Innovation through Discovery Experimentation

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ABSTRACT

As the military refocuses its training and acquisition from the counter-insurgency conflicts in Iraq and Afghanistan to the potential for major military conflict in an era of new technologies, there is a need to explore new concepts for using these new technologies. These explorations are essential for developing new tactics, techniques and procedures (TTPs), integrating new capabilities into existing forces, but are also critical in the choices of which technologies to mature and acquire. Discovery experimentation is a process for using simulation to place emerging technologies in the hands of warfighters engaged in virtual battlefields to explore the military utility of new concepts for using emerging systems. Discovery experimentation is designed to allow learning and modification from trial to trial and in that way differs significantly for both traditional scientific experimentation and technology demonstrations. In support of the US Air Force, research staff from the Institute for Defense Analyses conducted a multi-trial, discovery experiment to explore new concepts in close air support (CAS) employing Network-Enabled weapons. This paper will use this experiment to further define discovery experimentation; how it can use existing facilities and simulations with modifications to conduct the exploration; identify potential adversary counters, and how the data acquisition and results of progressive trials altered the initial concept to extract new TTPs and define requirements for supporting equipment. A small team of CAS experts (instructor level) experimented with the new technology in a stressing threat environment responding to the call for fires from an experienced military commander and fires officer. The concept and supporting data that emerged provides initial evidence that the new approach might be capable of addressing more targets in less time than had been possible with traditional tactics might be possible.

ABOUT THE AUTHORS

S. K. Numrich, PhD, CMMS, has been a member of the research staff at the Institute for Defense Analyses since 2005. She is a research physicist with a background in underwater acoustics, environmental factors and modeling, and computer simulation. A former technical director at the Defense Modeling and Simulation Office, she has a strong background in distributed simulation and issues in VV&A. She managed the development of mine warfare components for Maritime JSAF and has served on simulation committees for The Technical Cooperation Program, NATO's Research and Technology Board, and I/ITSEC.

Kevin Woods, PhD, has been a member of IDA's research staff since his separation from the US Army in 2004. His initial degree from Auburn is in Organizational Management followed by an MA in National Security and Strategic Studies and PhD in history from the University of Leeds, UK. He served as concept developer for Experimentation at JFCOM and led the discovery experimentation team on novel concepts in close air support completed by IDA for the Air Force in 2016. He is a frequent speaker and lecturer on strategic studies.

Joel Resnick came to IDA after serving as Deputy Assistant Secretary of Defense for Strategic Planning and Analysis. He holds a BS in from the City College of New York and MS from MIT, both in electrical engineering. He began his career at MIT Lincoln Laboratory and subsequently served as analyst for US Arms Control and Disarmament Agency, and for Program Analysis and Evaluation, and as a Professional Staff Member, House Armed Services Committee. Mr. Resnick was one of the first to use discovery experimentation in the exploration of new operational tactics and force structure for Joint Forces Command.

Jack A. Jackson, PhD, a graduate of the Air Force Academy, came to IDA after serving as a fighter pilot, staff operations office in the Pentagon, and associate professor of operations research at the Air Force Institute of Technology. An analyst with academic credentials in mathematics, computer science and operations research, Dr. Jackson has led numerous analytical tasks at IDA, most recently the Weapons Centric Close Air Support (WCC) in which discovery experimentation was the procedure followed to explore new capabilities for CAS.

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BACKGROUND

The foundations of discovery experimentation lie in the age-old tradition on the part of the military to improve operations by trying out new tools, force structures, and tactics, techniques, and procedures (TTPs) during operations. Wanting to improve performance through adaptation during the thick of battle provided a clear and unquestionable motivation, finding another time and environment where failure and death were not companions seemed a better idea altogether. The rate of technological innovation in the Twentieth Century spurred interest, if uneven application, in interwar experimentation. Morse and Kimball expressed this need in the following terms (Morse and Kimball, 1946):

> *This idea of operational experiments, performed primarily not for training but for obtaining a quantitative insight into the operation itself, is a new one and is capable of important results. Properly implemented, it should make it possible for the military forces of a country to keep abreast of new technical developments during peace, rather than have to waste lives and energy catching up after the next war has begun.*

As the military's research and technology development apparatus grew, the notion of demonstrating technology in the context of military training exercises became increasingly common. The training exercise provided a venue in which an emerging technology could be handed to the warfighter to use, provided appropriate training and instruction were also provided. The technologist could see how the warfighter attempted to use the new device and went away from the exercise with a much clearer notion of the specific potential military utility of their new capability. One of the problems with using training exercises as a venue is that exercises have an overriding training purpose and the technologist who seeks to demonstrate new technology usually learns that few things can interfere with the schedule or tempo of the training itself. If a demonstration is cancelled because of a training need, there is no guarantee that it will be rescheduled at a later stage of the exercise. This preeminence of training goals places an additional burden on the demonstration and leads to the attitude that the demonstration cannot afford to fail where afford means both technically and financially. Once again there is little or no room for failure, even if failure is lack of opportunity to demonstrate.

The ability to explore the military utility of future systems is recognized as a force multiplier. Technology is not the only capability to be examined through experimentation, but new ideas and tactics can also be explored. According to the National Academy in a study done for the Navy (National Academy of Sciences, 2004),

> *By simulating future systems, they (military commanders) can also learn how those systems will work in simulated combat environments and how to use forces equipped with such proposed systems. By such means they can explore new ideas and concepts for the use of variously composed and equipped forces against diverse anticipated threats, and they can learn how to integrate such forces on a large scale in the joint and combined force environment.*

More recently, Michael Tyson, a Marine Corps senior fellow at the Atlantic Council's Brent Scowcroft Center on International Security, echoed the National Academy's sense for the worth of experimentation in no uncertain terms (Tyson,2014).

> *As the most powerful country on the planet, both economically and militarily, we should, without a doubt, conduct aggressive experimentation to learn not only learn what to do, but also actively seek to learn what not to do. We will benefit from both results, as we will develop future leaders and operators that are not afraid to take risks in pushing the edges of our own abilities.*

While the idea of experimentation seems useful and even important, there are a number of obstacles preventing the broad use of experimentation. Anita Jones, former Director for Defense Research and Engineering, listed several of the roadblocks to the use of experimentation (Jones, 2000). The first was the cost, assuming that militarily realistic experimentation had to involve expensive copies of new and risky devices that embody unproven technologies. Clearly if there were a way to experiment before the technologies were embodied in the devices, that roadblock could be removed. The second roadblock involved providing devices and military personnel over a protracted period of time to both test the devices and develop TTP for their use. Conceiving of alternative forms of experimentation might serve to alleviate this problem. The final problem persists today. Because we fight jointly, experiments should be conducted jointly and there are currently few if any budgets for joint experimentation. However, the greatest barrier to engaging in experimentation is a lack of understanding and appreciation of what discovery experimentation means and how it can be carried out.

WHAT IS DISCOVERY EXPERIMENTATION?

The Department of Defense uses three distinct types of experiment in the course of doing business. To confuse one type of experiment with another and to constrain an experiment of one type to operate under the rules and guidelines of another is to vitiate its validity and utility. The three types can be used separately or in carefully planned combination to provide synergy, but one cannot substitute for another and still yield desired results. Thus, we begin by defining all three types of experiments, recognizing that the paper will focus on discovery experimentation.

Hypothesis Testing

Hypothesis testing is near and dear to the heart of every empiricist. It is the classic form of experiment used by scholars to advance knowledge by seeking to falsify specific hypotheses (specifically if…then statements) or discover their limiting conditions (Alberts and Hayes, 2002). In many cases, hypothesis testing is used to test the veracity of theories. The image in Fig. 1, created by the artist Yantish, includes two caricatures of hypothesis testing experiments. The legendary experiment by Galileo using the Tower of Pisa to test the law of gravity and the demonstration of that experiment by astronaut David Scott on the moon's surface. Scientists use hypothesis testing to build knowledge or refine to domain of validity of known scientific experiments.

Hypothesis testing requires rigorous establishment of conditions or parameters that will be held constant or varied according to a well-defined plan. Data are collected from the experiment over multiple executions to prove or disprove the hypothesis under question. The legendary experiment by Galileo disproved the prevalent theory of gravity that objects fall at speeds relative to their mass. Scientists accept the veracity of hypothesis testing only if it can be replicated by other researchers under the same conditions. The constraints on parameters, data collection and replication are key features of hypothesis testing experiment.

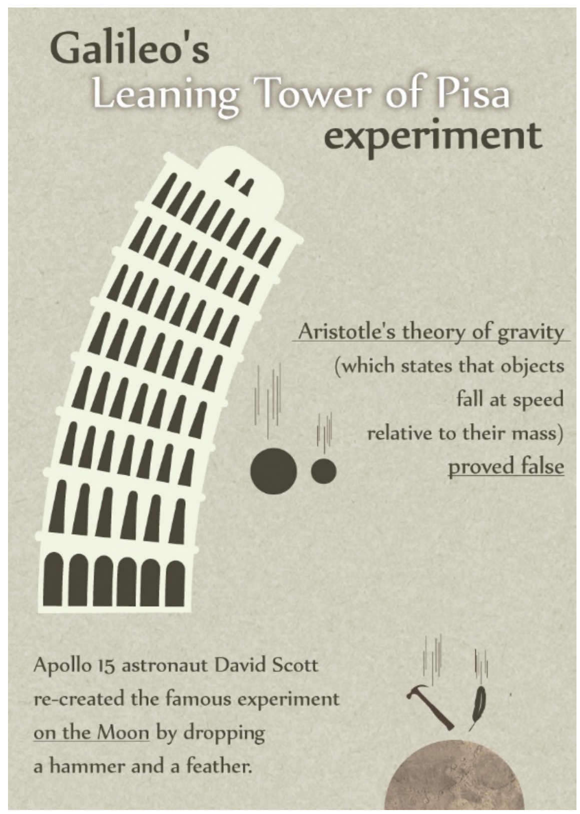

Figure 1. Hypothesis Testing: Gravity

Demonstrations

Demonstrations are often called experiments, but differ from hypothesis testing in that what is being demonstrated is already known to be accepted as truth. "Demonstration experiments, are analogous to the experiments conducted in a high school, where students follow instructions that help them prove to themselves that the laws of chemistry and physics operate as the underlying theories predict (Alberts and Hayes, 2002)." In Fig. 1, when David Scott dropped a hammer and a feather on the moon, he was performing a demonstration experiment illustrating the law of gravity.

In the Department of Defense (DoD), the services use technology demonstrations (or experiments) to introduce a new technology or procedures to the operational community. In many cases, these experiments have become a routine part of the innovation process in which, under carefully orchestrated conditions, the developers seek to show the operators that the innovation can provide added efficiency, effectiveness or speed in military operations. The technologies are based on well-established principles. Demonstrations are designed to collect data once during training events when operators can use the new innovation under conditions resembling field operations. These are "one-off" experiences. There is no baseline, nor is there any intent to collect confirmatory data at a later date. Conditions are not and cannot be carefully controlled. Thus in many aspects demonstration experiments differ from hypothesis testing. From the start, the intent is different and to preserve that intent, rules of hypothesis testing are not applied.

Discovery Experimentation

This final category of experimentation and the one that will be the focus of the rest of the paper is the discovery experiment. The objective of using discovery experimentation in DoD is to explore a concept, refine it in an operational (or synthetic operational) setting, and determine military utility well before the innovation is concretized and fielded. A capability that sounds wonderful to the innovator can sometimes have marginal military utility in actual practice. For both fiscal and operational reasons, it is highly desirable to find this out before the new capability is fielded at considerable expense and potential danger to the operator if it fails to work as anticipated.

The objective of the discovery experiment is to learn; therefore, while it begins with well-defined boundary conditions and an initial data collection plan, the value of the experiment lies in being able to modify boundary conditions in response to the performance and in that way refine the capability. This notion of progressive learning does not relieve the experimentation team from refining the concept prior to initiating work on the experiment itself, nor does it place less value on developing a data collection plan. If anything, the combination of expert data collection and observations by subject matter experts more critical than for hypothesis testing if the results of one trial are to be used to modify the next. However, the experimentation team must be willing to modify the data collection plan in response to the results of the experiment. As we continue to explore discovery experimentation, we will address concept refinement, data planning, experiment execution, and the feed-back and feed-forward of the progressive learning.

Experimentation Campaign: Reducing the Risk of Innovation

While a discovery experiment can be conducted as a singular event, it is best used as a part of a campaign in which a blend of tools is used to take an innovation from concept through to operations. Each stage of the campaign is used to refine the conceptual capability using the feed-back from the just-completed stage and feeding forward the refined capability to the next stage of experimentation. The spirit of the discovery experiment persists throughout the phases in which different tools are used in the refinement process. The implicit objective of the experimentation campaign is to force the capability under consideration to "fail" as early as possible in the process with the clear understanding that it is better to expose a fatal weakness in a war game or simulation than in real-world operations against a well-equipped adversary. The structure of a concept-to-capability campaign is shown in Fig. 2 (Woods, Kramer, Numrich, Resnick, &Jackson, 2016)

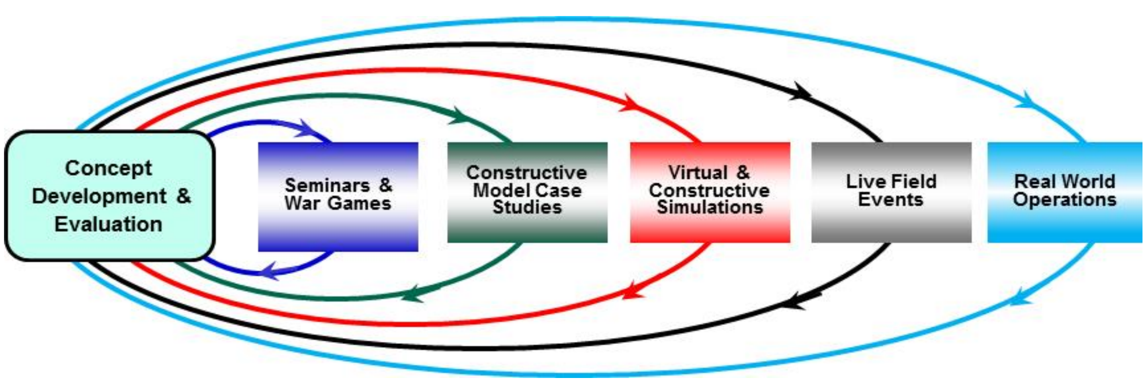

Figure 2. Generic Concept-to-Capability Campaign

Concept Development and Evaluation

Concept (or innovation or capability) development and evaluation is a continuing process across all phases of the campaign. The developer of the innovation, the campaign design team and some subject matter experts participate in this process as the feedback from each phase is used to refine the innovation prior to the next phase.

Seminars and War Games

In the early stage of refinement, subject matter experts familiar with the technology and with the operational environment debate and wargame the innovation. The innovation must emerge successfully from this stage to be taken seriously as a potential capability.

Constructive Model Case Studies

If there are models available capable of inserting the innovation into the simulation, these models are exercised to further subject the capability to an operational environment. All performance parameters are assumed and there is no human intervention into the execution of the model. To achieve maximum utility, the model should be capable of portraying an adversary.

Virtual and Constructive Simulations

This stage is vitally important as it represents the first time a trained warfighter engages with the innovation in an operational environment and the best point for exploring military utility. In most cases, the targeted simulation will have to be modified to introduce the innovation into the mix of systems in the simulation; however, the fidelity of the innovation needs to be no more than is essential to test broad capabilities. This phase may be a crossroads. For innovations that are new concepts in force structure or TTPs, the process may continue as pictured in Fig. 2; however, for capabilities that are tools or systems, this is the point where the system, presently a concept, is turned into a rough prototype and then reintroduced into the virtual and constructive simulation environment before proceeding.

Live Field Events

These exercises are extremely valuable, particularly in providing details of the physical and operational environment missing from simulations. Prior stages intuit the effect of the electromagnetic environment, for example, but a well-designed field exercise may be able to provide a far more complete replica of the actual electromagnet environment to be encountered in a military engagement. Weather, terrain, day and night, and a fully adaptive adversary are other potential advantages of live events. At this stage, the innovation or prototype is refined to the point where it can be deployed in operationally.

Real-World Operations

Everything up to the point of real work operation is simulation, even field exercises at combat training centers. Actual operations, particularly in wartime, are the experiments one does not wish to run because failure could be measured in human casualties. However, experimentation does take place during combat, and failure is sometimes a result. The development, used and eventual demise of tank-destroyer battalions in World War II form an example of an innovation that proved highly successful in wargames and in Louisiana maneuvers, but was eventually abandoned (Denny, 2003). The goal of the experimentation campaign is to reduce the degree of liability when the innovation goes to war. Further, the lessons that emerge from the crucible of real world operations can serve as a feedback mechanism to refine or kill the innovation.

Each stage of this process reduces the risks associated with innovation. The remainder of the paper will describe the process of using the stages in Fig. 2 through the use of a virtual and constructive simulation environment to refine a new concept for employing close air support (CAS).

SETTING UP A DISCOVERY CAMPAIGN

Ideally, the campaign is begun when the innovation is a concept amenable to continuous refinement. The example used in the paper began with a problem and evolved over a period of six months into a concept sufficiently concrete that it could be subjected to test and evaluation in a simulation environment. The general military problem area of CAS was of interest because of the projected retirement of the A10 aircraft, the iconic USAFCAS platform, the high demand for 5th generation aircraft in non-CAS missions, the growing effectiveness of adversary tactical air defense systems against existing 4th generation CAS capable platforms, and the potential of facing a near-peer adversary in a contested environment where US air superiority had not as yet been achieved. The question was stated in the following manner (Woods et al., 2016):

> *How can the Joint Force Commander create CAS effects during the early phase (before US forces establish air superiority) of a major conventional operation or campaign without incurring unacceptable risks to the joint force or its mission?*

CAS is defined as "air action by fixed- and rotary-wing aircraft against hostile targets that are in close proximity to friendly forces and that require detailed integration of each air mission with the fire and movement of those forces." (JP3-09.3, 2016).

A *contested environment* is one where the adversary has the capabilities to deny US ability to operate or can restrict US freedom of action in air, space, or cyberspace. In a *highly contested* environment, an adversary possesses the capabilities to interfere prohibitively in one or more domains that requires applying advanced warfighting techniques and capabilities to create desired effects (US Air Force, 2013). The concept began with the notion of conducting CAS in a contested environment – one in which there may be a hesitancy to use fifth generation aircraft due to high risk.

Refining the Concept

The experimentation team hosted a number of workshops and conferences with the CAS community (US Marine Corps, US Navy, US Army and US Air Force) during which the problem was confirmed as of military importance. The community recognized the necessity of conducting conventional ground maneuver with CAS support against a near-peer without first achieving air superiority as a significant and growing possibility.

The innovative concept that emerged from these discussions was to shift the mission burden of CAS from the platform delivering the munition to the control of the munition from the forward ground element in the person of the Joint Tactical Air Controller (JTAC). The specific approach was named Weapon-Centric CAS or WCC and was based on the concept of allowing the JTAC to control smart weapons without requiring the high-value air platform to enter the threat envelope. This approach required weapons not as yet within the AF inventory. Two types of smart weapons were used:

- Stand-off network-enabled weapons (SNEWs) capable of being released from an aircraft on demand and gliding to their target under Global Positioning System (GPS) control
- Loitering network-enabled weapons (LNEWs), powered munitions released from an aircraft and left to loiter near the front until commanded by the JTAC.

Giving the JTAC control of such weapons would allow the aircraft releasing the weapons to remain out of danger of the adversary's tactical air defense shield. The concept as constructed in the laboratory is pictured in Fig. 3 (Woods et al., 2016).

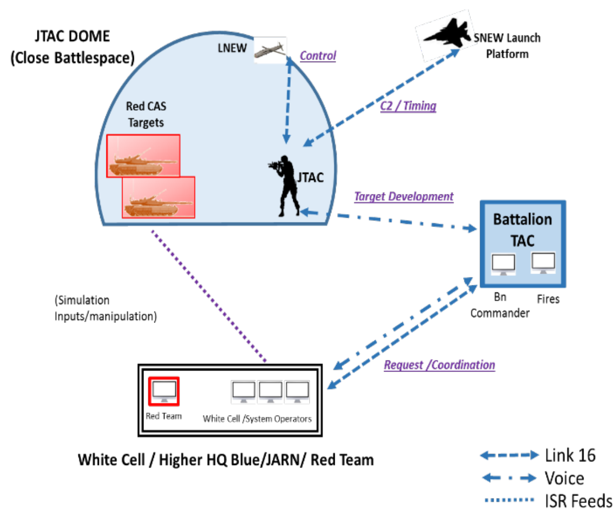

Figure 3. JTAC Employing LNEWs and SNEWs

Operationally, the initial concept placed the JTAC in the forward area of the battlespace, the usual position, taking requests for fires from the Army's Battalion commander located at Tactical Air Command (TAC) and providing terminal control of the weapons. If additional weapons or aircraft were needed, the Battalion commander could coordinate with the Joint Air Request Net (JARN) located further away from the front.

The next step in the process would have been to subject the WCC concept to test in a constructive simulation; however, no simulations with an adequate portrayal of CAS were available; therefore, the experimentation team sought a venue for human-in-the-loop (HITL) simulation capability.

Finding and Modifying the HITL Venue

Air Force Research Laboratory (AFRL) provided the HITL facility for the discovery experiments. The 711th Human Performance Wing at Wright Patterson Air Force Base runs a training facility used at times to train JTACs. The Integrated Combat Operations Training-Research Testbed (ICOTT) runs a simulation, the Modern Air Combat Environment (MACE), used at a number of Air Force sites to model the air combat environment. Mace feeds the actions in the simulation to the visual display facility, a half-dome, semi-immersive environment in which the JTAC can interact using an end-user device (EUD) that communicates with certain entities in the simulation. The dome at ICOTT is similar to that in Fig. 4 (provided courtesy of Battlespace Simulations, Inc.).

Figure 4. Dome Environment Similar to ICOTT's

The ICOTT had a number of simulated scenarios available for use, but since the weapons and their control were part of the new concept, neither the weapons nor an appropriate EUD were available. A battle rhythm of one trial each month from the initial acquaintance visit in January to the last of the trials in the experiment in May allowed time up front for the software engineers to simulate the new weapon types (SNEWs, and LNEWs) and create with the assistance of an instructor-level JTAC an EUD that would allow the JTAC to control the weapons as if he were doing so in the field. By March, the trials began and the hiatus of one month allowed the experimentation team to absorb the results of the just-completed trial and integrate what was learned into the conduct of the next trial. The practice of continuous learning was critical for refining the concept.

Data collection introduced another set of new requirements to the ICOTT. As a training research facility, ICOTT focused on measuring individual performance and compliance with the TTPs in pursuit of the stated goal of the training run. Quite to the contrary, the experimentation team was measuring the performance of the JTACs only to the extent that it was evident that the performance of each JTAC was in line with that of the other three participants. If all JTACs performed in like manner, running each JTAC through a given scenario was not necessary. Learning could take place more rapidly by adjusting the scenario after one or two trials rather than four. ICOTT staff who monitored the trials noted the steps followed by the JTACs; whereas, the experimentation team was more concerned with the contents of the messaging and the way the JTACs prepared for each step. This was a significant adjustment in focus. The same was true with the data collected from the computer runs. The experimentation team was concerned more about timing and kill tables than in tracing an individual's performance. The difference required different data to be collected and stored in the ICOTT system.

Finding Qualified Performers

Part of the validity of the HITL experiment depends upon the skill base of the performers. Experienced and capable warfighters make the results credible. The Air Combat Command (ACC) and the 19th Air Support Operations Squadron (ASOS) provided four instructor-level JTACs who participated in each of the three trails. In addition, two senior JTACs served in the roles of observer and member of the experimentation team. The ICOTT operators included former JTACs and pilots who had flown CAS. The military contingent was completed by Joint fires officer from Ft. Sill and two colonels on temporary assignment to IDA: an Army special operations officer (role played the ground force commander in the experiment) and an Air Force test pilot (who provided feedback on the operational and technical aspects of the platforms and air operations). The military expertise lent credibility to the findings as the experimentation progressed from one trial to the next.

CONDUCTING THE EXPERIMENT

As with most military operations and all experiments, the execution plan was established prior to the first trial, and, as with most military operations, the plan did not survive first contact. However, this was the anticipated result for the discovery experiment. The command and control structure, the location of the JTAC, and the data collection plan all changed during the successive trials.

Data Collection and Assessments

The data collection plan included two types of data: hard data included the results of the computer runs which would provide a confirmation of what happened and soft data collected from survey tools and after-action review, contextual data from which to ascertain what the JTACs thought happened and why they made their choices in response.

The soft data included the NASA Task Load Index from which we hoped to determine what types of stress the JTACs were feeling in each trial run, and a part task difficulty assessment based on the common tasks a JTAC must perform to help us tune the concept as needed. Both of these were self-assessments and in all cases the JTACs scored similarly. Debriefs taught us that we could use another tool for collecting data and, with the help of the ICOTT staff member who had flown CAS, we developed a tally sheet for what the JTACs felt had occurred in the previous run in terms of weapons used for each target and the number of re-attacks needed to effect the commander's intent for that target.

Some of the data sources added to the initial collection plan were records of communication between the JTAC and the Battalion commander concerning the commander's designation of a target and his intent for that target and the JTAC's plan for prosecuting that target. An additional source of data were the simulated Link-16 messages between the JTAC and the smart weapons as he directed them to their targets.

Not all desired data was available throughout the computer runs. Table 1 shows the desire data elements for the proposed analyses and the remaining columns list the source for the data with the availability in each box. Only four of the data items were always available. For all the rest, multiple sources had to be searched to determine whether or not the data could be extracted.

Table 1. Desired "Hard" Data, Sources, and Availability

Desired Data Element	Source for Extracting Data	Column1	Column2	Column3	Column4
	Scenario Description	PDU Data	Link-16 Message	JTAC Log	Radio Log
Start Time				10-30%	100%
Weapons Available	100%				
Time Target Assignment				10-30%	50-80%
Weapon-Target Plan				50-80%	10-30%
Time Weapon-Target Pairing			100%	50-80%	10-30%
Time Cleared Hot		100%	100%	10-30%	10-30%
Position in Flight		100% SNEW only			
Impact time		50-80%		10-30%	10-30%
Impact Location		50-80%			
Damage to Target		50-80%		10-30%	10-30%

The catalog of contextual data available from the self-evaluations, questionnaires and out-briefs is shown in Table 2. The instrument was used multiple times and by the end of the three trial, the total number of samples collected is shown in the last column. These data help track the performance of the JTACs to determine they were essentially interchangeable for the purposes of the trials. The surveys and out-briefs provided a sense of what the JTACs thought was going on and where they felt the needed additional training if the concept were to be adopted in some form. One notable areas was in learning to do targeting. JTACs normally call for fires and do terminal laser guidance, but they do not determine which weapon to use for a given target. The WCC concept required that the JTAC develop the targeting solution in addition to managing the weapon performing terminal guidance. The addition of these tasks led to adjustments in the command and control arrangements in the experiment and presumably under operational conditions.

Table 2. Catalog of Contextual or "Soft" Data

Perceptual Data Sources			
Instrument	**Subject(s)**	**Collection**	**Total Samples**
NASA Task Load Index	JTAC and Observer or JTAC1 and JTAC2	Each run in all Trials (31)	62
Part Task Difficulty Assessments	JTAC and Observer or JTAC1 and JTAC2	Each run in Trials 1 and 2	40
Elicited Response Survey (free text)	JTAC and Observer or combined JTAC1 and JTAC2	Each run in all three Trials	51
Outbrief Notes (IDA data collector)	JTAC and Observe or JTAC1 ad JTAC2 with Ground CDR and Fires Officer	Each run in Trials 1 and 2, after each set of 3 runs in Trial 3	24
After Action Review	JTACs	End of each Trial	12

Progressive Learning: Feed-back and Feed-forward

Accurate and comprehensive data collecting comprising both hard and soft data is critical if learning is to occur and be used to modify the innovation. In the series of WCC trials, the soft data provided most of the material for adjusting the initial concept.

Targeting

The very first lesson learned was unearthed during the first trial and was progressively refined throughout the second trial. During the first trial, the only weapon being used was the LNEW, loitering in the battlespace and available for use. The JTACs observed that they had no concept of how many weapons should be used for targets and they were certain that it would differ for moving as opposed to stationary targets. Pilots learn to develop targeting strategies, but JTACs were never trained to make those choices in the same way. The JTACs took the rule of thumb from the pilot on the ICOTT staff, refined it and extended it to choosing volleys of LNEWs and SNEWs as soon as the SNEWs became available in the simulation.

Command and Control

JTACs are normally positioned forward in the battlespace to have the best position for observing the adversary and providing terminal guidance for laser guided weapons. Therefore, the initial strategy continued to place the JTAC in the forward position. Using a combination of LNEWs and SNEWs, JTACs were able to prosecute more targets than under traditional circumstances, resulting in a significant increase in communication with the Battalion commander. Managing the radio communications and using a more complicated EUD for communicating with weapons, the task of communicating became unwieldy. The second evolution placed the JTAC in the Battalion TAC where intelligence data would be visible and not require additional radio communication. While this helped, it was not ideal. In the final run, the JTAC was joined in the Battalion TAC by another skilled JTAC whose role was to manage radio communication while the first JTAC formulated the targeting solutions and managed the communication with the weapons. Terminal targeting was done by a forward observer who was not a trained JTAC, but who was trained to do laser guidance. This final solution seemed optimal.

End-User Device

The initial design of the EUD was based on existing “digitally-aided CAS” terminal control devices and the existing TTPs for a JTAC with some notion of what would be needed to manage the weapons. Significant changes were made during the trials until the form of the EUD at the last trial seemed optimal. JTACs use hand-held devices and the specific device in use was also being modified at the time of the WCC experiment. The modifications made to the

EUD during the trials provided a set of requirements for the upgrade of their existing device should control of weapons be a desired capability. These requirements were handed over to the acquisition program of record.

These are examples of using feed-back from each iteration to improve the next. The improved concept was fed forward and became the concept tested in the subsequent run. This process enabled continuous refinement of the innovation long before it became a prototype or was suggested as an operational concept.

Providing Evidence, Not Necessarily Answers

While the HITL experiment provided considerable refinement in the initial concept and produced significant excitement and enthusiasm on the part of the JTACs and Army officers, it did not provide any definitive answers to the ultimate military utility of the concept. The evidence, particularly the speed with which the JTACs were able to re-attack targets, suggests that the concept is worth further study and exploration. Refinements in the experimental environment would be required since it was lacking in several parts of the battlespace important for measuring the effectiveness of the new concept. There was no realistic electromagnetic environment present. Weapons could not be jammed. Signals could not be modified or interrupted in a technically valid way. Furthermore, the entire concept rests on the availability of a networked battlespace. The JTACs relied on Link-16 to communicate with the weapons. There was no way to test the effect of that additional load on the battlespace network. The weapons used were modeled after smart weapons being considered for acquisition, but significant features of those proposed weapons were lacking in the modeled LNEWs and SNEWs. The ICOTT provided an impressive local environment, but the trails were at an engagement level of modeling. They did not take into account the larger battlespace, a context that could limit the availability of weapons and platforms to deliver them as well as the availability of communications bandwidth.

There is not a single venue capable of providing all the capability needed to complete the battlespace and run the WCC concept through another series of tests; however, the primary warfighter response was obtained from the ICOTT trials. From this point on, the WCC concept can be broken apart and the limitations tested separately in appropriate venues prior to considering field tests.

What we do know from the evidence provided by the HITL experiments is that the concept as originally conceived is not particularly effective, but with modifications such as those made during the trials, the proposed innovation could prove to be of military utility.

CONCLUSION

Discovery experimentation is not a free-for-all, but a carefully thought out and planned approach to addressing an issue long before it becomes a pressing problem. It allows humans to interact with new or potential concepts and capabilities and explore their military utility—something that is not often supported through traditional studies or experiments. It requires careful attention to the specification and collection of data that will provide solid evidence for the conclusions reached through executing the experiment. If all of these constraints are observed, discovery experimentation can be a valuable tool in the process of the larger capability-to-concept campaign

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