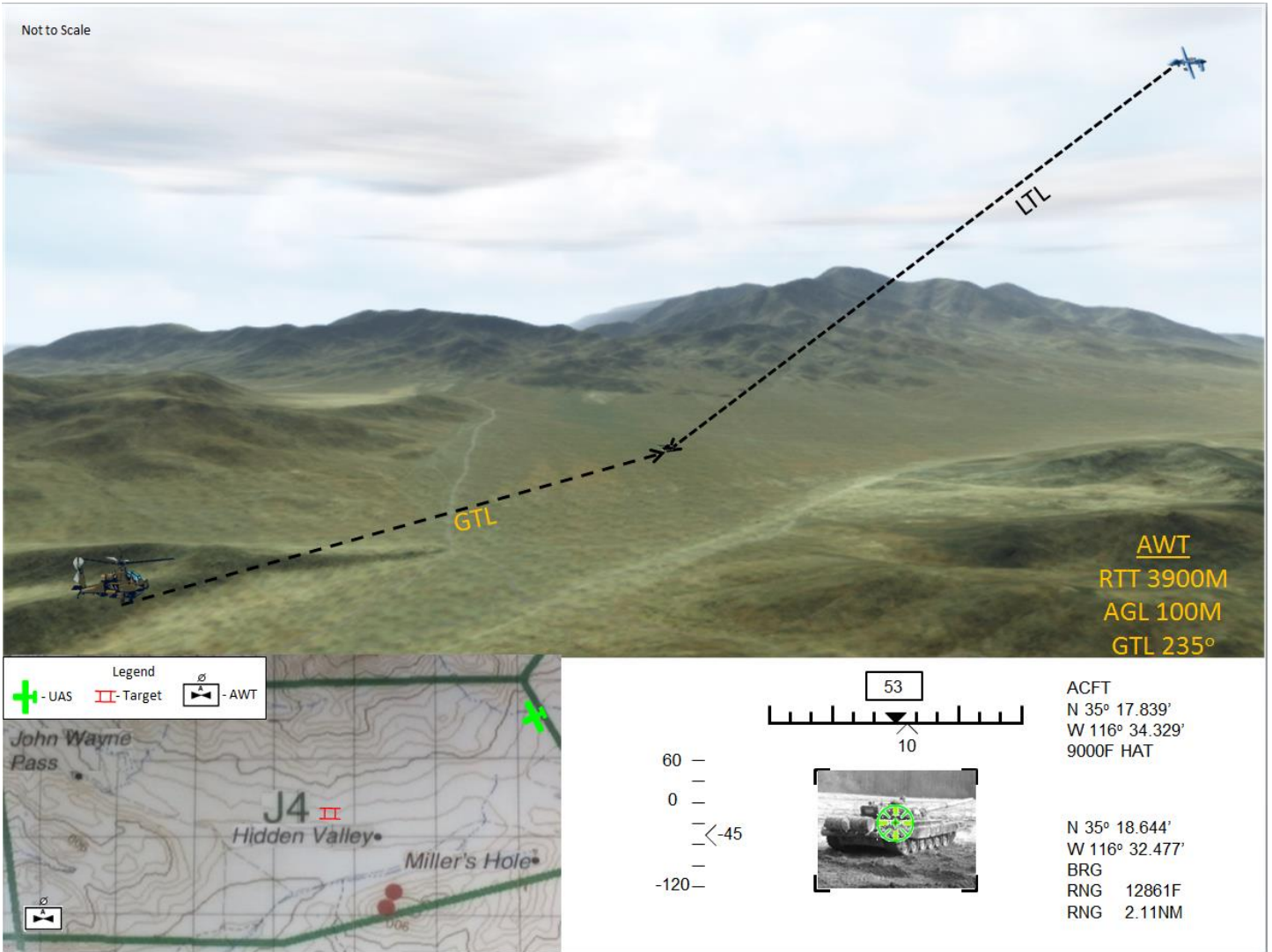
Instructions

There are four separate situations that will require you to determine if the depicted UAS is in an acceptable position in relation to the AWT. Use the information provided in the graphics for each situation to answer the questions.

Glossary

ACFT	Aircraft
AGL	Above ground level
AWT	Attack Weapons Team
Designator Fan	60-degree fan on both sides of the GTL
GTL	Gun Target Line
HAT	Height above target
Hellfire II Exclusion Zone	A 30-degree cone which originates at the firing aircraft, extending outward to the maximum range of the missile
LTL	Laser Target Line
RNG	Range
RTT	Range to target

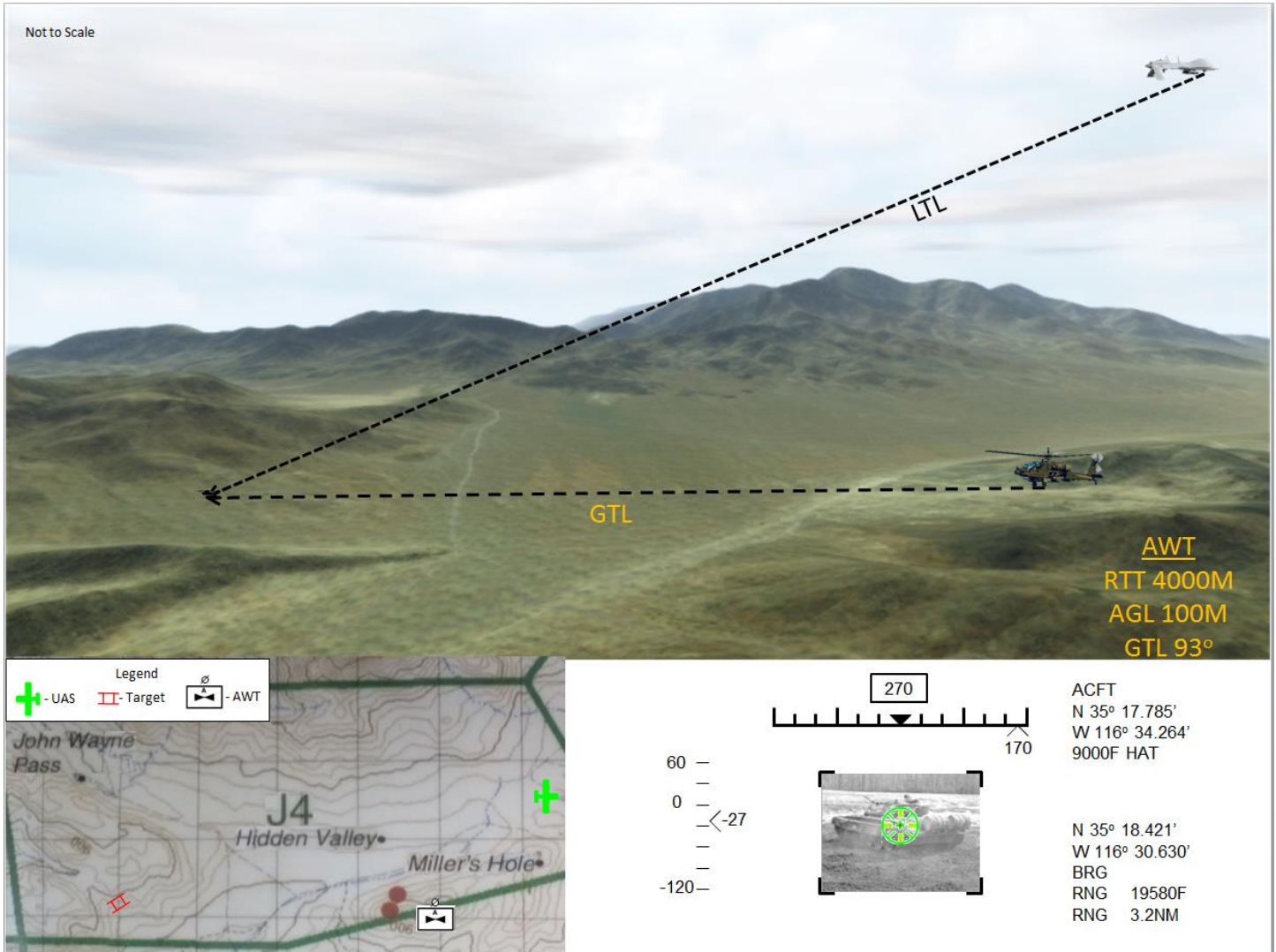
Scenario 1



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |   |   |                                       |
|---|---|---------------------------------------|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT   | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT  | <input type="checkbox"/> I don't know |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan | <input type="checkbox"/> I don't know |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range  | <input type="checkbox"/> The payload elevation is out of the acceptable range   | <input type="checkbox"/> I don't know |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> I don't know |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude   | <input type="checkbox"/> I don't know |
| <input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location   | <input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS  |   | <input type="checkbox"/> I don't know |

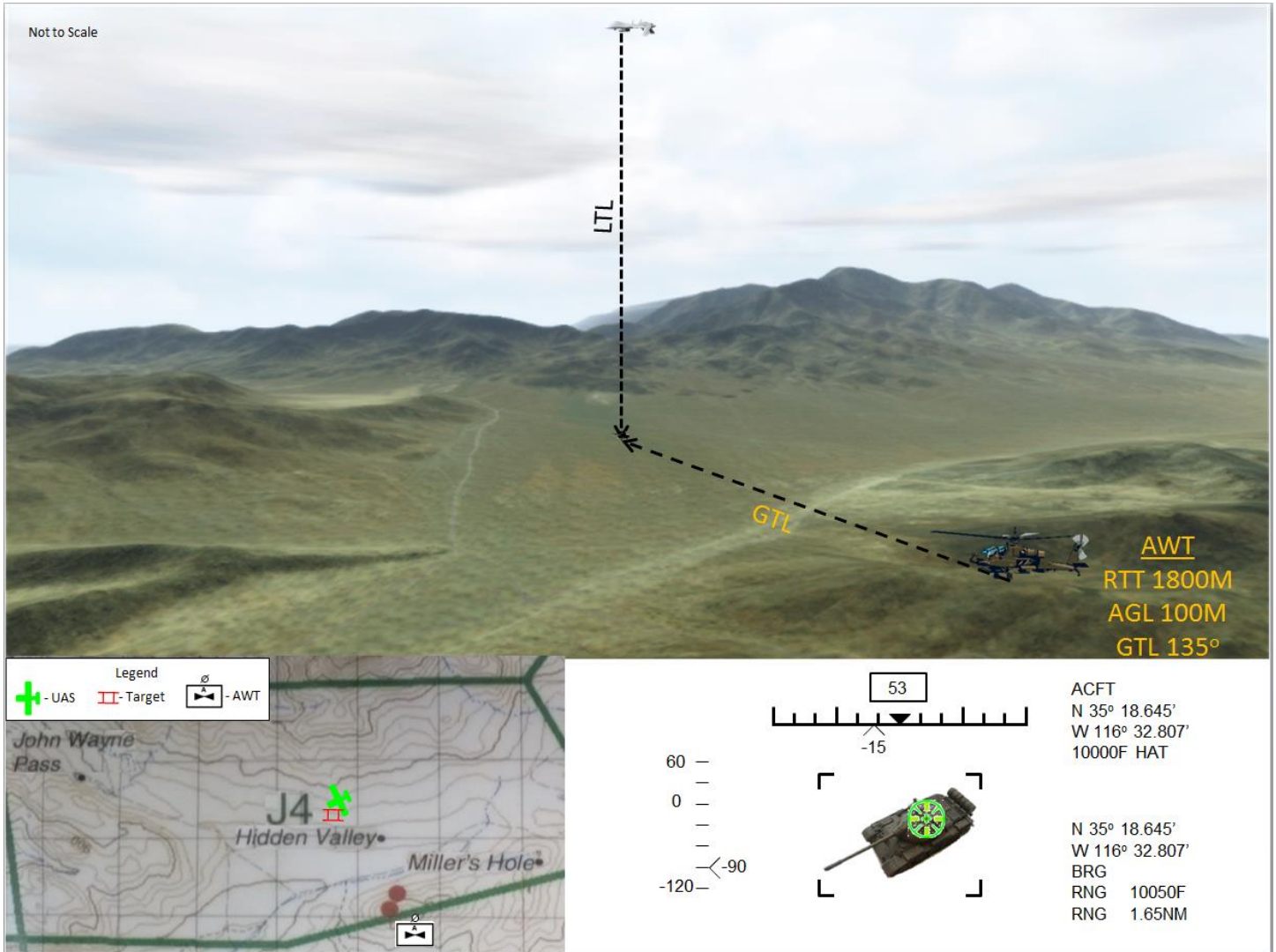
Scenario 2



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |   |   |                                       |
|---|---|---------------------------------------|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT   | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT  | <input type="checkbox"/> I don't know |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan | <input type="checkbox"/> I don't know |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range  | <input type="checkbox"/> The payload elevation is out of the acceptable range   | <input type="checkbox"/> I don't know |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> I don't know |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude   | <input type="checkbox"/> I don't know |
| <input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location   | <input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS  |   | <input type="checkbox"/> I don't know |

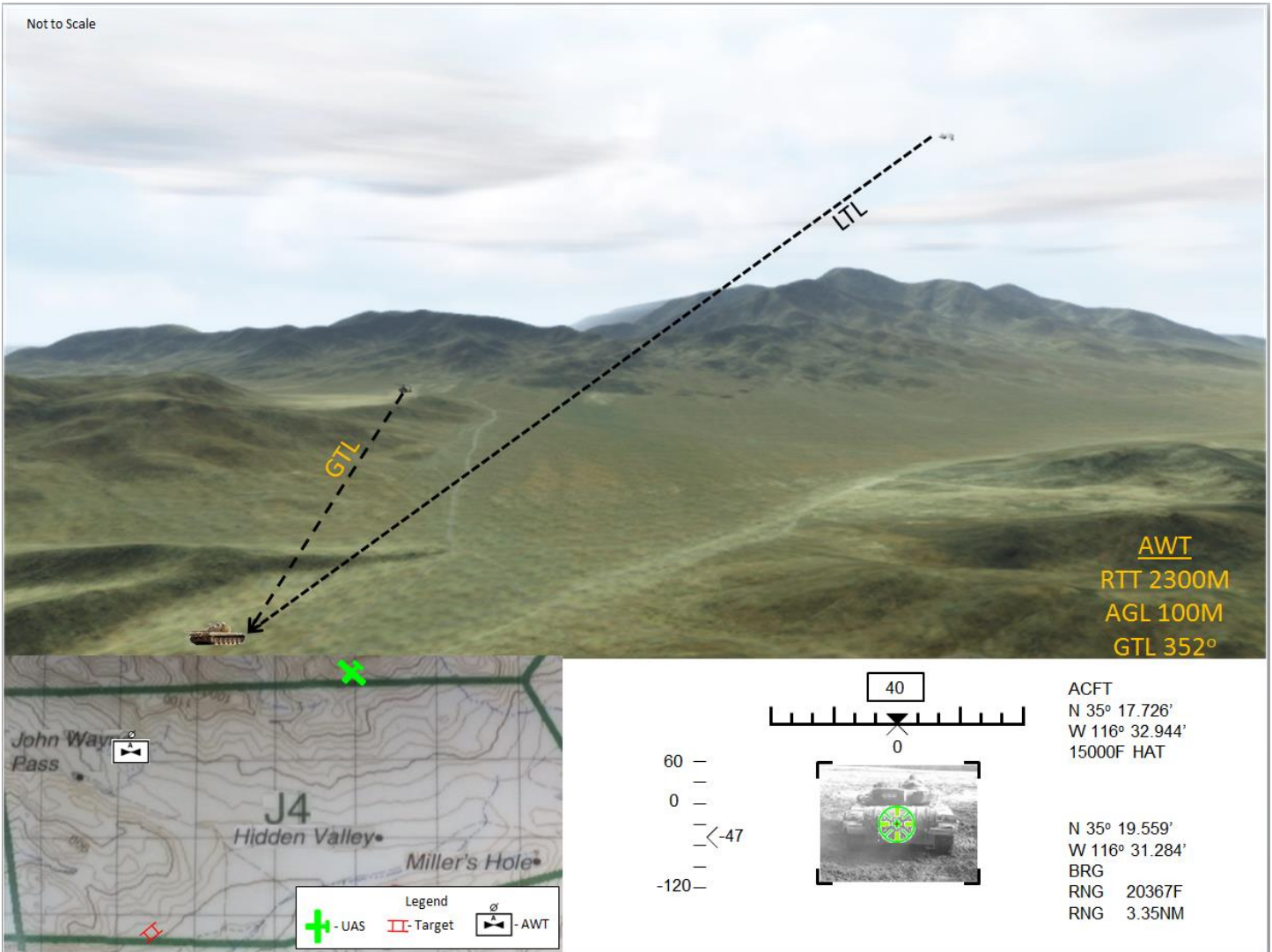
Scenario 3



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |   |   |                                       |
|---|---|---------------------------------------|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT   | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT  | <input type="checkbox"/> I don't know |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan | <input type="checkbox"/> I don't know |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range  | <input type="checkbox"/> The payload elevation is out of the acceptable range   | <input type="checkbox"/> I don't know |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> I don't know |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude   | <input type="checkbox"/> I don't know |
| <input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location   | <input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS  |   | <input type="checkbox"/> I don't know |

Scenario 4



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

## **Appendix D**

Gray Eagle Students Gunners Test Version C

Participant Code: \_\_\_\_\_

Date: \_\_\_\_\_

**MQ-1C**  
**UAS GUNNERY CONCEPTS TEST**  
**Version C**

Student Demographics

Are you certified as an aircraft operator (AO) and/or payload operator (PO) on any other UAS airframes? Circle either Yes or No.

Yes                      No

If Yes, write a checkmark next to each airframe in either or both the AO and PO columns.

<u>UAS</u>	AO	PO
Hunter		
Shadow		
Raven		
Puma		
Wasp		
Micro Air Vehicle (gMAV)		
Other: _____		
Other: _____		

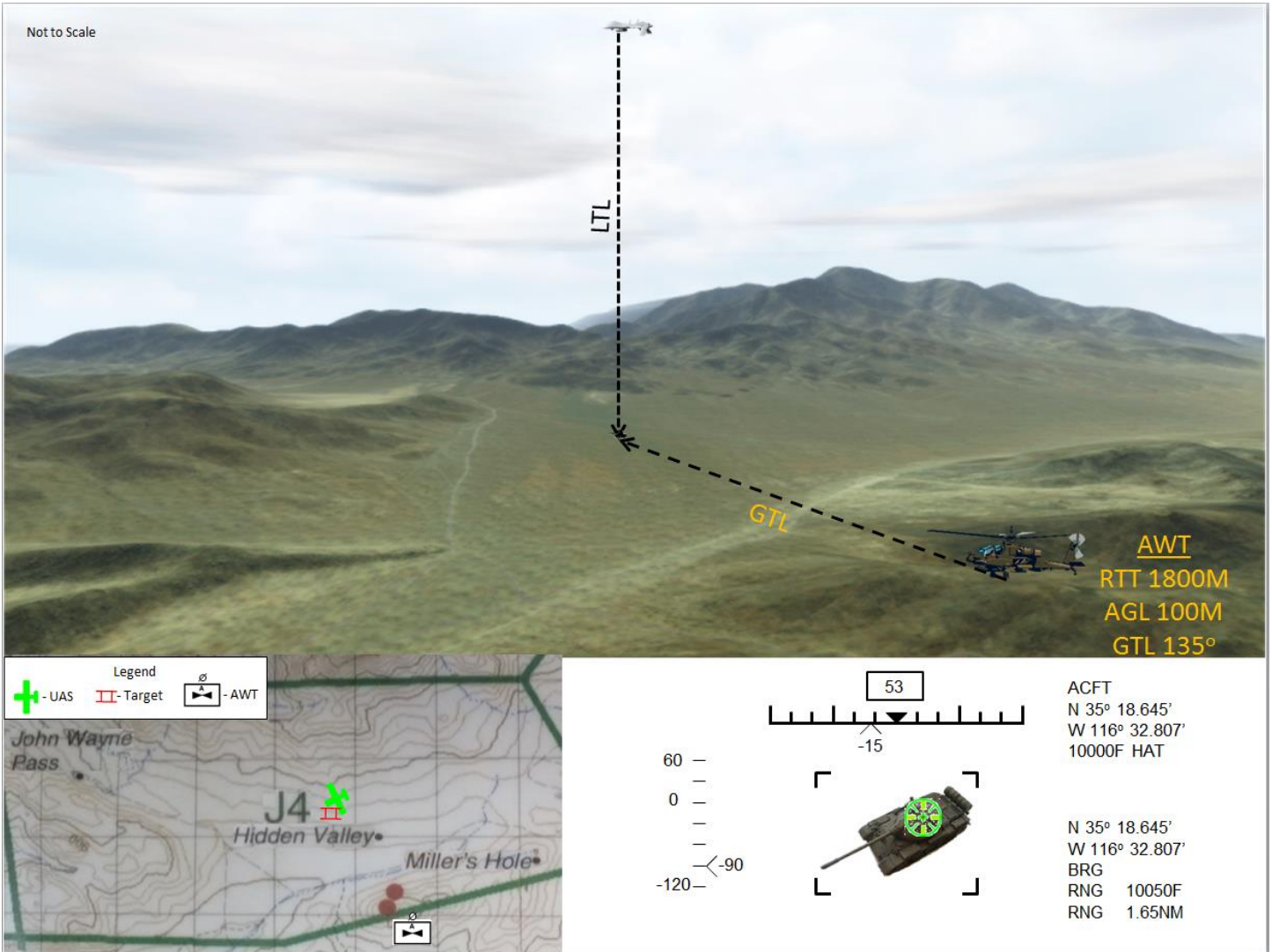
Instructions

There are four separate situations that will require you to determine if the depicted UAS is in an acceptable position in relation to the AWT. Use the information provided in the graphics for each situation to answer the questions.

Glossary

ACFT	Aircraft
AGL	Above ground level
AWT	Attack Weapons Team
Designator Fan	60-degree fan on both sides of the GTL
GTL	Gun Target Line
HAT	Height above target
Hellfire II Exclusion Zone	A 30-degree cone which originates at the firing aircraft, extending outward to the maximum range of the missile
LTL	Laser Target Line
RNG	Range
RTT	Range to target

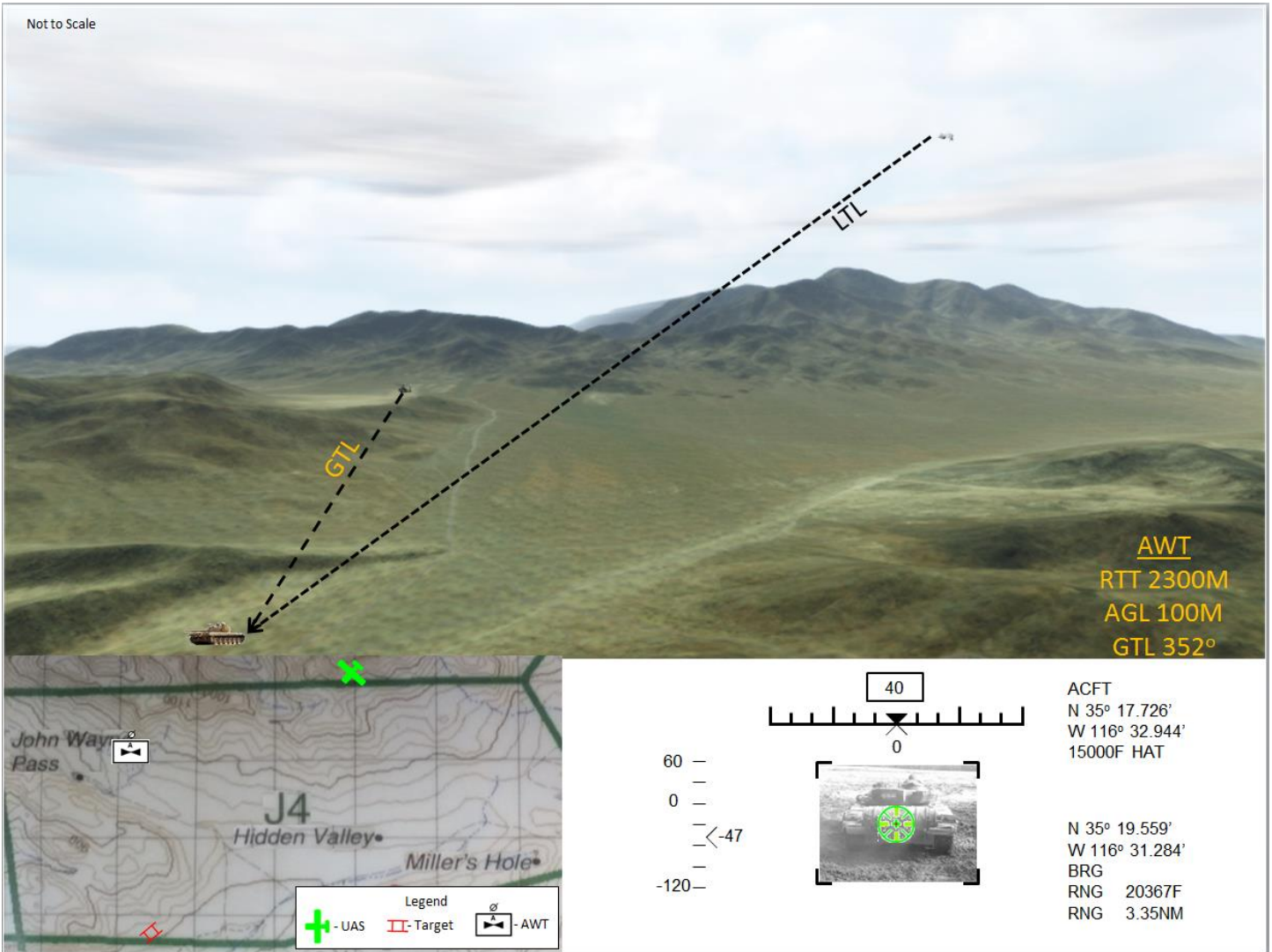
Scenario 1



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |   |   |                                       |
|---|---|---------------------------------------|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT   | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT  | <input type="checkbox"/> I don't know |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan | <input type="checkbox"/> I don't know |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range  | <input type="checkbox"/> The payload elevation is out of the acceptable range   | <input type="checkbox"/> I don't know |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> I don't know |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude   | <input type="checkbox"/> I don't know |
| <input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location  | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location   | <input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS  |   | <input type="checkbox"/> I don't know |

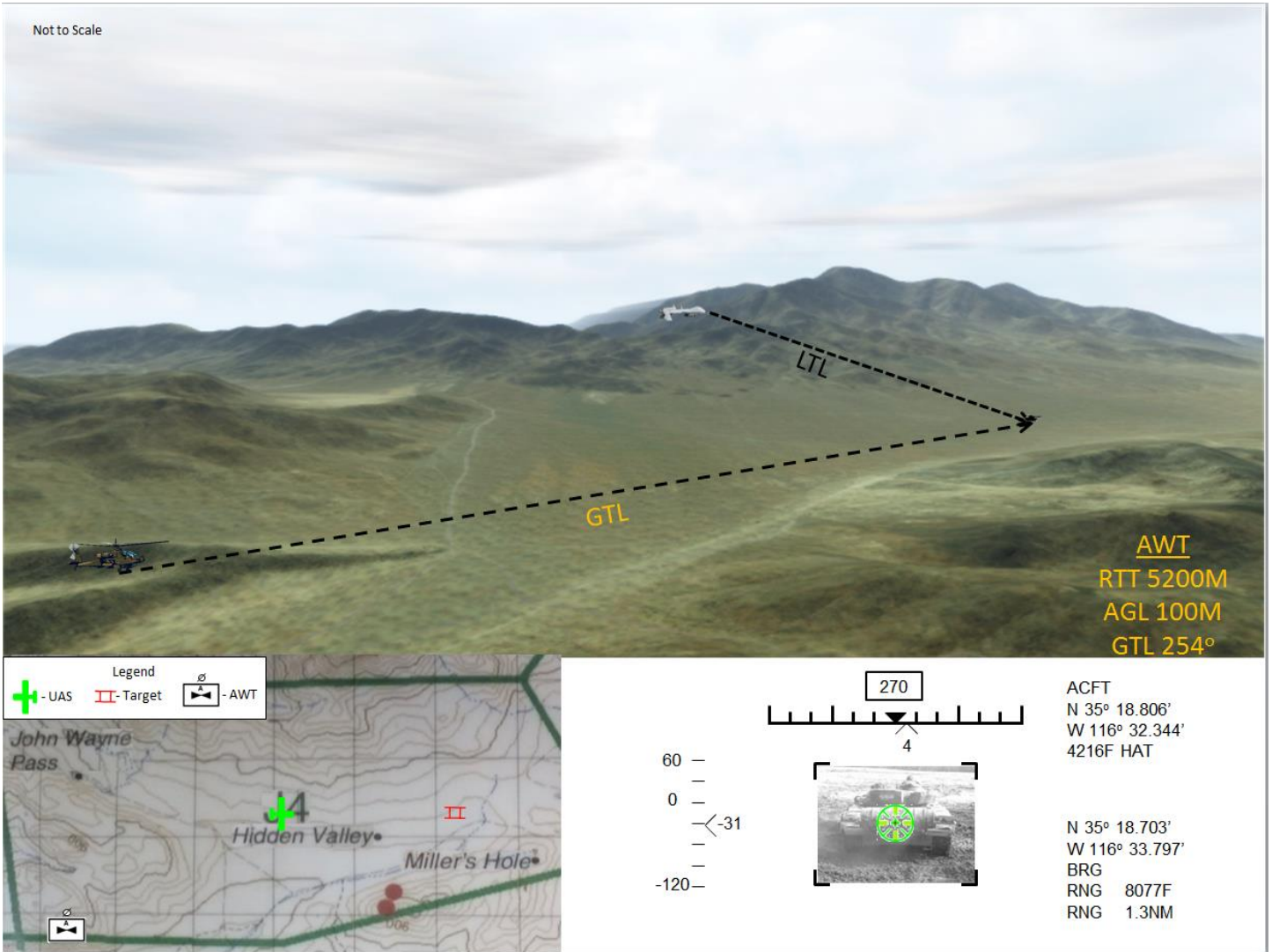
Scenario 2



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

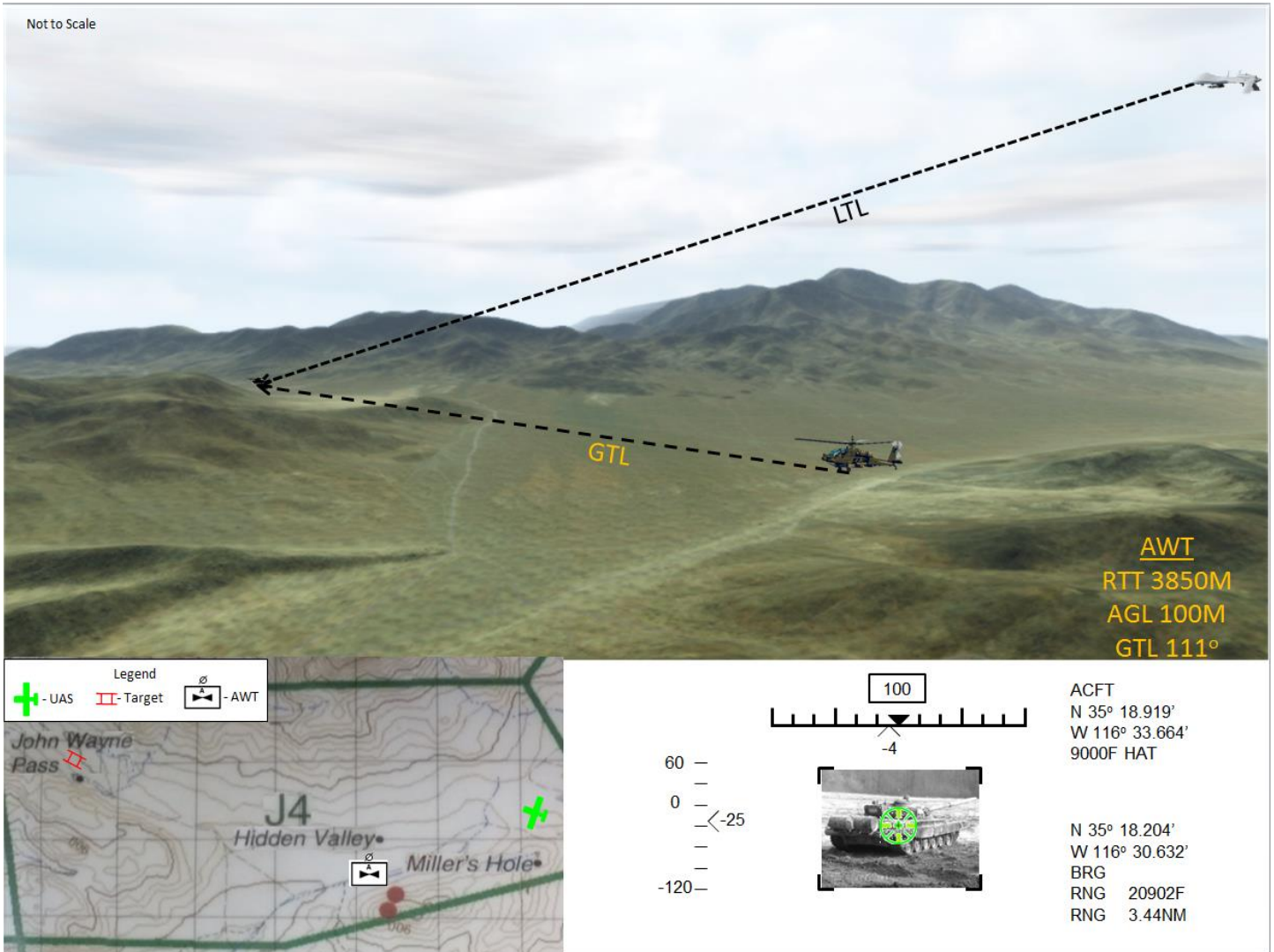
Scenario 3



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

Scenario 4



As the payload operator determine whether the UAS is in an acceptable position as the laser designator for the AWT during the “Missile Away” step of the remote engagement. Use the information provided in the three panels above to answer questions 1 – 5 below. Circle **is** or **is not** for question 6. If you don’t know, check the box.

- |  |  |  |
|--|--|--|
| 1. <input type="checkbox"/> The UAS appears to be correctly positioned in relation to the AWT  | <input type="checkbox"/> The UAS appears to be incorrectly positioned in relation to the AWT   | <input type="checkbox"/> I don't know  |
| 2. <input type="checkbox"/> The LTL bisects the sub-optimal zone of the designator fan<br><input type="checkbox"/> The LTL bisects the optimal zone of the designator fan  | <input type="checkbox"/> The LTL bisects the no-laze zone of the designator fan<br><input type="checkbox"/> The LTL bisects the safety zone of the designator fan  | <input type="checkbox"/> I don't know  |
| 3. <input type="checkbox"/> The payload elevation is within the acceptable range   | <input type="checkbox"/> The payload elevation is out of the acceptable range  | <input type="checkbox"/> I don't know  |
| 4. <input type="checkbox"/> The laser return appears to be detectable by the seeker based on the LTL to GTL offset   | <input type="checkbox"/> The laser return appears not to be detectable by the seeker based on the LTL to GTL offset  | <input type="checkbox"/> I don't know  |
| 5. <input type="checkbox"/> The UAS appears to be outside of the the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be outside of the of the hellfire exclusion zone based on location | <input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on altitude<br><input type="checkbox"/> The UAS appears to be within the hellfire exclusion zone based on location | <input type="checkbox"/> I don't know<br><input type="checkbox"/> I don't know |
| 6. This <b>is</b> / <b>is not</b> an acceptable position for the UAS   |  | <input type="checkbox"/> I don't know  |

