Thunder Run in the Classroom-Simulation Entity Detail in Education

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Abstract

In April of 2003 the American Army launched an attack into the heart of Baghdad called the Thunder Run. The 3rd Infantry Division saw most of the fighting against sizable force of moderately well armed Iraqi Army soldiers. This paper provides an in depth look into utilizing the Thunder Run scenario in conjunction with Joint Conflict and Tactical Simulation (JCATS) software and the Systems Decision Process (SDP). The comparison between two semesters will be made in order to determine if a difference in simulation entity utilization impacts the cadets' abilities to learn and benefit from the course material. JCATS is an advanced military simulation program and the SDP is a methodology developed by the Systems Engineering Department in order to formalize the decision making process. With these tools cadets explore the world of modeling and simulation and utilize analytical processes in the form of a semester long project by which to recommend to a decision maker a new armored vehicle design for the United States Army. The SDP utilizes problem definition, solution design, decision making, and solution implementation processes by which cadets through a serious of in progress reviews, simulation runs, factorial design analysis, and a final paper work through all the steps necessary to recommend a new armored vehicle design.

1. PURPOSE

The purpose of utilizing Thunder Run scenario in the classroom environment is to expose cadets to the analytical tools available when presented with complex problems that require multi-disciplinary solutions. Simulation coursework is an integral part of the Systems Engineering and Engineering Management curriculums at the United States Military Academy. Future leaders in both the military and civilian sectors must be knowledgeable in both the theory and practice of simulation and modeling.

In AY 07-1 cadets were required to create armored vehicles for use in their Thunder Run scenarios from the very most basic components. A cadet team was required to instantiate the gun, armor, all associated factors from the very most basic steps in the JCATS software. In AY 08-1 the program of study was changed to were the cadets were not required to create armored vehicles "from scratch" but instead were able to take components off of existing armored vehicles already portrayed in JCATS and switch out components with other armored vehicles already existing in JCATS in order to create unique armored vehicles specifically for their design of experiments.

2. SCENARIO

In April of 2003, the Army's 3rd Infantry Division received orders to attack into the middle of the heavily populated urban center of Baghdad. This attack, or "Thunder Run", consisted of several hundred well-armed Americans attacking into 8 million Iraqis. While the vast majority avoided the Americans and any possible fighting, there was a sizable force of moderately well armed Iraqi Army soldiers who put up strong resistance.

Cadet teams consisting of 3-4 cadets recreate this scenario in JCATS and are tasked to design a new armored combat system that is lethal, survivable, and transportable. The basic unit of maneuver is a platoon which has the constraint that a platoon must be transportable by two C-17 transport aircraft. A constraint of up to seven C-17s may be used to insert a combat-loaded company.

This scenario and requirement for redesigning equipment is very relevant in today's Army. Currently the Army is undergoing a period of transition and transformation unlike it has ever seen. Prior to the attacks on September 11th, 2001, there were only two brigades at Fort Lewis that were undergoing "Transformation". This plan called for the Army reorganizing and reequipping both a heavy and light brigade with lightly armored, heavily integrated, and motorized forces. Since Operations Iraqi Freedom (OIF), the Army Chief of Staff has begun another and much further reaching initiative. Beginning in 2003 all Army units began the process of transformation to reorganize into more independent and effective organizations.

"Schoomaker's restructuring plan calls for an increase in the active-duty combat brigades from 33 to 48, creating more versatile units available for rapid overseas deployment. Each new brigade will be more self-sustaining and have more combat power than current brigades, enabling the Defense Department to respond to smaller-scale contingencies by deploying a brigade of 5,000 soldiers, instead of a much larger division, with 20,000 soldiers." [1]

In class cadets are given an Operational Requirements Document (ORD) for the project that requires that each

cadet team to develop a combat system that, when deployed in a platoon of 3 to 5 vehicles, has the cross country mobility of a M2 platoon, and is able to defeat all expected ground and air threats in support of Army Transformation concepts.

3. STUDENT ASSESSMENT

In AY 07-1 cadet teams were required to create all facets of a candidate armored system beginning with the most basic steps. This resulted in a very detailed process of which focused on intense training within the JCATS software package. In contrast the following year this course was taught using the concept that JCATS would still be used, however, candidate vehicles would be constructed from previously created vehicles already in existence within the JCATS database. This resulted in the cadets spending less time performing the mechanics of vehicle construction and more time constructing the design of experiments and analyzing data.

During course end feedback reports it was noted that the percentage of "Strongly Agree" responses to questions about the course and meeting the learning objectives increased from 46% to 66% amongst cadet opinions. This gives a strong indication that by reducing the tedium in constructing the entity and instead placing the focus on the multiple runs of the simulation in the prescribed design of experiments and the analysis that follows greater student satisfaction was achieved.

Interesting to note is the steady state of grades. The second years grades were not significantly different from the first year and therefore it could be assumed that the change in curriculum affecting mostly the satisfaction of the students and not necessarily the understanding of course material.

3.1. Likert Tabulation (Cadet Feedback)

Using the course end feedback from both semesters the following data results were collected. The numbers 5-1 represent the "Strongly Agree"=5 and "Stongly Disagree"=1. The questions were grouped into 4 major topics of how the course project impacted the areas of "Learning", "Thinking", "Analysis", and "Course Objectives. A marked increase is noted in the second iteration of the course after changes were made to the method in which cadets were tasked to construct armored vehicles for the simulation.

AY 07-1	5	4	3	2	1
Learning	53.7%	33.3%	5.6%	1.9%	5.6%
Thinking	37.0%	44.4%	14.8%	3.7%	0.0%
Anaylsis	55.6%	25.9%	16.7%	1.9%	0.0%
Course Objectives	51.5%	28.3%	10.1%	9.1%	1.0%

Table 1. AY 07-1 Feedback

AY 08-1	5	4	3	2	1
Learning	76.0%	24.0%	0.0%	0.0%	0.0%
Thinking	70.8%	29.2%	0.0%	0.0%	0.0%
Anaylsis	64.6%	33.3%	2.1%	0.0%	0.0%
Course Objectives	58.0%	39.2%	2.3%	0.6%	0.0%

Table 2. AY 08-1 Feedback

3.2. Instructor Assessment

Throughout the course of both semesters I noticed a considerable difference in cadet attitudes towards JCATS. Initially when it was required to build the vehicles from scratch there was much frustration since it required large amounts of time to deal with the nuances of creating very specific and detailed attributes of an armored vehicle. During the second semester when I implemented the policy by which they can take pre-existing armored vehicles and switch out components with other pre-existing armored vehicles much more time was spent on the design of experiments and analyzing the statistical outcomes of the simulation.

Based on cadet feedback via the Likert ratings and my own observations I am recommending to the follow on course director to continue on with the course project policy that I began in the second semester.

4. JCATS

Joint Conflict and Tactical Simulation (JCATS) is an interactive simulation program that is managed by the Joint Warfighting Center (JWFC) which is a subordinate command of the U.S. Joint Forces Command (USJFCOM) located in Suffolk, Virginia. Lawrence Livermore National Laboratory is the original designer and developer of this program and still maintains close ties to JWFC and USJFCOM in order to further refine and advance JCATS as an excellent simulation tool.

The primary uses for JCATS are training, analysis, mission planning, and rehearsal. JCATS maintains the ability to simulate operations in urban terrain, woodland, desert, artic, or jungle terrains. Units can be disaggregated down to the individual solider or maintained as an entire division depending on scenario requirements. JCATS supports non-lethal as well as conventional weapons. JCATS also has the ability to very easily modify existing entities or to custom create entities should it be required.

JCATS is often part of a larger command and control exercise involving a myriad of other simulation software, however, the program is flexible enough to facilitate training at the lowest level of operations. The most impressive use of JCATS is observed at the National Training Center (NTC) in Fort Irwin, California. There the program is often used in conjunction with other live, virtual, and constructive simulations. Not only is JCATS used extensively by the United States Army. It is also utilized by

the U.S. Marine Corps and by U.S. Northern Command (USNORCOM) in support of homeland security exercises. [2]

4.1. Simulation Description

The simulation scenarios generated by the cadets teams are based on their own historical research into what actually occurred during the Thunder Run in 2003. Based on this information the scenarios created by each independent cadet team varies, however, common threads exist throughout all the teams' simulations.

An example of a cadet scenario of the Thunder Run is shown in Figure 1. This is only a single example of one of the various configurations that are acceptable for the Thunder Run. Please note that in this example American forces are positioned south of the city and will ultimately advance toward the Baghdad International Airport in the western area of Baghdad.

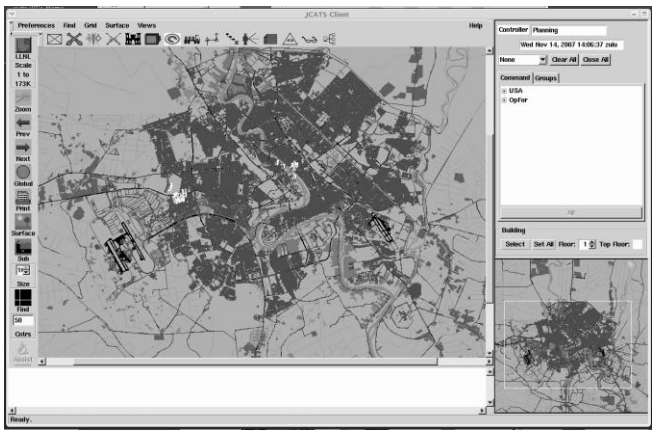

Figure 1. JCATS Simulation Graphical User Interface

4.2. Vehicle Characteristics in Simulation

When cadets construct armored vehicles for their JCATS scenario, the following factors are the main variables for each of their vehicle candidate types:

1. Main Weapon System
2. Armor Type
3. Engine
4. Communications System
5. Weapon Sight
6. Navigation System
7. Vehicle Speed
8. Vehicle Range
9. Minimum Crew
10. Vehicle Suspension
11. Main Weapon Reload Time
12. Main Weapon Rounds per Reload
13. Main Weapon Ammunition Carrying Capacity

Cadet teams exercise design of experiment (DOE) concepts in order to construct a full factorial design with each one of these factors set at two different levels. This is done in order to determine which factors are the most significant. Once the teams create their 2^{13} full factorial design in Minitab statistical software it is then replicated five times for a total of 40,960 design points. Results are assigned to their identified measures of effectiveness in terms of their response within their DOE. These results are provided by the instructor utilizing a Microsoft Excel and a weighting system by which certain factors set to different levels will generate a higher level within their measure of effectiveness. After the cadet teams receive the response results they begin their analysis to see if they can determine which of the thirteen above listed factors are the most significant. This is accomplished utilizing analysis of variance (ANOVA) and graphing functions offered by Minitab. After the teams determine the most significant factors they continue on with modeling their armored vehicles utilizing these most significant factors as their variables.

Some of these factors listed above are best analyzed using their JCATS simulation whereas other methods may be best analyzed using other testing sources. It is up to the cadet teams to determine which methods are most applicable for each factor, however, due to the weighting scheme of the DOE response results normally each cadet team with modify approximately six of the thirteen factors in order to achieve proposed armored vehicle courses of action to be entered into JCATS.

JCATS is a highly complex yet user friendly program which greatly facilitates learning in a classroom environment. It provides an excellent opportunity for the cadet teams to utilize both analytical thought and reason in determining a candidate armored vehicle system to recommend to a "senior Army decision maker". The process that the cadet teams use is known as the Systems Decision Process.

5. SYSTEMS DECISION PROCESS

The Systems Decision Process (SDP) is a methodology developed by the Systems Engineering Department at West Point in order to formalize the decision making process. Five inherent characteristics that make the SDP an ideal process to utilize are:

"1. The SDP encapsulates the dynamic flow of system engineering activities and the evolution of the system state, starting with the current status (what is) and ending with a system that successfully delivers value to system stakeholders (what should be).

2. It has a core focus on the needs and objectives of stakeholders and decision makers concerned with the value being delivered by the system.

3. It has four major phases organized into a logical progression (problem definition, solution design, decision making, and solution implementation) that embrace systems thinking and applies proven system engineering approaches, yet is highly iterative.

4. It explicitly considers the environment (its factors and interacting systems) that systems operate in as critical to systems decision making, and thus highlights a requirement for multidisciplinary systems engineering teams.

5. It emphasizes value creation (value modeling, solution enhancements, and value-focused thinking) in addition to evaluation (scoring and sensitivity analysis) of alternatives." [3]

The SDP is displayed in Figure 5.

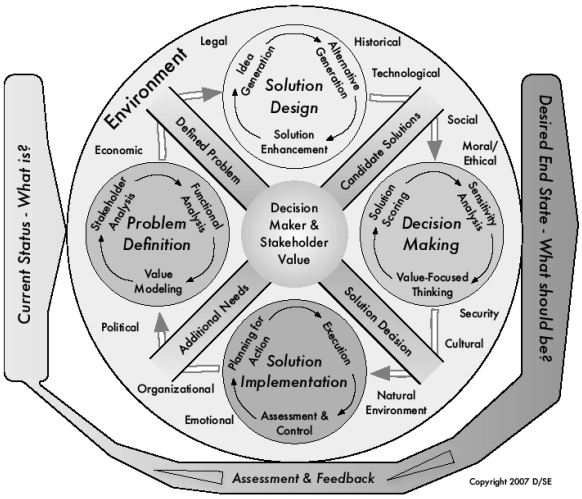

Figure 2. Systems Decision Process [4].

6. CONCLUSION

Simulation is an excellent tool for learning in the classroom environment. Not only does it provide realistic, hands on activities by which our cadets learn valuable lessons but it also contains a deep theoretical background that educates the cadets as they step through the process of creating a simulation, implementing the analytical tools required in order to inform the decision maker, and ultimately recommend a final course of action. It is important to realize that we shouldn't lose sight of the forest because we are focusing on the trees. By taking the rigor out of simply creating simulation entities and instead focusing the cadets' energies towards data collection and analyses, as educators we can enhance their learning experience.

There are many methods to teach simulation and decision making. By taking a real world scenario and energizing the cadets with the opportunity to work as a team, recreate a challenging simulation environment, perform statistical tests in varying situations, and ultimately brief their results to a "senior Army decision maker" the process of education is truly rewarding for both the students and instructor.

7. REFERENCES

[1] Loeb, Vernon, "*Army Expansion Could Last 5 Years Ranks Will Swell During Restructuring*", Washington Post, January 30, 2004, Page A19, http://www.washingtonpost.com/wp-dyn/articles/A61583-2004Jan29.html.

[2] United States Joint Forces Command Website, http://www.jfcom.mil/about/fact_jcats.htm, November 2007.

[3] Parnell, Gregory S., Patrick J. Driscoll, Dale L. Henderson, "*Decision Making in Systems Engineering and Management, Fall 2007 Edition*", Wiley Custom Services, 2007, Page 12.

[4] Parnell, Gregory S., Patrick J. Driscoll, Dale L. Henderson, "*Decision Making in Systems Engineering and Management, Fall 2007 Edition*", Wiley Custom Services, 2007, Page 13.

Biography

Major Stephen E. Gauthier is an Instructor/Analyst with Department of Systems Engineering at West Point, New York. He teaches Combat Modeling, Computer Aided Systems Engienering, and a Professional Engineering Seminar. He possesses a BS in Foreign Area Studies from the United States Military Academy (1993) and a MS in Operations Research from the Naval Postgraduate School (2006). Before becoming an Army operations analyst he was a UH-60 helicopter pilot. His past work has focused on stochastic modeling in evaluation the Army's Condition-Based Maintenance Program, budgeting models for the Director of Army Environmental programs, and values based modeling for assessment of the National Security Strategy. He is a member of the Military Operations Research Society (MORS), the International Council on Systems Engineering (INCOSE), and the Institute for Operations Research and Management Science (INFORMS).

Lieutenant Colonel Michael J. Kwinn, Jr., is an Associate Professor of Systems Engineering at the United

States Military Academy at West Point where he currently directs the Systems Engineering and Operations Research programs. He graduated from the United States Military Academy at West Point in 1984. He has received a Master of Science from the University of Arizona, a Master of Arts in National Security and Strategic Studies (with Distinction) from the Naval War College, and a Ph.D. in Management Science from the University of Texas at Austin. He has worked on systems engineering projects for over 10 years, most recently as the Director of the Operations Research Center (ORCEN) at the United States Military Academy. Some of his recent work is in the areas of acquisition simulation analysis, military recruiting process management, condition-based maintenance implementation and assessment systems development for combat operations. He is President-elect for the Military Operations Research Society (MORS), is a member of the International Council on Systems Engineering (INCOSE), the Institute for Operations Research and Management Science (INFORMS) and has served as an advisory member for the Army Science Board